# Handbook of Epistemic Cognition

The *Handbook of Epistemic Cognition* brings together leading work from across disciplines to provide a comprehensive overview of an increasingly important topic: how people acquire, construct, understand, justify, change, and use knowledge in formal and informal contexts. Research into inquiry, understanding, and discovery within academic disciplines has progressed from general models of conceptual change to a focus upon the learning trajectories that lead to expert-like conceptualizations, skills, and performance. Outside of academic domains, issues of who and what to believe, and how to integrate multiple sources of information into coherent and useful knowledge, have arisen as primary challenges of the twenty-first century.

In six sections, scholars write within and across fields to focus on and advance the role of epistemic cognition in education. With special attention to how researchers across disciplines can communicate and collaborate more effectively, this book will be an invaluable resource for anyone interested in the future of knowledge and knowing.

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# Handbook of Epistemic Cognition

Edited by
Jeffrey A. Greene, William A. Sandoval, and
Ivar Bråten

Routledge
Taylor & Francis Group
NEW YORK AND LONDON

First published 2016
by Routledge
711 Third Avenue, New York, NY 10017

and by Routledge
2 Park Square, Milton Park, Abingdon, Oxon, OX14 4RN

*Routledge is an imprint of the Taylor & Francis Group, an informa business*



*Library of Congress Cataloging in Publication Data*
Names: Greene, Jeffrey Alan, editor of compilation.
Title: Handbook of epistemic cognition / edited by Jeffrey A. Greene, William A. Sandoval, and Ivar Brêaten.
Description: New York : Routledge, 2016. | Series: Educational psychology handbook series
Identifiers: LCCN 2015029609| ISBN 9781138013407 (hardback) | ISBN 9781138013421 (pbk.) | ISBN 9781315795225 (e-book)
Subjects: LCSH: Cognitive learning—Handbooks, manuals, etc. | Learning, Psychology of—Handbooks, manuals, etc. | Metacognition—Handbooks, manuals, etc.
Classification: LCC LB1062 .H248 2016 | DDC 370.15/2—dc23LC record available at http://lccn.loc.gov/2015029609

ISBN: 978-1-138-01340-7 (hbk)
ISBN: 978-1-138-01342-1 (pbk)
ISBN: 978-1-315-79522-5 (ebk)

Typeset in Minion
by diacriTech, Chennai

Dedication

- Jeffrey A. Greene dedicates his work on this volume to his wife, Mira Brancu, and their children, Jacob and Avery. The many hours of work necessary to produce this volume depended upon their understanding, and more importantly, their love and support.
- William A. Sandoval dedicates his work on this volume to the teachers and children at the UCLA lab school from whom he has learned so much about epistemic cognition. He is grateful to the Learning Technologies Research Group at UCLA for their openness and criticism, especially Suna Ryu, Sihan Xiao, Jarod Kawasaki, Jackie Wong, David DeLiema, and Noel Enyedy. Special thanks to Rick Duschl for years of support in all matters epistemic.
- Ivar Bråten dedicates his work on this volume to his dear partner, Ann Kristin Heller, and his son Jørgen Bråten, the two persons in the world that occupy his mind most when he is not thinking of research. Additionally, he wants to thank his collaborators in the TextDIM research group at the University of Oslo for their continuing loyalty and support.

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# ACKNOWLEDGMENTS

This volume is the result of the vision and hard work of many people. Patricia Alexander, as Series Editor for Educational Psychology Handbooks by Routledge, developed the idea for this volume. We are grateful and honored to have been invited to edit this volume, and thank Patricia for her guidance throughout the process of creating this Handbook, and for her contributions. We also extend our gratitude to our Routledge Editor Rebecca Novack for her advice, support, and encouragement. Trevor Gori and Matthew Friberg, also from Routledge, handled much of the business of the Handbook, freeing us to focus on the content of the volume.

We owe much to the scholars who served as reviewers for chapters in this Handbook: Lisa Bendixen, Saskia Brand-Gruwel, Geraldine Clarebout, Andrew Elby, Leila E. Ferguson, Florian Feucht, Ellice Forman, Michele Gregoire Gill, Susan Jurow, Richard Kitchener, Barbara Koslowski, Eve Manz, Hugo Mercier, David Moshman, Alina Reznitskaya, Gregg Schraw, Gale Sinatra, Marc Stadtler, Johan van Strien, and Helge I. Strømsø. The chapter authors were very appreciative of their assistance, and the reviews were important guides for improving and focusing the chapters.

Finally, as Editors, we are profoundly grateful for the many scholars who served as chapter authors. These authors made this volume possible, and we have been inspired and productively challenged by their insights, critical critiques, and suggestions for future research and practice regarding epistemic cognition.

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# 1

# AN INTRODUCTION TO EPISTEMIC COGNITION

*Jeffrey A. Greene, William A. Sandoval, and Ivar Bråten*

In the twenty-first century, it is not enough for people to know *what*; they must also know *why*. The world is becoming increasingly complex and interconnected (OECD, 2013). Information and information sources proliferate rapidly, even overwhelmingly, with the growth of technology (Leu, Kinzer, Coiro, Castek, & Henry, 2013). Ever more frequent interactions between diverse and disparate cultures demand a critical reflexivity (World Bank, 2011). These and other factors have led educators, policymakers, and the public to recognize that students must acquire the knowledge, skills, and dispositions needed to be critical consumers and creators of the world in which they live. Calls for increased focus on these knowledge, skills, and dispositions have gone by many names, including critical thinking (Bonney & Sternberg, 2011), twenty-first century learning skills (National Education Association, 2014), digital literacy (Metzger & Flanagin, 2008), and more discipline-specific language such as education about the nature of science (Duschl, 2008), historical understanding (Wineburg, 2000), and mathematical problem solving (Schoenfeld, 1992), among others. Attempts at educational reform such as the Common Core Standards (NGACBP, 2010) and the Next Generation Science Standards (NGSS Lead States, 2013) have pushed educators and students to focus more on conceptual understanding and critical evaluation than the mere acquisition and use of information. Regardless of the terminology used, the modern world, and the current zeitgeist in education policy, research, and practice, have brought to the forefront the scholarship captured in this Handbook on epistemic cognition, which concerns how people acquire, understand, justify, change, and use knowledge in formal and informal contexts.

Research into epistemic cognition has roots in psychology (Kitchener, 1983; Perry, 1968), disciplinary education (Driver, Leach, Millar, & Scott, 1996), the sociology of science (Kuhn, 1962), and philosophy, reaching back as far as Plato's work on the nature, source, limits, and justification of knowledge (Goldman, 1986). Such long and vigorous scholarly tributaries have met to form a powerful, and at times volatile, river. While we have chosen to use the term *epistemic cognition* to characterize this multi- and interdisciplinary research area, others might argue for a different moniker. Within education research itself, the terminology varies including personal epistemology (Barzilai & Zohar, 2014; Hofer & Pintrich, 2002), epistemological resources (Hammer & Elby, 2002), nature of science (Osborne, Ratcliffe, Collins, Millar, & Duschl, 2003), public understanding of science (PUS; Bromme & Goldman, 2014), and epistemic cognition (Chinn, Buckland, & Samarapungavan, 2011; Greene, Azevedo, & Torney-Purta, 2008; Hofer & Bendixen, 2012; Kitchener, 2002). Many scholars have lamented the disparate, and sometimes contradictory, terminology in the field, claiming that it leads to conceptual confusion among researchers and practitioners alike, and that it erects walls between scholarly disciplines that otherwise share interest in the phenomenon of epistemic cognition (Hofer & Bendixen, 2012; Sinatra & Chinn, 2012).

## A GUIDE TO UNDERSTANDING DIFFERENCES IN TERMINOLOGY IN EPISTEMIC COGNITION

Many of the debates about the best terms to describe this area of research likely come from varied interpretations of the term *epistemic cognition* itself, including different understandings of those two specific words, and their derivatives. Within the field, and even within the chapters in this Handbook, differences in terminology can easily lead to confusion. To assist readers of this Handbook, both those new and those experienced in this area of research, in this chapter we provide descriptions of how scholars vary in their use of the following terms: epistemic, epistemology, epistemological, knowledge, cognition, and beliefs. Our purpose in describing these differences is not to suggest that particular terms are superior to others, or that particular combinations should not be used. Rather, we offer this analysis to help readers better understand important differences in terminology in the field, and what they indicate about current and future research in epistemic cognition.

### *Epistemic, Epistemology, and Epistemological*

Epistemic is derived from the Greek term *episteme*, which means knowledge, what is known, or the way of knowing. This term is typically used as an adjective, implying "of or relating to knowledge" (Kitchener, 2011, p. 92). Therefore, epistemic cognition translates to *cognition of or relating to knowledge*. Throughout this Handbook, authors refer to a variety of phenomena qualified by the adjective "epistemic," including epistemic aims, beliefs, change, climate, competence, judgments, norms, practices, reasoning, and stances, among others. The decision to differentiate "epistemic" cognition, practices, and the like from standard (i.e. nonepistemic) cognition, judgments, etc., suggests that researchers posit that in some way, or to some degree, people's thinking, actions, and goals differ when the focus is knowledge, as opposed to other foci (e.g. avoiding effort or increasing one's self-concept; Chinn, Rinehart, & Buckland, 2014).

The term *epistemology* is comprised of *episteme* and a derivation of the Greek term *logos*, which means "theory of, account of, or discourse about" (Kitchener, 2011, p. 92). Therefore, epistemology literally translates as "theory of knowledge." The term *personal epistemology*, suggesting the study of people's individual theories about the nature and limits of knowledge and knowing, was prominent in the early psychological scholarship in this area (e.g. Hofer & Pintrich, 2002). The term is still used in contemporary scholarship (e.g. Barzilai & Zohar, 2014), but it is not as prominent as it once was. Some authors have referred to the "epistemology" of academic domains, or the particular warrants and means by which experts in that domain justify claims as knowledge.

Schommer (1990) used the term *epistemological beliefs* to characterize her work in this area of research. Kitchener (2002), among others, has argued that this term directly translates to "beliefs about the theory of knowledge," and that while some people may in fact have such beliefs (e.g. philosophers), it is more likely that students and nonphilosophers have *epistemic beliefs*, which translates as "beliefs about knowledge." Kitchener further posited that most education researchers are likely interested in the latter, not the former. Nonetheless, numerous terms using the adjective "epistemological" rather than "epistemic" continue to proliferate in this area of research (e.g. epistemological resources; Elby & Hammer, 2010), and in most cases it appears that the scholars who use this term mean it in the way that Kitchener described "epistemic."

### *Knowledge*

Adding to the complexity of terminology used in the field that we are calling epistemic cognition is that the term *knowledge* is used in myriad ways. Philosophical epistemology includes, among other foci, the study of how people can reliably and accurately differentiate knowledge from guesses, doubts, or other kinds of mental representations (i.e. thoughts within an individual) or claims (i.e. statements shared between individuals; Chinn et al., 2011). Chinn et al. (2011) have referred to the different possible perspectives on a claim or mental representation (e.g. believe a claim, knowing a claim, doubting a claim) as *epistemic stances*. Normatively within philosophy, *believing* is an epistemic stance where the person holds the claim as true, with or without necessarily having reflected upon it or having evidence for it. *Knowing* is a specific kind of epistemic stance, more restricted than believing, where the person has evaluated the evidence for the claim and judged it to be sufficient to treat the claim as knowledge, as opposed to opinion or conjecture (Goldman, 1986). In practice, when people claim to "know" something (e.g. "I know that cats are a kind of mammal") it suggests greater confidence that the claim is an accurate representation of the world, compared to saying that they "think" or "guess" (e.g. "I think that a platypus is a mammal"). This distinction is important, because in their everyday lives people think with, act upon, and respond to "knowledge" differently than they do to other kinds of claims or mental representations (e.g. guesses, wishes).

Philosophical epistemology has certainly influenced how educational researchers conceptualize epistemic cognition, and knowledge, but there are differences in usage of the term knowledge across and within both disciplines. Empirical research has shown that the word knowledge and its derivatives are used in different ways, by laypeople and experts (cf. Alexander & Dochy, 1995; Alexander, Winters, Loughlin, & Grossnickle, 2012). From our reading of the educational research literature on epistemic cognition, scholars in this field have used the term knowledge in at least four different ways.

**Knowledge that and knowledge how.** Philosophers, psychologists, and educators distinguish between *propositional* and *procedural knowledge*. Propositional knowledge is "knowledge that" and often is called factual, declarative, or, if more extensive, conceptual knowledge. Procedural knowledge, on the other hand, is "knowledge how" to do something. Propositional knowledge includes mental representations of a bicycle itself, whereas procedural knowledge includes mental representations of how to ride that bike. While both can be made explicit, procedural knowledge is often the more tacit of the two. Some scholars have argued for a third kind of knowledge, conditional knowledge, which refers to an understanding of when, or under what conditions, it is appropriate to use declarative and/or procedural knowledge (Paris, Lipson, & Wixson, 1983).

**Prior knowledge.** In psychology and education, scholars often refer to "prior knowledge," meaning all that is stored and accessible in long-term memory. Kitchener (2002) has argued that in fact "knowledge" is a narrower, more restricted subset of mental representations. Many of the mental representations stored in a person's long-term memory are not "knowledge" in the *epistemic* sense. Nonetheless, education researchers often do not differentiate between knowledge mental representations versus "not-knowledge" ones (e.g. guesses, doubts). Therefore when education researchers use the term *prior knowledge*, they often mean for it to include mental representations or claims that have the epistemic stance of know, as well as other stances such as doubt, or do not believe.

**Individual versus social knowledge.** At times, scholars use the term knowledge to refer to mental representations in an individual's mind. In other situations, scholars use the term knowledge to refer to claims that have been codified and agreed upon by groups of people. A person can "know" a secret, such as where a valuable object is hidden. This is individual "knowledge." On the other hand, groups of people can come together to agree that particular claims are "knowledge," or not. For example, prior to the twenty-first century, the astronomy community considered Pluto to be a planet; this was agreed-upon knowledge in that community. However, in 2006 the International Astronomical Union changed Pluto's status from planet to dwarf planet, thus changing the "Pluto is a planet" claim from "knowledge" to "not-knowledge." Formal (e.g. scholars in a discipline) and informal (e.g. neighbors) groups of people can come together to decide upon what they consider knowledge or not. Such groups can also agree upon practices or processes as reliable ways of establishing that particular claims are or are not knowledge, and such practices and processes are called *epistemic norms* (Goldman, 1999).

**Knowledge in the world versus knowledge in context.** As argued by Chinn and Rinehart (2016/this volume), realism is not necessarily a naïve position. There are numerous scholars, including many educational researchers, scientists, and philosophers, who argue that there is an "objectively real" world outside of the human experience (Chinn et al., 2014). These scholars believe that while it may be the case that humans will never be able to obtain a perfect mental representation of this "real" world, humans can construct increasingly productive and useful models of that world, which they call "knowledge." For these scholars, a particular human's understanding of reality may never be perfect, but it is nonetheless useful and therefore warrants being called "knowledge."

On the other hand, some scholars in cultural psychology (Lave & Wenger, 1991), science studies (Longino, 1990), and philosophy (Fuller, 1988) do not conceptualize "knowledge" as a mental possession of individuals, reflecting a "reality" out in the world. Rather, they argue that particular propositions or procedures constitute knowledge only in relation to interactions between individuals and particular contexts. For example, in some contexts the concept of evolution is considered knowledge, and is useful and recognized. In other contexts, creationism is considered knowledge, and evolution is not. In the latter context, a deep understanding of evolution would not be helpful or normative, and therefore, from a contextualized point of view, it is not appropriate to refer to evolution as "knowledge" in that context. Within the epistemic cognition literature, this had led some scholars to argue that research into epistemic cognition must be situated in context, and that it is a mistake to characterize particular epistemic stances or beliefs as adaptive or sophisticated in all contexts. Rather, the knowledge status of a particular proposition or procedure, and its "sophistication," depend upon the context in which they are being evaluated (Chinn et al., 2014; Elby & Hammer, 2001; Sandoval, 2012).

**Summary.** Clearly, scholars within educational research and philosophy, among other disciplines, use the term knowledge in many ways. We are intentionally withholding any arguments we might make about which view(s) of knowledge we hold as most defensible. The important point is that throughout this Handbook authors use the term knowledge differently, often in one or more of the ways previously described. Greater clarity on the various ways of conceptualizing knowledge can lead to new directions for research in epistemic cognition, for example exploring how students justify declarative versus procedural knowledge claims, or how contextualized views of knowledge might influence where epistemic cognition research occurs (cf. Sandoval, 2012).

### *Cognition and Beliefs*

One major distinction in this area of research involves scholars who describe their work as the study of epistemic cognition (e.g. Chinn et al., 2011; Greene et al., 2008; Kitchener, 2002) versus those that describe it as the study of epistemic, or epistemological, beliefs (e.g. Schommer, 1990). While at times the term *cognition* is used to mean roughly the same as "mental representation" (e.g. "People have cognitions about bicycles"), more often it is used to refer to mental processes such as attending, remembering, decision-making, reasoning, and perceiving. Some scholars have argued there are particular cognitive processes, or particular manifestations of those processes, that are focused solely on epistemic issues, and therefore they refer to this subset of cognition as "epistemic cognition." Other scholars have focused more upon "epistemic" or "epistemological beliefs," which they conceptualize as an influence upon, and result of, cognitive processing. Schommer-Aikins (2004) argued for the term *beliefs* as the best descriptor for this field because she viewed the phenomena as being nonconscious or tacit in nature, having both cognitive and affective qualities, being resistant to change, and having a strong yet often unexamined effect upon thinking. Murphy (Murphy & Alexander, 2016/this volume; Murphy & Mason, 2006) has also argued for the term *epistemic belief* due to the affective aspects of the phenomena. Often in the literature on epistemic cognition, it is not clear whether authors view the phenomena as particular mental representations that are one of many objects acted upon in standard models of cognition (i.e. epistemic beliefs), or whether they view the phenomena as a series of unique cognitive processes that are activated when the object of cognition is the epistemic (i.e. epistemic cognition). A combined view is also possible, where epistemic beliefs are the content upon which epistemic cognition processes act (Sinatra, 2016/this volume).

### *Final Thoughts on Terminology*

A close reading of the chapters in this Handbook, and the larger literature bases from which this Handbook draws, will reveal various "camps" or trends across psychology, education, and philosophy subdisciplines. These camps differ not only in the terms they use, but also in other ways they conceptualize epistemic cognition. Differences regarding domain generality, domain specificity, situatedness, and scope are proliferate and profound. The posited mechanisms of change vary. The prominence of aspects of social epistemology (i.e. the study of the social aspects and manifestations of knowledge; Goldman, 1999) waxes and wanes across psychological and disciplinary education views of epistemic cognition. These distinctions are discussed throughout this Handbook. After reading this introduction to terminology in the field that we call epistemic cognition, it is our hope that readers will be better able to understand each chapter in this Handbook, and the distinctions across chapters. Understanding those distinctions is one way to make connections between those chapters that elucidate new directions for research.

## GOALS OF THIS HANDBOOK

We developed this Handbook to bring together the work of scholars from multiple, sometimes disparate, fields of education research including psychology, disciplinary education, and informal education. We felt this Handbook could serve as a venue where ideas from multiple education subfields could cross-pollinate, enriching all involved (Sinatra & Chinn, 2012). However, it was never our intent to produce a common, all-inclusive definition of epistemic cognition or characterization of this field. While much could be gained by standardizing the terminology and foci of epistemic cognition research (Alexander, 2016/this volume; Hofer, 2016/this volume), we see continued benefits to allowing multiple conceptualizations of epistemic cognition to prosper (Elby, Macrander, & Hammer, 2016/this volume; Kienhues, Ferguson, & Stahl, 2016/this volume). As with any relatively new field of scholarship, the centrifugal forces that naturally expand the breadth and scope of research in epistemic cognition (e.g. the proliferation of epistemic "something" terms, see Chapter 30) may lead to conceptual overreach (Hofer & Bendixen, 2012), or the expansion of the term *epistemic cognition* to the point that it encompasses everything (i.e. all learning), and therefore explains nothing (Murphy, Alexander, & Greene, 2012). We proffer that the potential reward is worth the risk. Education in the twenty-first century includes many centripetal forces, such as calls from policymakers for education institutions to use "evidence-based" educational models (Pashler et al., 2007) that pressure scholars to define and demonstrate "what works," perhaps before such claims have been sufficiently explored or adequately justified. Our goal for this volume is to push against these forces, and to do this we encouraged chapter authors, and likewise we encourage readers, to allow themselves to think divergently. We support productive exploration of the many manifestations of epistemic cognition across the subdisciplines of education research, and hope that this exploration leads to novel connections that shed new light on how people can more effectively pursue and use knowledge in the modern world.

## OVERVIEW OF SECTIONS AND CHAPTERS

This Handbook is comprised of six sections. The first three sections include chapters written by authors who are primarily grounded in scholarship from the fields of psychology, disciplinary education, and formal and informal learning environments, respectively. The fourth section includes reviews of promising interventions designed to foster productive change in epistemic cognition. The fifth section includes chapters reviewing how to measure epistemic cognition, and how it relates to, and can be informed by, other scholarship from within and beyond education research.

Each section ends with a chapter written to respond to the ideas proffered within that section. The chapters in each section, including the response chapter, provide a comprehensive, and appropriately critical, view on the trends, constructive clashes, and opportunities for future research within each area. The final chapter in this volume responds to the Handbook as a whole, identifying trends, clashes, and opportunities across the areas covered in the five preceding sections. Through the syntheses and responses within and across the many different manifestations of epistemic cognition scholarship across subdisciplines of education research, this Handbook provides not only a contemporary view of the state of the art, but also myriad productive paths for future research and practice.

### *Section I: Psychological Perspectives on Epistemic Cognition*

The first section of the Handbook includes chapters written from scholars working primarily in educational, developmental, or social psychology. Hofer provides an overview of the origins of epistemic cognition research in psychology, and the three waves of scholarship that have since defined and reshaped the field. Throughout this chapter, Hofer identifies connections with epistemic cognition scholarship arising out of other areas such as philosophy and science education, foreshadowing the connections made throughout this Handbook. She ends her chapter with provocative challenges to the field, including how the lack of a clear set of common terms may be alienating to teachers, policymakers, and scientists, thus limiting the public good that can be derived from epistemic cognition research.

Iordanou, Kendeou, and Beker focus on the development of argumentative reasoning, and the relations between such reasoning and epistemic cognition. By reviewing the literature on argument construction as well as argument evaluation and comprehension, these authors identify numerous connections with concepts and developmental trajectories in epistemic cognition. They go beyond the mere identification of such connections by reviewing work on using dialogic argumentation interventions to promote the use of normative evidence and criteria, two key aspects of epistemic cognition and argumentative reasoning in science. They also ask provocative questions about what aspects of epistemic cognition can and should transfer across domains and tasks.

By reviewing research on the development of logical and causal reasoning skills, Moshman and Tarricone demonstrate how those skills inform, and are informed by, cognition in academic disciplines. Following a synthesis of the developmental literature on these types of reasoning, the authors identify how logical and causal reasoning skills become the foundation for the acquisition of knowledge and practices within disciplines, which in turn shape those reasoning skills. For these authors, inquiry and argumentation activities are tools that can be used to promote epistemic cognition, including normative forms of logical and causal reasoning.

Researchers have posited that the development of children's Theory of Mind (i.e. the ways in which children perceive and attribute mental states to themselves and others) precedes the manifestation of their epistemic cognition (Burr & Hofer, 2002; Chandler, Hallett, & Sokol, 2002). Sodian and Kristen provide a synthesis of Theory of Mind research, including somewhat surprising findings regarding how infants demonstrate nascent capacity for understanding the mental states of others. These findings suggest that researchers interested in studying the development of epistemic cognition may need to turn their attention to populations much younger than those studied in the past. The research reviewed in this chapter outlines a number of insightful, and clever, means of studying cognition in pre-verbal children.

Clément illustrates how cognition itself is fundamentally shaped by social factors, and how even young children think about what they observe from, and are taught by, others. Through his review of developmental research on children's understanding of social interactions and knowledge, Clément demonstrates that even the most individual of cognitive constructs, such as personal epistemology, are shaped by social interactions starting in infancy. Likewise, children display nuanced filtering of social messages (e.g. testimony) they receive from other adults through the use of multiple criteria about the source, and the message conveyed by that source. Recently, more and more researchers have been investigating the issue of source evaluation (e.g. Rapp & Braasch, 2014), and Clément's chapter, like the others in this section, suggests that such investigations should be informed by work from developmental and educational psychology.

Finally, in her response to the topics and ideas in this section of the Handbook, Alexander identifies several essential questions about the ever-broadening scope of epistemic cognition research. Critically, she reminds researchers that it is just as important to identify what epistemic cognition is not, as what it is. She highlights disciplinary boundaries around the ideas in this section of the Handbook, and questions their placement and conceptualization. Finally, by identifying concerns about potential differences between what learners say versus what they do, in terms of epistemic cognition, Alexander foreshadows issues that have troubled, and inspired, authors in other sections of the Handbook. In doing so, Alexander provides paths forward to connect the work of psychological perspectives on epistemic cognition with those that arise from other areas of education research.

### *Section II: Disciplinary Perspectives on Epistemic Cognition*

Educational researchers within the disciplines have long been concerned with how students come to understand the nature of the subjects they are taught. This concern has increasingly become explicitly focused on epistemic aspects of knowing and learning within academic disciplines. Elby, Macrander, and Hammer summarize an origin story of the study of epistemic cognition in science education. Their story includes how developmental perspectives drawn from personal epistemology research in psychology have been related to studies of students' conceptions of the nature of science as compared to normative views derived from the history and philosophy of science. They then describe how these threads are currently pursued in research aimed at changing conceptions of the nature of science, understanding how such conceptions might be related to students' engagement in specific practices of science, like experimenting or modeling, and how such studies of practice may in turn aid in theorizing the form of epistemic beliefs about science.

VanSledright and Maggioni take a similar approach in outlining how historians have articulated the epistemology of their discipline, and how educational researchers in history have sought to understand both students' conceptions of history and their historical problem solving. A provocative insight from their analysis is how the notion of objectivity in history, the inevitable gap between what really happened in the past and humans' current ability to grasp that past, is particularly troubling and has driven a good deal of the kinds of practices historians have developed to address it. Their chapter highlights how historical problem solving research only indirectly indicates potential underlying conceptions of the nature of history, and the attendant difficulty of changing such conceptions to more normative forms.

Depaepe, De Corte, and Verschaffel demonstrate that mathematicians themselves vary on the epistemological perspectives they take on mathematical knowledge, with absolutist perspectives holding to views of objective mathematical truth competing with fallibilist perspectives that view mathematical knowledge as socially constructed. Depaepe and colleagues summarize research on both teachers' and students' epistemic beliefs, specifically about mathematics and math learning, and show how such beliefs influence both teaching and learning in mathematics.

Lee, Goldman, Levine, and Magliano introduce an analysis of literary interpretation to the field of epistemic cognition. They present a sweeping overview of the many disciplines that bear on understanding literary interpretation. They summarize schools of literary theory and criticism that take strikingly different views on the objectivity of text meaning, with consequent differences in processes of text interpretation. They highlight findings from language processing and text comprehension research to suggest how basic psychological processes are implicated in people's efforts to make meaning from literary texts. Their analysis opens up a set of interesting challenges to research on epistemic cognition by expanding attention beyond knowledge as it tends to be defined in more "definite" disciplines like math or science, and highlighting literary "interpretation" as a particular kind of epistemic artifact.

In responding to these chapters on disciplinary epistemic cognition, Sandoval highlights how all of them construct normative views on epistemic cognition grounded in analyses of the nature of the disciplines themselves. He argues this move avoids simplistic arguments about what counts as a naïve or sophisticated view of knowledge and knowing by demonstrating how the processes disciplines have developed to build and evaluate knowledge are contingent in multiple ways. Moreover, the disciplinary analyses in these chapters not only show the domain specificity of epistemic cognition, but articulate discipline-specific epistemic forms (e.g. scientific models, historical accounts, mathematical proofs) and processes used to produce them. Sandoval notes that disciplinary education researchers, as represented in these chapters, have tended to import models and measures of epistemic cognition from educational psychology, and he suggests ways in which general models of epistemic cognition could benefit from looking more closely at this disciplinary work.

### *Section III: Epistemic Cognition Within and Beyond the Classroom*

The third section of the Handbook focuses on epistemic cognition both inside and outside the context of the classroom. The authors of the chapters included in this section demonstrate that epistemic cognition is relevant not only to learning and performance in school, but also to people's private and professional lives outside classrooms.

Bricker and Bell provide a detailed review of three studies that highlight the importance of exploring epistemic cognition across contexts (i.e. in both schooled and unschooled settings) as well as over time. Relevant to issues concerning the measurement of epistemic cognition, they also illustrate how different settings for collecting and interpreting data may paint different pictures of youths' epistemic cognition. Bricker and Bell argue that researchers need to study epistemic cognition across contexts and timescales using multiple methods.

In his chapter on epistemic cognition in legal reasoning, Weinstock focuses on how jurors, that is, lay legal reasoners, reach conclusions in deciding a case. He discusses epistemic aspects of legal reasoning and reviews research on the role of epistemic cognition in jurors' consideration of evidence, interpretation of reasonable doubt, and deliberation with other jurors about the verdict. Weinstock suggests that training in argumentation and efforts to foster evaluativist epistemic cognition may be needed to better align the reasoning of jurors with formal definitions of knowledge and means of knowing in the legal context.

Strømsø and Kammerer review research on the role that epistemic cognition plays in learning from informational texts, print as well as digital. In doing this, they focus on the relationship between epistemic cognition, including Internet-specific epistemic beliefs, and reading and learning on the Internet. Strømsø and Kammerer suggest that the relationship between dimensions of epistemic cognition and learning from texts may vary with individual and cultural differences as well as with technologies and reading materials.

Buehl and Fives present a framework describing the role of epistemic cognition in learning how to teach and teaching practice. This framework is based on empirical work on teachers' beliefs about teaching knowledge and incorporates features of several theoretical models of epistemic cognition. Throughout the chapter, they exemplify different aspects of the framework by referring to two recent studies of teacher learning and practice. Buehl and Fives highlight that epistemic cognition is influenced by epistemic aims as well as by a range of individual difference variables, including prior knowledge, epistemic stances, epistemic virtues and vices, and teaching experiences.

In the final chapter of Section III, Greene responds to the four chapters summarized above. Leveraging philosophical work in social epistemology, Greene argues that understanding epistemic cognition requires an examination of the multiple epistemic systems that people experience within and beyond the classroom. These epistemic systems can be local, such as the knowledge and means of knowing deemed normative by a teacher in a classroom, as well as broader, such as the systems that are created by school districts, judicial systems, and professional communities (e.g. determining content for the Praxis exam in teacher education in the United States; determining normative standards and practices in science). Drawing an analogy to Bronfenbrenner's (1979) ecological systems theory, Greene calls for research on how individuals navigate among, and reconcile, multiple epistemic systems to determine the knowledge that is appropriate for a given context.

### *Section IV: Epistemic Cognition Interventions*

The fourth section deals with interventions to change epistemic cognition at different educational levels. This is a burgeoning area of research within epistemic cognition relevant not only to students and researchers interested in epistemic cognition but also to practitioners and policy makers.

In her chapter on teaching to change epistemic cognition among elementary school students, Bendixen provides an extensive review of intervention studies conducted within the academic disciplines of science, mathematics, history, and language arts. She posits that these studies show that children at this educational level are able to understand and apply epistemic cognition in fairly sophisticated ways. When discussing the theoretical and educational implications of this body of work, Bendixen argues that a dialogic approach to teaching, and involving students in argumentative discourse within the disciplines, are particularly valuable ways of fostering adaptive epistemic cognition in elementary classrooms.

Brownlee, Schraw, Walker, and Ryan discuss connections between pre-service teachers' personal epistemologies and their learning and pedagogical practice, review existing research focusing on changes in pre-service teachers' personal epistemologies, and present a model for changing the personal epistemologies of pre-service teachers. Discussing this model, Brownlee and colleagues argue pre-service teachers need to reflect on their own epistemic beliefs and how they relate to classroom teaching practices as a starting point for calibrating epistemic beliefs and teaching practices. In this calibration process, a particular form of "meta-reflexive" process, involving reflection, reflexive thinking, and resolution, plays a major role.

In their chapter on the role of diverging information in epistemic change, Kienhues, Ferguson, and Stahl review research indicating that relatively brief encounters with conflicting information on science-related topics may lead to changes in epistemic cognition. At the same time, they acknowledge that epistemic cognition may influence how individuals deal with and comprehend conflicting information. In trying to explain how epistemic change may follow from briefly working with conflicting information, Kienhues and colleagues emphasize the contextualized nature of epistemic cognition and epistemic change.

Muis, Trevors, and Chevrier discuss the role the epistemic climate of the learning environment plays in epistemic change. They review intervention work where researchers attempted to change epistemic cognition via manipulation of some feature of the epistemic climate. In presenting a framework for epistemic change, Muis and colleagues discuss how the epistemic climate in terms of pedagogical approach, teacher authority, curriculum, evaluation, and support may influence students' epistemic cognition.

Bråten responds to the four chapters summarized above by challenging the common ground taken by the authors concerning the mechanism of epistemic change, the general importance of multiple perspectives, and the role of higher-order thinking in epistemic change. In addition, he discusses three issues that seem fundamental to bringing research on epistemic cognition intervention forward. These concern the need to build empirically based, testable models to guide interventions for epistemic change, the need to clarify the meaning of epistemic change itself, and the need to construct and validate measures that are sensitive to different forms of epistemic change.

### *Section V: Measuring and Modeling Epistemic Cognition*

As might be inferred from our discussion above about the variety of epistemic constructs in play and the definitions of knowledge that abound, work on measuring and modeling epistemic cognition has so far been more divergent than convergent. Mason reviews the most common approaches to measuring epistemic cognition, as these have been developed in relation to particular theoretical perspectives on modeling epistemic cognition. Her coupling of measures to their theoretical assumptions highlights a number of issues of both theory and method. She also reviews recent efforts to develop measures that attempt to account for the recognition of the contextual influences that seem to operate on epistemic cognition. She thus helpfully raises a number of measurement issues for the field, as they relate to producing quantifiable measures of epistemic cognition amenable to statistical analysis.

Kelly offers a sharply contrasting alternative to measuring epistemic cognition, operating from a strongly situated perspective on cognition and an attendant ethnomethodology of research. Kelly asserts that a social perspective on epistemology demands research methods that can observe and analyze epistemic practices in interaction. From his view, epistemic change means a change in practice, and understanding practices requires ethnographic methods that can trace how cognitive, social, and material resources are organized interactively during particular efforts to build knowledge. He uses an example from engineering education to illustrate key features of this approach.

The remaining chapters in this section consider how epistemic cognition may be related to other areas of psychological research. Barzilai and Zohar examine the relations between epistemic cognition and metacognition, harking back to Kitchener's (1983) seminal definition of epistemic cognition as a form of metacognition. Barzilai and Zohar outline a model they call "epistemic thinking" that frames both cognitive and metacognitive aspects of epistemic cognition, drawing on contemporary models of metacognition that distinguish between knowledge, skills, and experiences (subjective feelings) of metacognition. They use an example to show how their model might account for epistemic cognition in action.

Chen and Barger examine how motivation influences epistemic cognition. They describe how motivation constructs might be used to explain differences in epistemic cognition; for example, how differences in goal orientations toward academic subjects might trigger different epistemic aims for learners. They highlight how motivation researchers have worked to come to terms with some of the same issues of domain and task specificity as scholars in epistemic cognition, and argue that research must begin to account for the influences of motivational differences on epistemic cognition.

Murphy and Alexander take a similar tack in analyzing how epistemic cognition is both an influence on and an instance of conceptual change. They review how conceptual change, as it is typically defined, is affected by people's ideas about what knowledge is and what it means to know. They also apply a conceptual change framework to understanding how people may or may not change their own ideas about knowledge and knowing. They argue that conceptual change requires reflective examination of one's understanding, an examination that depends on tacit and explicit ideas about knowledge and knowing. They then turn this lens to epistemic cognition itself, arguing that people's conceptions of knowledge and knowing can themselves be objects of reflection and understanding. They argue that promoting this sort of examined understanding is a critically needed transformation of schooling.

Chinn and Rinehart extend their recent examinations of the ways in which closer attention to philosophical trends in epistemology can extend and improve research in epistemic cognition (Chinn et al., 2011, 2014). Here they examine more recent philosophical scholarship for its implications for psychological and educational research. Among the points they make is that epistemologists now see positions like relativism not as omnibus stances toward knowledge, but as predicate relations, such as knowledge relative to culture, or justification relative to task. They go on to discuss how philosophy is increasingly cognizant of and concerned with contextual aspects of knowledge claims and their justification. A clear implication from their philosophical analysis is that efforts to characterize individuals as having generalized epistemologies are philosophically naïve. They use their philosophical analysis to assert four claims about the nature of epistemic cognition that mirror the stance taken by Kelly: epistemic cognition is fundamentally social, its focus is socially organized practices, it is situated in specific contexts, and it inevitably entails ethical considerations of the role of knowledge in human relations.

Sinatra concludes this diverse section with reflections on the potential connections between beliefs and practice. She notes that among the chapters there is variance in how much authors attend to cognitive structures versus cognitive processes, and the degree to which cognitive processes are theorized in individual versus social forms. Sinatra notes that even among authors focused on structures, such as Barzilai and Zohar or Murphy and Alexander, their examples focus on interactional processes. Sinatra encourages this focus on analyses of practice as a way of elucidating epistemic cognition in action, while calling for clearer conceptualization and measurement of the cognitive structures that might constitute epistemic belief. She urges the field of epistemic cognition to think more clearly about how beliefs and processes are mutually related and how they manifest and change through interaction.

### *Section VI: Future Directions for Epistemic Cognition Research*

In our last chapter, we respond to direct and indirect calls for clarity and future research directions by the authors in this Handbook. We understand that our decision to encourage divergent thinking about epistemic cognition in this Handbook leads to both interesting possibilities and continued challenges. Specifically, we review the proliferation of epistemic "something" terms and what it means for a field whose nomenclature has been called "bewildering" (Gottlieb & Wineburg, 2012). One potential cause for the divergences in terminology and foci could be differences in how knowledge is conceptualized. Issues of domain specificity and situativity have implications for how, and where, to understand, measure, and influence epistemic cognition. We examine subtle differences in views of epistemic development and epistemic change, as well, and what those differences imply for modeling and shaping epistemic cognition over time. Finally, having seen the kinds of insights that can arise when epistemic cognition researchers from varied academic disciplines are brought together in a single volume, we argue for continued, and more intentional, collaboration across these disciplines. What knowledge is, how it is determined, and its best uses, are issues that have challenged scholars since the time of Plato. We are convinced that multidisciplinary efforts, such as this Handbook, hold great promise for bringing better clarity to this bewildering but also timely and critically important topic.

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# Section I

## Psychological Perspectives on Epistemic Cognition

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# 2

# EPISTEMIC COGNITION AS A PSYCHOLOGICAL CONSTRUCT

## Advancements and Challenges

*Barbara K. Hofer*

What is knowledge? How do we know what we know? What influence might this set of beliefs have on how we think, reason, and learn? To offer a simple example, when I was seven my parents bought a set of encyclopedias and with giddy enthusiasm, I began reading the entries in sequence, motivated by the belief that if I were only to read each of these volumes, I would know all there was to know in the world. My beliefs about knowledge (my own folk epistemology) were that it was finite, constant, uncontested, existing as a discrete set of facts, conveyed by authorities through books. Knowing, I believed, came about by reading and remembering information, absorbing the knowledge of experts—a pure transmission model of learning that relied solely on memorization. It was not long, and much closer to A than Z, that I not only became bored with the process and returned to reading out of interest, but also knew I was not retaining all that I read, a substantial disappointment. Such realizations, however, have fueled a lifetime of interest in understanding how people learn, the role individual conceptions of knowledge and knowing play in the process, and how these perspectives change over time. This interest is shared by an ever-growing body of researchers, whose extensive knowledge on the topic is the subject of this Handbook.

What individuals believe about knowledge and knowing and how they think and reason about the epistemological aspects of knowing are all part of a psychological construct now being called epistemic cognition. This set of cognitive processes has a deeply influential role in learning, both formally and informally, throughout life, as well as in everyday encounters with new information and in the assessment of competing authorities. This matters not only during schooling but is also critical to an educated citizenry who have the competence to assess the abundance of information available on any complex topic. Recent examples of public confusion in the US about such scientific topics as climate change, vaccinations, evolution, and the teaching of creationism in the schools all suggest the difficulties posed when individuals have difficulty weighing epistemic claims (Bromme & Goldman, 2014; Sinatra, Kienhues, & Hofer, 2014), and the implications for communities, educational systems, and the planet. The need for clear thinking on these issues becomes ever more evident, and those who study epistemic cognition have a critical role to play in establishing and asserting the value of the construct and its role in education.

Beliefs about knowledge and knowing, their patterned development over time, and their relation to other cognitive processes have been studied by a wide array of researchers over the past five decades, with exponential growth in the past dozen or so years. Although philosophers have long been interested in epistemology, defined as the nature and scope of knowledge, and its origins, limits, and justification, psychologists are now making an important contribution in investigating how people actually think and reason about epistemic issues. This research broadly includes such concerns as what individuals count as a valid source of knowledge, the perceived certainty and simplicity of knowledge, and the processes by which individuals weigh competing truth claims, justify what they know, and validate their own knowing (Hofer & Bendixen, 2012).

With this volume, the editors stake a claim on a term that has previously had more limited meaning, and which might now serve to unite a somewhat disparate field of scholarship. Epistemic cognition is one of several attempts over the years to create an inclusive term that might encompass this wide-ranging set of research programs focused on a similar set of processes. This body of work has also been identified as *personal epistemology* (Hofer & Pintrich, 2002), an umbrella term chosen for the first edited anthology on the topic (whose initial working title, ironically, was *Epistemic Cognition)*. The need for an inclusive term is critically important at this juncture in time, as it could help individuals from disparate fields (e.g. educational psychology, developmental psychology, higher education, science education, math education, learning sciences) more easily identify similar research lines and learn from one another's work.

Research on epistemic cognition has grown exponentially, from a body of work that could be comprehensively surveyed in a single review article less than 20 years ago (Hofer & Pintrich, 1997), to a sweeping array of articles, chapters, special issues of journals, and edited volumes, requiring a handbook such as this one to address. The engagement of new researchers entering the field from diverse graduate programs, differing academic backgrounds, and most notably, disparate cultures, has brought about a dramatic expansion in research on epistemic cognition. Multiple challenges persist, however, and although researchers have been addressing many of the concerns quite systematically, others have also arisen. This chapter provides a brief overview of the field by delineating three waves of development, describes the challenges that have been addressed to date, and identifies broader issues for the research community to address collaboratively in the years ahead.

## EPISTEMIC COGNITION: DEFINING THE FIELD

Epistemic cognition, broadly conceived, is a term used to describe a set of mental processes that involve the development and employment of one's conceptions of knowledge and knowing. The construct has been studied under varied nomenclature over time, such as epistemological beliefs (Schommer, 1990; Schommer-Aikins, 2004), epistemological theories (Hofer & Pintrich, 1997), folk epistemology (R. F. Kitchener, 2002), reflective judgment (King & Kitchener, 1994, 2004), epistemological reflection (Baxter Magolda, 2001), women's ways of knowing (Belenky, Clinchy, Goldberger, & Tarule, 1986; Clinchy, 2002), epistemological resources (Elby & Hammer, 2010; Hammer & Elby, 2002), and epistemic cognition (Chinn, Buckland, & Samarapungavan, 2011; Greene, Torney-Purta, & Azevedo, 2010; K. S. Kitchener, 1983). Research has also been conducted on beliefs about epistemology at a disciplinary level, such as beliefs about math (De Corte, Op 't Eynde, Depaepe, & Verschaffel, 2010; Muis, 2004a, 2004b; Schoenfeld, 1992; Weber, Inglis, & Mejia-Ramon, 2014), history (Maggioni, VanSledright, & Alexander, 2009; VanSledright, 2004; Wineburg, 1991), and science (Deng, Chen, & Tsai, 2011; Lederman, 2007; Samarapungavan, Westby, & Bodner, 2006; Sandoval, 2014).

In the first usage of the term "epistemic cognition," Kitchener (1983) described it as a higher-order process in a three-level model of cognitive processing, with basic cognition at the first level (e.g. perceiving, reading, memorizing) and metacognition at the second, involving a monitoring of one's cognitive processes. Epistemic cognition, resting on the foundation of the first two levels, was postulated as occurring when individuals considered the *limits*, *certainty*, and *criteria* for knowing (K. S. Kitchener, 1983). This process was later described as the foundation of critical thinking, evoked when solving ill-structured problems (King & Kitchener, 2002). The connection among cognition, metacognition, and epistemic cognition has been theorized in several different ways (Barzilai & Zohar, 2014; Hofer, 2004a; Kuhn, 1999), but several aspects remain central. One is that prior accounts of cognition and metacognition alone do not account for the type of mental processes involved in epistemic cognition. Secondly, the psychological construct that involves beliefs about knowledge and knowing needs to be understood as a *process*, a set of mental activities that involve the activation and application of epistemological understanding. Thirdly, epistemic cognition is an essential element of critical thinking and a meaningful topic worthy of educational attention. All of these properties are at the core of an evolving understanding of epistemic cognition.

Although Kitchener and King continued to use epistemic cognition to describe their work on reflective judgment (King & Kitchener, 2002), the term began to be used by other researchers primarily within the last decade, with several attempts to bring a philosophical perspective to an understanding of the term. In arguing for epistemic cognition as the most precise descriptor for the field, Greene et al. (2008) described it as a term that "emphasizes knowledge and the processes involved in its definition, acquisition, and use" (p. 143). Heeding Murphy's call for better integration of philosophy into educational psychology broadly and into personal epistemology research especially (Murphy, 2003), the authors also separated ontological and epistemic cognition, and expanded the notion of justification of knowledge. Epistemic cognition was also the overarching term chosen to define a more highly elaborated integration of philosophy and psychology in a new model that offers an expansion of relevant dimensions (Chinn et al., 2011; Chinn, Rinehart, & Buckland, 2014).

As noted, the range of terms used to describe this construct have varied by researchers and by discipline, and within this chapter the terms that are historically accurate are generally used to describe those research traditions, as it seems anachronistic to suggest otherwise. In addition, it may be fruitful for the field to view epistemic cognition as a broad set of cognitive processes that encompass these other constructs, as subsets of the larger field. For example, the use of the term epistemic cognition does not necessarily imply that constructs such as epistemic beliefs or epistemological resources or epistemic aims are invalid or have been supplanted, but might suggest that we need to better understand how each cognitively operates and how they work together within this overarching construct. The problem with using the term epistemic cognition to stand for all prior work in the field, however, is to risk ignoring the nuanced distinctions among them as well as to dismiss the differing cognitive properties of each of these constructs, how they are instantiated in practice, and how they can best be studied.

Furthermore, in regard to terminology, although there have been numerous calls to adhere to philosopher R. Kitchener's differentiations of when to use "epistemic" and when to use "epistemological" (R. F. Kitchener, 2002), this practice has not been widely followed. As he notes, the term "episteme" refers to knowledge, and "epistemology" to a theory of knowledge. Thus epistemic beliefs would refer to beliefs about knowledge and knowing, and epistemological beliefs would refer to beliefs about epistemology, making the former a more accurate representation of what researchers have addressed. He also notes that philosophers view cognitions as considerably weaker than a state of knowledge, and that "epistemic cognition is cognition (representation) about the epistemic, but it need not be knowledge about the epistemic" (Kitchener, 2002, p. 93). My hope is that as the field moves toward the use of epistemic cognition to describe a broad body of research, leaders in this field will err on the side of inclusiveness, drawing on a history of diverse research paradigms and models and using that richness to create a more sharply honed theoretical synthesis. Such a synthesis would clarify the components of epistemic cognition and how they operate as well as how they develop over time, and identify how these processes are related to other aspects of cognitive development and are influenced by education, culture, and other environmental factors.

## RESEARCH ON EPISTEMIC COGNITION: THREE WAVES OF SCHOLARSHIP

In the progression of research on epistemic cognition, three waves of scholarship are notable. The first of these is the primarily qualitative, interview-based research that led to the creation of several parallel developmental models (Baxter Magolda, 1992; Belenky et al., 1986; King & Kitchener, 1994; King, Kitchener, Davison, Parker, & Wood, 1983; Kuhn, 1991; Perry, 1970). The second wave involved a reconceptualization of the construct as a set of beliefs (Schommer, 1990), assessed by questionnaires with Likert-scale items. Research proliferated as a result, particularly in regard to linking epistemic beliefs to other constructs.

The third wave involves the flourishing of research in the past decade or so that has been characterized by several key themes. These include theoretical development and new paradigmatic models, greater attention to philosophical underpinnings of the field, research on domain generality and specificity, the expansion of methods and measures, the inclusion of broader populations other than college students, the cultural proliferation of research, a rethinking of grain size and situating epistemic cognition, more work on the relation to other constructs, and the application to new contexts and issues, such as digital literacy and the public understanding of science.

### *The First Wave: Developmental Models of Epistemic Cognition*

As described in depth elsewhere (Hofer & Pintrich, 1997), interest in college students' beliefs about knowledge and knowing originated with Perry's qualitative, phenomenological, longitudinal study of Harvard undergraduates (Perry, 1970, 1981). Consistent with psychological paradigms of the period in which he began his research (pilot studies began in 1953), Perry expected to find that personality differences were likely to explain the different ways in which students made sense of their educational experiences. Perry designed his first measure, the Checklist of Educational Values (CLEV), by drawing on research on authoritarian personality, allowing him to select for further interviews those students who scored at the extremes or the mean of what he described as dualistic or contingent thinking, or who had shown significant change during an academic year. Years later, in the analysis of the resulting open-ended interviews conducted over four years of college, Perry (1970) and his research team concluded that the differences they observed were not evidence of personal style, as they had expected, but instead offered evidence for a scheme of intellectual development during college. More in tune with the invariantly sequenced, hierarchically integrated stage theories prominent in psychology at the time this work was published (Erikson, 1959; Kohlberg, 1969; Piaget, 1972), the "Perry scheme," as it has come to be called, delineated nine positions of intellectual and ethical development. These cluster into four categories: dualism, multiplism, contextual relativism, and commitment within relativism.

Although Perry did not use the term epistemological development, researchers who followed recognized in his stages an evolving understanding of what it means to know and, accordingly, how one goes about the processes of learning and understanding. Some researchers then followed similar processes as Perry, creating interview questions designed to elicit how college students made meaning of their own experiences over time (Baxter Magolda, 1992; Baxter Magolda & Porterfield, 1985) or how women, in particular, viewed knowledge and knowing (Belenky et al., 1986). Although Perry's questions had been unusually open-ended ("Would you like to say what has stood out for you during the year?"), others designed ill-structured problems around topics such as the safety of chemical additives in foods (King & Kitchener, 1994), with interview questions that probed epistemic thinking, such as whether experts could disagree and whether more than one point of view might be possible (Kuhn, 1991).

These early models of epistemic cognition portrayed the construct as a highly integrated, multidimensional conception, one that evolved in response to educational and environmental conditions. An analysis of the extant models showed similar dimensions and progression of development (Hofer & Pintrich, 1997), regardless of the number of stages in the model or the methods employed. The underlying assumption was that as students progressed in their development, these facets worked together. Individuals were generally described as moving from an objectivist, absolutist stance toward knowledge and knowing toward a more subjectivist, relativist position, before learning to effectively coordinate the two, thus operating with an evaluativistic perspective (Kuhn, Cheney, & Weinstock, 2000).

The central contributions of this first wave of research are foundational in some lines of current work, by several of these same researchers who have continued to contribute immeasurably to the field, and by those who have followed. This group of researchers identified a construct that had not yet been addressed by psychologists, and one that seemed to play a significant role in higher education and to be connected to the process of critical thinking (Kurfiss, 1988) and argumentation (Kuhn, 1991). They identified open-ended methods that allowed for a phenomenological take on students' meaning making and pioneered questions designed to elicit epistemic cognition in response to ill-structured problems. They used their findings to create developmental models that became useful heuristics for understanding development during the college years, assisted by other researchers and those who helped translate research into practice (Knefelkamp, 1998; Knefelkamp & Slepitza, 1978; Moore, 2002), which helped post-secondary educators understand the value of higher-order epistemic stances and how education might foster such thinking. These developmental models are the basis of a strand of research that informs student development work in higher education (Baxter Magolda, Creamer, & Meszaros, 2010; King & Baxter Magolda, 2005). As noted earlier, this was also the period when the term epistemic cognition was coined (K. S. Kitchener, 1983), even though it was not in wide use by others.

### *The Second Wave of Research: Paradigmatic Shifts, Dimensionality, and Connections to Other Constructs*

Schommer's proposal for a model of *epistemological beliefs*, with dimensions that were believed to be more or less independent (Schommer, 1990), challenged the assumptions of developmental models, launching a second wave of research that has continued alongside the developmental research paradigm. This conceptualization of the construct described a set of beliefs that could be tapped through self-report measures, by responses to items rated through Likert-type scales. Drawing from such sources as Perry's CLEV, beliefs about mathematics (Schoenfeld, 1985, 1992), and items written to assess beliefs about intelligence (Dweck & Leggett, 1988), Schommer created a 63-item measure that for the first time made it possible not only to assess larger groups of students than could be assessed using interview methods, but also to link epistemology to other constructs. In this model, sophistication proceeds in a linear direction that can be captured through degree of agreement with a set of items initially written to tap five dimensions: fixed ability, quick learning, simple knowledge, certain knowledge, and source of knowledge. As noted in an earlier review (Hofer & Pintrich, 1997), the developmental models were also multidimensional, but the progression was expected to advance across dimensions at each stage, in a more integrated fashion. Those models also included more attention to the nature of justification in knowing, and did not include fixed ability or quick learning.

A flurry of research followed Schommer's work, and over the next decade other models and measures were offered, with various dimensional configurations and names (Hofer, 2000; Kardash & Howell, 2000; Schraw, Bendixen, & Dunkle, 2002). Schommer also pioneered the investigation of linkages between epistemological beliefs and other constructs of interest to educational psychologists, showing that beliefs were related to comprehension (Schommer, 1990), performance, and strategy use (Schommer, Crouse, & Rhodes, 1992). Others explored how epistemic beliefs connected to such constructs as need for cognition (Kardash & Scholes, 1996) and conceptual change (Windschitl & Andre, 1998), among others.

Parallel to these developments taking place in educational psychology, science educators were growing increasingly interested in how student beliefs about the nature of science (the values and assumptions of science as a way of knowing) influenced the ability to learn and understand science (Lederman, 1992), a body of work that has also continued to expand. In addition, researchers began to assess epistemological interventions (Elan & Clarebout, 2001), an area of inquiry that has continued to grow, and to challenge the domain specificity of the field (Buehl, Alexander, & Murphy, 2002; Hofer, 2000), demonstrating how individuals could hold differing epistemic beliefs about specific disciplines. The most significant contribution of this second wave of research was that it offered a paradigmatic shift that changed the field and made the work known to educational psychologists, who were eager to assess relations with other constructs and now had a method to do so.

### *The Third Wave of Epistemic Cognition Research: Theoretical, Cultural, and Methodological Expansion*

In the past dozen years, research on the topic of personal epistemology and epistemic cognition, broadly defined, has grown exponentially, and research on epistemic cognition has become a prominent topic in educational psychology journals and a growing area of research in the learning sciences. Although the nomenclature varies, related research continues to appear within higher education, developmental psychology, science education, and teacher education, as well as in other areas. A healthy tension began to permeate the field as researchers debated issues of dimensionality, grain size, domain and topic specificity, and the role of context, and offered new paradigmatic models, measures, and methods of analysis. Advancements have been prominent in several areas, as described below.

**Theoretical development and new paradigmatic models.** Although use of the terms epistemic and epistemological beliefs continue to appear in a large number of articles, researchers have also challenged whether epistemic understanding exists at that level, or might be organized as theories (Hofer & Pintrich, 1997), or operate as more fine-grained epistemological resources (Hammer & Elby, 2002; Hammer & Elby, 2003), or be more situated and contextual (Sandoval, 2005, 2014). Paradigmatic approaches to epistemology have grown, particularly in the rethinking of the relation to metacognition (Barzilai & Zohar, 2014). In particular, theoretical models have also been elaborated by drawing more on the philosophical origins of the field, as described next.

**Greater connection to philosophy.** Several epistemic cognition researchers have done notable work in reading philosophy more deeply, working with philosophers directly, and developing new models that take philosophical epistemology seriously (Chinn et al., 2011; Greene, Azevedo, & Torney-Purta, 2008; Murphy, 2003). Central to any philosophical account of epistemology is the nature of justification (R. F. Kitchener, 2011), and expanding the dimensions of epistemic cognition to encompass the various means by which knowledge is justified (Greene et al., 2008) has been a critical contribution to the field.

Further alignment with philosophical accounts of epistemology can help advance the field of epistemic cognition. In a paper linking personal epistemology and philosophical epistemology, philosopher R. F. Kitchener (2011) listed ten major questions of epistemology that he expects "any adequate epistemology would addresses… and hence that PE (personal epistemology) should include" (p. 89). These include areas addressed to some degree in various programs of epistemic cognition research, such as the nature of truth, the sources of knowledge and whether they are external to the individual or internal, as well as the role of justification. Kitchener also listed others that are less often explored by personal epistemology or epistemic cognition researchers, such as the respective roles of reason and sense experience, definitions of propositional knowledge, and the nature of a priori versus posteriori knowledge. His comments provide potential fruitful insights for further research in this regard. Psychologists have also begun to take traditional philosophical problems and address them experimentally (Starmans & Friedman, 2012).

Furthermore, epistemology has been regarded by many philosophers as social in nature (Goldman, 2011), and this has merited the recent attention of epistemic cognition researchers (Bromme, 2003; Greene et al., 2008). This inclusion of the social dimensions of knowledge is likely to have significant applicability in more culturally inclusive models of epistemology (Hofer, 2008). Social epistemology, while acknowledging individual epistemic decision-making, takes into account the role of evidence provided by others, such as arguments and opinions (interpersonal social epistemology), as well as group judgments, such as those made by juries (collective social epistemology), and community and societal level influences on the knowledge state of a society (e.g. institutional social epistemology; Goldman & Blanchard, 2012). As Goldman and Blanchard (2012) noted, this latter perspective is particularly relevant to the public understanding of science, a growing topic of attention in epistemic cognition (Sinatra et al., 2014). This particular aspect of epistemology seems to show promise for future development of psychological models of epistemic cognition as well as the potential to direct researchers' attention to constraints and affordances of knowledge building that influence individuals, such as classrooms (e.g. epistemic climate; Bendixen & Rule, 2004; Feucht, 2010), schools, communities, the media, and the political climate.

Simultaneous with this third wave of epistemic cognition in psychology is the rise of interest among philosophers in how people think about the issues that philosophers have long pondered and theorized, including epistemology (Beebe, 2014). Grasswick (2014), for example, has explored issues of epistemic trust in regard to how laypersons perceive climate change experts, and examined the role of positionality in knowledge production. The field of experimental philosophy is growing as well (Alexander, 2012; Machery & O'Neill, 2014), with philosophers making use of psychological methods to explore traditional philosophical issues, and this is a fruitful time for collaboration on shared research. Not only do psychologists need to learn from and connect with philosophers on matters of shared interest, but philosophers are also learning from psychologists as they begin to undertake experimental studies of laypersons' employment of epistemology.

**Domain generality and domain specificity.** Although arguments were made for moderate domain generality early in the second wave of research (Schommer & Walker, 1995), this issue now seems well-resolved in support of the existence of domain specificity (Hofer, 2006a; Muis, Bendixen, & Haerle, 2006). Epistemic cognition appears to operate at three levels: general beliefs about knowledge, disciplinary perspectives on beliefs (e.g. that knowledge might be more certain in one field than another), and beliefs that are specifically about disciplines (the nature of science, for example; Hofer, 2005). Researchers are also actively pursuing the idea of topic-specific beliefs. What we know far less about is how domain-specific and domain-general beliefs operate together, although one recent study suggests that this may vary by level of background in the field (Schommer-Aikins & Duell, 2013). One persistent issue is that researchers differ in what they mean by domain (Hofer, 2006b) with educational psychologists presuming it to be synonymous with discipline (Muis et al., 2006) and developmental psychologists referring to matters of taste, aesthetics, and values, for example (Chandler & Proulx, 2010; Kuhn et al., 2000; Mason, Boldrin, & Zurlo, 2006; Wainryb, Shaw, Langley, Cottam, & Lewis, 2004). More precision and clarity are needed in this area.

**Methodological critiques and expansion.** The study of epistemological development began with interview studies and then an attempt to codify assessments of stages into written measures, followed by a period in which epistemological beliefs were studied through Likert scales. Although these methods all continue, use of the Likert scale has become particularly problematic, for several reasons (Hofer, 2005). One issue is that the scale suggests a linear progression, which runs counter to the developmental view that meaning is restructured at each level, from absolutism to multiplism to evaluativism.

Likert scales may capture the low end of the spectrum well, in identifying agreement with certainty of knowledge (e.g. "truth is unchanging in this field"). Complete disagreement with such a measure of certainty, however, is more likely to indicate multiplism rather than a fully sophisticated epistemic understanding, and it is unclear how evaluativism can be inferred at all from such measures, when used to capture a construct by summing responses. Secondly, similar problems exist in the applicability and relevance of what counts as sophisticated or availing beliefs in Likert scale measures in many contexts, particularly in discipline-specific and topic-specific studies of epistemic beliefs (Bråten, Strømsø, & Samuelstuen, 2008). The problem is the presumption, inherent in the measurement, that sophistication always proceeds away from certainty and a reliance on experts. This means that those who question the certainty of what is known about gravity or doubt the authority of experts on the topic of evolution would be seen as exhibiting advanced epistemic beliefs. Researchers need to rethink what counts as sophistication or what beliefs are actually availing in regard to diverse topics, contexts, and educational settings, and then design measures that better capture this complexity. Moreover, little evidence of reliability and validity exists for the survey instruments most often in use (Clarebout, Elen, Luyten, & Bamps, 2001; DeBacker, Crowson, Beaslery, Thom, & Hestevold, 2008), and this is further complicated when they are used in other cultures, with little consistency in findings (Buehl, 2008).

New measures and methods have been developed and refined and added to the repertoire of techniques used to assess epistemic cognition, as reviewed in the related chapters in this volume (Kelly, in press; Mason, in press). These have included a semantic differential instrument (Stahl & Bromme, 2007), use of think-aloud protocols (Ferguson, Braten, & Stromso, 2011; Hofer, 2004a; Mason, Boldrin, & Ariasi, 2010), as well as classroom observational methodologies (Elby & Hammer, 2010; Hofer, 2004b), the use of card sorts and network analysis (Peters-Burton & Baynard, 2013), and mixed methods studies (Bromme, Pieschl, & Stahl, 2010).

**Inclusion of broader populations.** Interest in college student learning has continued since the original line of work on epistemological development, and is the population that serves as the basis for many studies of epistemic beliefs, whether by interest or convenience. In this third wave of research, however, many researchers have expanded the age range of those studied, including preschoolers (Barth, Bhandari, Garcia, MacDonald, & Chase, 2014; Burr & Hofer, 2002; Wildenger, Hofer, & Burr, 2010), elementary school children (Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 2002), and a growing number of studies of adolescents (Cano, 2005; Murphy et al., 2010). What seems to be a pressing need is to organize the findings into a more coherent and nuanced developmental account than the rough three-level heuristic that seems to have survived the decades, as well as to further involve adult participants in order to better understand the function of epistemic cognition in society (Kuhn, 1991), and to conduct studies that include both children and adults (Greene & Yu, 2014) and students and experts (Samarapungavan et al., 2006). The field would benefit from further analyses of real-world epistemic judgments, such as the studies of juror reasoning (Weinstock, in press; Weinstock & Cronin, 2003).

One of the most significant developments in the expansion of populations studied during this third wave has been research on teachers' epistemic beliefs and the role they play in students' beliefs and learning (Brownlee, Schraw, & Berthelsen, 2013), as reviewed in a later chapter (Buehl & Fives, in press). Another line of current research examines how epistemological beliefs may be related to pre-service teachers' motivation for choosing science teaching, an important line of inquiry (Kilinc & Seymen, 2014).

**Cultural proliferation.** Perhaps one of the most exciting and important aspects of the recent exponential growth of epistemology research has been the entry of scholars from across the globe (Hofer, 2008; Khine, 2008) and now spanning the continents. For the most part, these researchers have used existing Western measures and translated them, with mixed success (see Buehl, 2008, for a comprehensive review). Although new measures have also been designed (Stahl & Bromme, 2007), surprisingly little has been done to create measures that might more effectively tap what could be culturally distinctive about epistemic understanding in other environments. Issues of the role of authority (Hofer, 2010), the social nature of knowledge, and how the purpose of knowledge is viewed may all differ, for example, between North America and many Asian countries, yet existing measures likely would be insensitive to these distinctions. The next wave of research may challenge existing models further, perhaps with more research that expands dimensionality and challenges the universality of the continuum of sophistication implied in existing models. Further comparative cross-cultural work is needed, but is also hampered by instrumentation; as Buehl (2008) noted, current measures that lack a cultural conceptualization of dimensionality are not likely to be appropriate for assessing group differences.

**Rethinking grain size and situating epistemic cognition.** A significant subject of attention in the field during the last decade has been a consideration of the grain size and context of epistemic cognition. In addition to an expansion of studies addressing epistemic cognition within various disciplines (Mason, 2003; Muis, 2004b; Sandoval, 2014; Tsai, 2005; VanSledright, 2004), researchers have turned their attention to topic-level beliefs, such as epistemic beliefs about climate change (Strømsø, Bråten, & Samuelstuen, 2008) and the Internet (Chiu, Liang, & Tsai, 2013; Strømsø & Bråten, 2010). What is needed is a model of how different levels of beliefs operate together, and in what types of contexts particular levels take precedence in guiding understanding.

The situated nature of epistemic cognition has become a fertile area for understanding how these processes operate, and this issue also relates to debates about scale. Are these fine-grained resources (Elby & Hammer, 2010; Hammer & Elby, 2003) dependent on context for activation, or are they beliefs that are accessible to the individual through self-report (Schommer-Aikins, 2002)? How labile are they? How malleable? Sandoval (2014) has argued for a contextual, situated view of epistemic cognition, tied to activities and their structure. From this perspective, a developmental account of epistemic cognition for science educators would eschew the invariant stages of earlier psychological models and focus more on students' experiences with science, both in and out of school, how individuals come to understand science, and how this cognition is situated in the settings in which it occurs (Sandoval, 2014). These varying views of epistemic cognition that have become increasingly well articulated during the past decade are helping to shape a new generation of researchers, and point the way to new methods and questions.

**Relation to other constructs.** Other than the cultural explosion, work on connecting epistemic cognition to other constructs has probably been one of the most pronounced developments in the field. Researchers have worked to delineate the connections to metacognition (Barzilai & Zohar, 2014; Bromme et al., 2010; Hofer, 2004a; Hofer & Sinatra, 2010; Kuhn, 1999; Mason & Bromme, 2010) and self-regulation (Pieschl, Stahl, & Bromme, 2013). We also are learning more about the role of epistemic climate (how the nature of knowledge and knowing is represented in classrooms; Feucht, 2010; Muis & Duffy, 2013) and how it fosters epistemic cognition. The relation to other constructs includes need for cognition and need for closure (DeBacker & Crowson, 2006), conceptual change (Mason, 2010; Mason & Boscolo, 2004; Murphy, Alexander, Greene, & Edwards, 2007), motivation (Buehl & Alexander, 2005), volition (Rule & Bendixen, 2010), and argumentation (Kuhn, Zillmer, Crowell, & Zavala, 2013; Mason & Scirica, 2006; Yang & Tsai, 2010). (See Hofer & Bendixen, 2012, for a more comprehensive review.) More work is merited to address not only how epistemic cognition relates to other cognitive constructs, but also what teachers can do to foster more meaningful connections, for example, between epistemic cognition and self-regulation.

**Exploring epistemic cognition in new contexts.** At a time when technology has exponentially enhanced our access to information, epistemic cognition researchers have recognized that information and digital literacy are fundamentally epistemological issues. In their online searches, individuals make judgments about the veracity and certainty of what they read (Hofer, 2004a), are challenged to construct knowledge from multiple viewpoints (Barzilai & Eshet-Alkalai, 2015), and need both effective skills of self-regulated learning and productive epistemic cognition (Greene, Yu, & Copeland, 2014). The ease of digital access to information, the hidden and vested interests of online providers of information, and the shaping of content to specific consumers all suggest the importance of teaching epistemic strategies as part of digital literacy, as well as the need for further research in these areas. A growing body of work has addressed this topic (Ferguson et al., 2011; Mason et al., 2010; Strømsø & Bråten, 2010).

**Intervention studies.** Researchers have long been curious about the role that education plays in the development of epistemic cognition, particularly from a developmental perspective during the college years (King & Kitchener, 1994; Widick, Knefelkamp, & Parker, 1975). Similarly, following the logic that more availing epistemic cognition is beneficial to the learning process, researchers have begun to examine interventions with both teachers (Gill, Ashton, & Algina, 2004) and students (Mason & Scrivani, 2004; Muis & Duffy, 2013), including short-term interventions (Kienhues, Bromme, & Stahl, 2008). This work is still in its initial phases and merits further attention from researchers, with the need to explore how best to intervene, the structure and timing of interventions, and the duration of effects. One recent line of work posits the idea of "epistemic conceptual change" as a means of promoting reasoning and thinking in science, with suggestions for teachers (Sinatra & Chinn, 2012), a model that might help guide additional interventions.

## ADVANCEMENTS IN EPISTEMIC COGNITION AND CHALLENGES FOR RESEARCHERS

Roughly at the start of the third wave of research on epistemic cognition, Pintrich (2002) identified a key set of issues for the field, commenting that "the research on personal epistemologies is moving from an area of … interest to a fairly small group of dedicated researchers to a position of salience in the general research effort on development and learning" (p. 413). Most of these issues have been addressed extensively since that time, such as domain generality and specificity; the relation to cognition, motivation, and learning; components of epistemic cognition; and measures and methods (although work remains, of course).

Concerns about the nature of the construct, one of the issues Pintrich listed, have become far more sophisticated and nuanced in the last decade, involving a deeper reading of the philosophical literature, as noted earlier (Chinn, Buckland, & Samarapungavan, 2010; Greene et al., 2008). There is a pressing need for reconciliation among approaches and the development of congruent models that can guide the fourth wave of research, as well as tests of proposed models (Bendixen & Rule, 2004). What remains to be seen is whether the use of the term epistemic cognition as defined by Greene et al. (2008), as broadly encompassing the processes involved in the definition, acquisition, and use of knowledge, will open the door to a broader research agenda. How knowledge is acquired and used, for example, involves the entire learning process, and this creates a larger category of potential concepts than those relating to the origins, justification, and limits of knowledge and knowing. In addition, Chinn and colleagues, for example, have suggested that epistemic cognition consists of aims and values, epistemic ideals, and reliable processes for achieving epistemic ends (Chinn et al., 2014). Others have elaborated on expanding the nature of justification (Greene et al., 2008), and some initial assessments support the utility of this contribution (Bråten, Ferguson, Strømsø, & Anmarkurud, 2013; Greene & Yu, 2014). In addition, the field also needs further cultural examination and possibly expansion of the dimensions, as existing models originated in the West.

Another area that has received little recent attention is the mechanism of change and the process of development. Most early models converged on a general progression of development toward greater sophistication over time, but new issues emerged with situated models (Hammer & Elby, 2002), as well as the idea of recursion (Chandler, Hallett, & Sokol, 2002). Both are continuing to get attention, but it remains unclear whether contextualist models can be reconciled with developmental accounts. Issues of recursion, with individuals looping back through developmental progressions, particularly at various transitions in education, may speak to the contextual nature of development.

## BROADER CHALLENGES FOR EPISTEMIC COGNITION RESEARCHERS

In addition to the concerns raised above that are continuing to be addressed, broader challenges have arisen. The list of further research prospects will no doubt be expanded at length in this volume, chapter by chapter. In addition, however, there are several larger concerns for this growing body of researchers to address together, as a community of scholars invested in a topic we believe to be of meaning and importance to a wider audience.

**Consensus on naming the field.** As noted earlier, we would benefit as a research community from agreeing on a term that broadly contains the array of scholarship being conducted by those interested in the cognitive processes that involve epistemic reasoning, thinking, and understanding. This volume may help establish epistemic cognition as that term, allowing us to find one another's work at conferences and in journals, regardless of our disciplinary training and divisional affiliations.

One problem with terms in this field, whichever they may be—epistemological beliefs, personal epistemology, epistemic cognition—is that they seem inaccessible to those outside of academia. In honoring the construct's philosophical origins in our naming conventions, we may risk losing a broad audience of teachers, journalists, scientists, and others who could make use of the very ideas we champion. Epistemology is not a term in ordinary discourse, and no matter what form of it is used to create a psychological construct, the terms may appear to have an air of academic pretension, although that is not intended. What makes it possible for us to discuss our findings with each other may be keeping others from making use of them.

**Refinement of models and theoretical synthesis.** Sometimes we still seem to be describing parts of the same elephant, without certainty that we are aware of the whole being. We need a better integration of approaches, and models that combine a developmental perspective with the conceptions of resources, beliefs, frameworks, and theories, with a deeper understanding of the processes by which these elements work together, and in various contexts. The higher education community sees advanced epistemological development as a desirable outcome of a college education; educational psychologists see epistemic beliefs as predictors of learning; some science educators and learning scientists view epistemic resources as a contextual variable. Epistemic cognition is all these things: multidirectional in its influence, situated, contextual. We are in need of better models that explain these interrelationships so we can better interpret and utilize the research being generated.

**Increasing awareness of the construct among psychologists, learning scientists, and educators more broadly**. Although growth in the field has included multiple edited volumes (Bendixen & Feucht, 2010; Brownlee et al., 2013; Hofer & Pintrich, 2002c; Khine, 2008; Taylor & Ferrari, 2011) and special issues of journals such as *Educational Psychologist*, *Metacognition and Learning*, *Contemporary Educational Psychology,* and *Asian Pacific Researcher*, this focus of attention does not seem to have led to the type of wider awareness in either the psychological or educational community that might be expected. Currently research on the connection to other variables seems unidirectional, in that epistemic cognition researchers investigate the relation with other constructs such as motivation and learning strategies, but the construct is seldom used by others as an additional explanatory variable in broader studies. This may also be an artifact of measurement problems, however, and the vagaries of terminology in use.

**The need for "translators" and reaching a broader audience of practitioners**. In some areas of psychology and education, research has reached practitioners through authors capable of expressing ideas and findings in layperson terminology and identifying implications for practice. Examples abound, such as Willingham's "Ask the Cognitive Psychologist" columns in *American Educator,* or books on teaching for college faculty (Svinicki & McKeachie, 2014), or books on motivation for teachers (Anderman & Anderman, 2013). Others have learned how to successfully convey their own research to lay audiences, a growing trend in psychology; Dweck's (2006) reframing of her research on incremental theories of ability into the idea of a "growth mindset" is notable in its impact on teachers, parents, and students. Do we need an even simpler way of describing our work than "epistemic cognition"? Or do we just need to get better and more comfortable at explaining what it means when we talk to teachers and students?

For a topic that is the subject of dozens of books and thousands of articles and that has been shown to play an influential role in learning and to be influenced by educational processes, there is very little visibility in teacher education or in the field of information literacy. Given what we have learned about the role of epistemic cognition in the learning process, as well as the influence of teachers' beliefs (Buehl & Fives, in press), we need to make this a construct teachers would not only think was important to understand but would know how and why to foster in their classes. Yet research on the topic has appeared only intermittently and briefly in the top educational psychology texts and rarely in developmental textbooks. Do we need to do more to make it clear why it matters? Or are we writing in ways that make our findings less than accessible? This seems to be a primary challenge for the field in the next era. We need to go beyond writing for other researchers and academics and learn to write for those who can use this information. Foremost, this would be teachers, who address epistemic beliefs as impediments to learning on a daily basis, but may not be aware of it and lack a sense of the construct in a way that would make it applicable to instruction. Imagine a textbook chapter, for example, that would provide teachers with the research on epistemic cognition, but also provide tools to foster an examination of their own epistemic cognition and a means of examining their classroom practices in this light, as well as understanding their students' epistemic beliefs, development, and epistemic processes.

**Making it clear to a larger audience why it matters to understand epistemic cognition.** Epistemic cognition can offer an explanatory mechanism not only for student learning processes, but for why laypersons may have divergent beliefs about such well-established scientific claims as evolution, climate change, and a variety of issue of public importance (Sinatra et al., 2014). Scientists are beginning to address issues of science denial in their journals (Rosenau, 2012), seeking psychological explanations for rejection of scientific consensus on central principles and topical issues that have been largely resolved by scientists but remain questionable for much of the public. Epistemic cognition researchers have much to offer to help with such an understanding as well as to help educators understand how to effectively teach such issues as climate change (Lombardi, Sinatra, & Nussbaum, 2013). Those who communicate about science in the media could also benefit from our knowledge of how individuals may misinterpret the tentative nature of science.

## CONCLUSION

The field of epistemic cognition has progressed in three waves of development and is well poised for major accomplishments in the years ahead. In 2003, Mayer noted that the field was still in its infancy and showed stunted growth, given 30 years of prior research at that time. He argued that moving the field forward required "a productive attitude towards science, a set of testable theories, a set of useful research methods, and a solid base of empirical results" (Mayer, 2003, p. 317) and argued that publishing in mainline, peer-reviewed journals would be a step toward respectability. Given the work that has been done since that time, and the vast number of peer-reviewed articles in top-tier respectable journals, researchers are to be commended for considerable advancements in the progression of epistemic cognition research. As each of the following chapter authors are likely to outline for us, much work remains as well. Those of us engaged in this enterprise can help make it clear to others that epistemic cognition is not only an educational concern but also involves the development and application of a critically useful set of skills that can be applied, and which continue to develop, throughout life.

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# 3

# ARGUMENTATIVE REASONING

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## INTRODUCTION

In this contribution, we have been tasked with the goal of discussing argumentative reasoning. Argumentative reasoning, defined as the construction and evaluation of arguments, is a general human process of which more specific forms of reasoning are a part (Oaksford, Chater, & Hahn, 2008). That argumentative reasoning lies at the heart of thinking is an idea that can be traced back to the early philosophers including Plato, Socrates, and Aristotle, who considered reasoned arguments to be the core of thinking (Kuhn, 1991).

Argumentative reasoning is, therefore, pivotal for academic success and necessary for successful functioning in a democratic society (Kuhn, 2005; Newell et al., 2011). The importance of developing argumentative reasoning is reflected in recent curricular reforms and policy initiatives in the United States, such as the Common Core State Standards (Common Core State Standards Initiative, 2010), which emphasize the importance of the ability to comprehend arguments during reading and to construct arguments during writing. Nevertheless, national US data show that only 5 percent of twelfth graders can evaluate and recognize arguments at an advanced level (National Assessment of Educational Progress, 2013), suggesting that argumentative reasoning does not develop to sufficient levels without explicit instruction.

Research on argumentative reasoning has focused on argument as a product or argumentation as a process. The term *argument* refers to a product, constructed in written or oral form by an individual, consisting of a claim and one or more supporting reasons or evidence that are connected to the claim with warrants (Toulmin, 2003). The term *argumentation*, in contrast, refers to the dynamic social process that takes place between at least two individuals, who alternate turns and seek to understand each other's view (Kuhn, Hemberger, & Khait, 2014).

Argumentative reasoning is involved in both argument construction and argument evaluation and comprehension. In the literature, there are two quite distinct lines of research examining argumentative reasoning. One line has focused on the construction of arguments, with an emphasis on how to support the development of argumentation skills, while the other line has focused on the comprehension and evaluation of arguments in the context of reading, focusing on understanding the specific factors that influence comprehension and evaluation, such as reader individual differences, text characteristics, and task demands.

In this chapter, we review work on argumentative reasoning from these two lines of research. In the first section, we review research on the development of argumentative reasoning from a developmental perspective. Most researchers following this perspective have studied argumentative reasoning in the context of argument construction in social and individual contexts (e.g. writing). In the second section, we discuss argumentative reasoning from a reading comprehension perspective. Most researchers following this perspective have examined comprehension and evaluation of arguments during reading. In the third section, we discuss the relationship between argumentative reasoning and epistemic cognition. In the fourth section, we discuss the potential of argumentation as a means of improving epistemic cognition. Finally, in the last section, we lay out a number of future research directions in the interest of stimulating further work in this area.

## ARGUMENTATIVE REASONING FROM A DEVELOPMENTAL PERSPECTIVE

The scant evidence of research regarding the argumentative reasoning skills of young children suggests that even very young children have some competence in weighing and producing simple arguments (see Mercier, 2011, for a review). Young children are able to discern good arguments from poor ones (Eisenberg-Berg & Geisheker, 1979), they use reasons to support their arguments, and they justify their claims based on common ground assumptions, that is, assumptions that individuals take for granted (e.g. who Santa Claus is) (Köymen, Rosenbaum, & Tomasello, 2014). Mercier et al. (2014) examined the ability of preschoolers (3-, 4- and 5-year-olds) to weigh simple arguments. Their findings showed that children as young as 3 years old preferred an argument from perception to a circular argument, implying the existence of basic skills of argument evaluation even in 3-year-olds. However, older children exhibited more consistency in their preference for the argument from perception, suggesting that there is a developmental progression in argument evaluation performance. In addition, Anderson et al. (1997) examined the properties of fourth graders' naturally occurring arguments and concluded that young children show some competence in producing simple arguments with logical syntax. These basic, simple argumentative skills of producing simple arguments, exhibited by young children, are not sufficient, though, for the citizens of the twenty-first century (Mercier, 2011). Skilled argumentation involves more complex argumentative skills, namely the ability to produce counterarguments and rebuttals. Walton (1989) identified skilled argumentation as the ability to address and undermine the opponent's position by identifying and challenging weaknesses in his or her argument, as well as securing commitments from the opponent that can be used to support one's own argument.

Research suggests that children and even adults exhibit serious weaknesses in argumentation in terms of Walton's (1989) criteria (Iordanou & Constantinou, 2014; Jiménez-Aleixandre, Rodríguez, & Duschl, 2000; National Assessment of Educational Progress, 2013). That is, individuals focus on exposition of their own position to the neglect of attending to their opponent's claims, and attempting to weaken the force of opposing claims through counterarguments. Also, individuals fail to use evidence to support their arguments and counterarguments consistently. As a result, many researchers have attempted to support the development of argument skills either by direct instruction or through offering opportunities for extensive practice in a social context. One line of research, focusing particularly on the development of written arguments, has employed approaches to improving the production of arguments by drawing on argument schemas and writing-specific skills. These approaches include explaining what constitutes a good argument to the student (Nussbaum & Schraw, 2007); providing examples (Nussbaum, 2008); providing hints and models of arguments from experts (Bell & Linn, 2000); teaching strategies that help produce good written arguments (De La Paz & Graham, 1997; Graham & Harris, 1989); teaching students to organize the structure and order of presenting arguments, as well as including both pro and contra arguments in their essays (Butler & Britt, 2011); training students to use outlines (Erkens, Jaspers, Prangsma, & Kanselaar, 2005), graphic visualizations (Lu & Zhang, 2013; Nussbaum & Schraw, 2007), and interactive dialogical computer programs (Larson, Britt, & Kurby, 2009); and assigning students goals to focus on both sides of an argument (Page-Voth & Graham, 1999; Wolfe & Britt, 2008), content, and audience (Midgette, Haria, & MacArthur, 2008). The efficacy of the aforementioned interventions has been to some extent established with respect to proximal outcome measures (Andrews, Torgerson, Low, & McGuinn, 2009), but transfer to distal outcome measures has been relatively limited (Nussbaum, 2008).

Another line of research has focused on supporting the development of argumentative reasoning through argumentative, collaborative dialogues that take place in a social context. In this approach, dialogic argumentation is viewed as a productive vehicle for developing both individual and dialogic argumentative competencies. The development and implementation of several curriculums involving dialogic argumentation between peers showed that collaborative dialogic argumentation supports the development of argumentative reasoning skills (Anderson, Chinn, Chang, Waggoner, & Yi, 1997; Berland & Reiser, 2011; Kuhn et al., 2014; Schwarz & De Groot, 2007). A series of studies has shown that a curriculum based on extensive engagement in dialogues with peers who hold an opposing position on a socio-scientific topic and reflective activities supported the development of students' argumentation skills (Crowell & Kuhn, 2014; Iordanou, 2010; 2013; Iordanou & Constantinou, 2014, 2015; Kuhn, Goh, Iordanou, & Shaenfield, 2008; Kuhn, Zillmer, Crowell, & Zavala, 2013). Specifically, dense engagement in argumentation over an extended period of time proved to be a facilitative condition for supporting participants' ability to produce two-sided rather than one-sided arguments (Crowell & Kuhn, 2014; Iordanou, 2010) and to employ evidence to justify their arguments and their counterarguments (Iordanou & Constantinou, 2014, 2015).

Besides improvements in individuals' argumentation skills obtained in the context of the aforementioned instructional approaches or interventions, there is also evidence of transfer. Specifically, the gains observed in collaborative computer-based argumentation skills transferred from the social to the individual plane, as evidenced by improvements in individuals' written argumentation (Kuhn et al., 2013; Kuhn, Goh et al., 2008), and across communication modes, as shown by improvements in individuals' face-to-face argumentation (Iordanou, 2013). In addition, transfer has been observed across topics within a particular domain (Crowell & Kuhn, 2014; Kuhn, Goh et al., 2008) and across knowledge domains. Specifically, Iordanou (2010) examined transfer across domains by having sixth graders engage in a collaborative argumentative curriculum on either a science or a social topic, while a third group of sixth graders served as a control. Findings showed that participants, besides exhibiting improvements in their argumentation skills in their intervention topic, transferred these improvements across both domains. However, a difference in the magnitude of transfer was observed. The science condition led to a larger increase in the levels of counterargument on the science topic, while the social and science conditions were equally effective in increasing levels of these strategies on the social topic. This finding may be due, in part, to the potential influence of meta-level strategic understanding (i.e. understanding of the goals of an argument) (Kuhn, Goh et al., 2008; Iordanou & Constantinou, 2014) and epistemic understanding, which we discuss in the "Argumentative Reasoning and Epistemic Cognition" section later in the chapter (Iordanou & Constantinou, 2015; Kuhn et al., 2013; Ryu & Sandoval, 2012).

Evidence for development of meta-level understanding, along with development in argumentation strategies, comes from research that examined meta-talk, which is the talk participants engage in about the discourse itself. Specifically, an examination of participants' meta-talk using the microgenetic method, which involved a close examination of participants' argumentative reasoning during extended practice in argumentation, showed that participants developed a meta-level understanding of argumentative strategies (Kuhn, Goh et al., 2008; Kuhn et al., 2013) and of the role of evidence in argumentation (Iordanou & Constantinou, 2014, 2015). These findings suggest that meta-level understanding of argumentation also develops through sustained engagement in argumentation in the social context, and supports the development of argumentative reasoning skills.

In summary, research on the development of argumentative reasoning has focused primarily on the construction of arguments. Different approaches have been employed for supporting the development of argument skills including direct instruction, scaffolding, and extensive practice in argumentative dialogues in the social context. Taken together, the findings have shown that argumentation skills can be successfully developed when they receive specific attention. The findings regarding transfer across communication modes, topics, and domains suggest that argumentation skills are both domain general and domain specific. In addition, besides improvements at the procedural level, improvements have also been observed at the meta-level, suggesting that argumentative reasoning is multifaceted (Kuhn et al., 2013; Duschl, 2008). As we mentioned previously, the focus of this work has been primarily on the construction of arguments, rather than comprehension of arguments. We turn to this issue next.

## ARGUMENTATIVE REASONING FROM A READING COMPREHENSION PERSPECTIVE

Comprehension and evaluation of arguments often take place in the context of reading texts. Thus, reading comprehension processes themselves also directly influence the development of argument skills. Reading comprehension involves the complex interactions between reader individual differences, the demands of the task, and the characteristics of the text (Snow, 2002). Even though there are many definitions of what actually constitutes successful reading comprehension, a core component of most definitions is that it involves the construction of a mental representation of the text in readers' memory (McNamara & Magliano, 2009). This mental representation is the product of reading, what is often called the situation model (van Dijk & Kintsch, 1983). Independent of the unit of analysis or grain size, the widely adopted view is that situation models are represented in the form of interconnected networks of information or *semantic networks* (Collins & Quillian, 1969). These networks represent information in the text and prior knowledge as a system of interconnections in memory. The networks are typically represented as diagrams of nodes (e.g. concepts, idea units) and links (i.e. relations) often depicting complex relations.

Thus, it is reasonable to assume that comprehension of arguments in the context of reading critically depends on the construction of a situation model during reading, and that the coherence and interconnectedness of the situation model will reflect the extent to which an argument has been successfully understood. It also follows that factors known to influence the construction of situation models will also influence the comprehension of arguments. These factors include reader individual differences, such as prior knowledge and beliefs; text characteristics, such as text structure and text cohesion; and task demands, such as reading goals.

Indeed, research has highlighted several reader individual differences that influence comprehension of arguments, including the extent to which readers hold knowledge related to the issue (Nussbaum & Kardash, 2005; Nussbaum & Schraw, 2007; Rouet, Britt, Mason, & Perfetti, 1996), beliefs and attitudes related to the issue (Wolfe, Britt, & Butler, 2009; Wolfe, Tanner, & Taylor, 2013), and interest (Golanics & Nussbaum, 2008). This research has also highlighted a specific aspect of prior knowledge that is critically important for the comprehension of arguments, the argumentation schema (Nussbaum & Schraw, 2007; Piolat, Roussey, & Gombert, 1999; Wolfe et al., 2009). The argumentation schema includes a set of expectations about the structure, content, and purpose of argumentative texts. There is strong evidence that during reading, claims activate the argumentation schema in readers' memory, and that this schema facilitates the comprehension of arguments (Britt & Larson, 2003) by also activating knowledge, attitudes, and beliefs related to the theme (Wolfe, 2012).

Research also has highlighted several text characteristics that influence comprehension of arguments during reading, including argument and text structure. With respect to argument structure, claim–reason arguments are comprehended faster and better than reason–claim arguments (Britt & Larson, 2003), presumably because claims activate the argumentation schema more so than reasons (Wolfe et al., 2009). With respect to text structure, texts that include arguments and counterarguments (i.e. two-sided texts) are perceived as more credible and persuasive (O'Keefe, 1999) than texts containing only a single argument (i.e. one-sided texts). This research examined the effects of text structure on argumentation in argumentative, persuasive, and refutation texts. *Argumentative texts* aim to advance a position (Wolfe, 2012), and as such, they are often two-sided, including arguments and counterarguments. They emphasize evidence-based argumentation, rather than persuasion, thus the author assumes a relatively neutral stance (Buehl, Alexander, Murphy, & Sperl, 2001), and it is left to the reader to evaluate both sides. *Persuasive texts* aim to change attitudes or beliefs, often about controversial issues, by supporting a single viewpoint (Petty & Cacioppo, 1986), and as such they are either one-sided or two-sided (Murphy, 2001, 2007; Murphy & Alexander, 2004, 2008). One-sided persuasion texts exclude other-side arguments, and even though they align nicely with the "myside bias" phenomenon observed in the production of arguments for both children and adults (Kuhn, 1991; Sandoval & Millwood, 2005), they are less effective in persuading readers than two-sided persuasion texts (Wolfe et al., 2009). In the case of two-sided persuasion texts, which include other-side and my-side arguments, the balance is clearly in favor of the author's side, who assumes a clear my-side stance. The effectiveness of two-sided persuasion texts depends on the complex interactions between many factors above and beyond the text itself, including the nature, value, and strength of readers' beliefs

(Chambliss & Garner, 1996), as well as motivated reasoning (Dole & Sinatra, 1998; Gregoire, 2003; Murphy & Alexander, this volume; Sinatra, Kienhues, & Hofer, 2014).

*Refutation texts* aim to change knowledge, often what is termed misconceived or incorrect knowledge (Hynd, 2001), and as such they are often two-sided. Refutation texts combine characteristics from argumentative and persuasive texts. Like argumentative texts, they emphasize evidence-based argumentation. Like persuasion texts, the balance is clearly on the author's side, who assumes a clear my-side stance. A unique component of refutations texts is that "my-side" corresponds to normative knowledge that is clearly specified, whereas the other side corresponds to incorrect knowledge that is misconceived or ill-specified. The effectiveness of refutation texts depends almost exclusively on the causal explanations that support the normative knowledge, and specifically on the interconnectedness of the explanation (Kendeou & O'Brien, 2014; Kendeou, Smith, & O'Brien, 2013; Kendeou, Walsh, Smith, & O'Brien, 2014).

Further, research also has highlighted that task demands, such as specific goals during reading, influence the comprehension of arguments and the extent to which readers integrate arguments from different documents or sources (Anmarkrud, Bråten, & Strømsø, 2014). Specifically, goals to read and construct arguments promote comprehension of arguments more than goals to summarize or explain (Wiley & Voss, 1996, 1999). Further, tasks that require comprehension of conflicting viewpoints result in integration that is organized around an argument schema (Britt & Rouet, 2012). In this context, integrative processes such as evaluation and monitoring of different viewpoints strongly relate to argumentative reasoning.

Gaining a better understanding of comprehension and evaluation of arguments in the context of reading comprehension is important because it can help to identify the source of argumentative reasoning failures that pertain to reading comprehension itself. For example, high school and college students often show deficiencies in evaluating arguments, and specifically in identifying flawed arguments in the texts they read (Wolfe et al., 2009). These limitations may be due in part to failures to activate all constituent parts of an argument, namely the argument schema (Kurby, Britt, & Dandotkar, 2006; Wolfe et al., 2009); failures to accurately represent the arguments in memory, namely constructing a situation model; or, failures to retrieve the arguments from memory (Britt, Kurby, Dandotkar, & Wolfe, 2008). Identifying the specific source of the failure is important for the design of interventions or instructional approaches to improve argumentative reasoning during reading. Indeed, training studies designed to improve comprehension of arguments have highlighted the benefits of training on specific factors that are known to influence reading comprehension, such as providing elaborate and specific goals for reading (Wiley & Voss, 1996, 1999), activating argumentation schemas (Lin, Horng, & Anderson, 2014), and using computer tutorials to scaffold comprehension (Larson, Britt, & Kurby, 2004).

It is important to note that comprehension and evaluation of arguments has been examined in other literatures as well, including persuasion in social psychology (Petty & Cacioppo, 1981), conceptual change in science education (Dole & Sinatra, 1998), and reasoning fallacies in logic (Hahn & Oaksford, 2006). Work in these areas has shown that individuals have the capacity to produce and evaluate arguments, especially when they engage in group discussions (Mercier, 2011). Furthermore, work on reasoning skills in different fields (Mercier & Sperber, 2011) has highlighted what has also been documented in the reading comprehension literature, namely that successful comprehension and evaluation of arguments depends on the interactions between individual differences, message characteristics, and task or context demands.

## ARGUMENTATIVE REASONING AND EPISTEMIC COGNITION

Beyond the general skills that are entailed in the construction and evaluation of arguments discussed in the previous sections, argumentative reasoning also encompasses meta-level dimensions. Besides the meta-strategic understanding that we have already discussed (Kuhn, Goh et al., 2008; Iordanou & Constantinou, 2014), argumentative reasoning is supported by epistemic cognition. Individuals' beliefs about knowledge and how it is constructed are likely to influence their engagement with knowledge (Sandoval, 2005). To differentiate knowledge and beliefs about the nature of knowledge and knowing from the acquisition of knowledge, Kuhn (2001) proposed the term *meta-level knowledge*, while Barzilai and Zohar (2014) suggested the term *epistemic metacognitive knowledge*. The latter term is further differentiated into epistemic metacognitive knowledge about persons (i.e. knowledge about the individual as knower, about other people as knowers, and about human knowledge in general), and about strategies and tasks (i.e. knowledge about how to pursue an activity that will result in knowing). The relation between argumentation and epistemic cognition has been described explicitly in Kuhn's (2001) and Chinn et al.'s (2011) models. In Kuhn's (2001) model, epistemic understanding is conceptualized as a fundamental meta-level foundation that supports argumentative reasoning. In her theoretical framework about intellectual performance, she identified two kinds of meta-level knowing that support the execution of argumentation. The first is procedural meta-knowing, which refers to meta-task and meta-strategic understanding, as well as to management of the task and the strategies one has available to use. The second meta-level knowing is declarative meta-knowing, which refers to one's epistemic understanding regarding knowledge and knowing. This declarative or epistemic meta-knowing determines whether known strategies are executed. Epistemic meta-knowing informs intellectual values, which deal with questions such as "Is there a point to arguing?" and determines which strategies are applied. In Kuhn's model, the developmental task that underlies the progression towards mature epistemic understanding is the coordination of the subjective and objective dimensions of knowing (Kuhn, Cheney, & Weinstock, 2000). In this context, epistemic understanding progresses from the absolutist level, where the objective dimension of knowing dominates and knowledge is conceived as an objective, external entity, which is knowable with certainty, to the multiplist level where the uncertain and subjective nature of knowledge dominates, and then to the evaluativist level where a balance is achieved between the objective and subjective dimensions of knowledge.

Chinn et al. (2011) proposed a model of epistemic cognition that involves five interconnected components. These components are (a) epistemic aims and epistemic values; (b) the structure of knowledge and other epistemic achievements; (c) the sources and justification of knowledge and other epistemic achievements, together with related epistemic stances; (d) epistemic virtues and vices; and (e) reliable and unreliable processes for achieving epistemic aims. Argumentation is one type of reliable process (i.e. processes by which knowledge is achieved), along with perception and testimony, for achieving epistemic aims (i.e. goals related to finding things out, understanding them, and forming beliefs). Chinn and his colleagues suggested that individuals' beliefs about the conditions under which argumentation is considered a reliable process predict and explain individuals' learning processes as well as the outcomes of the learning processes on particular tasks.

Several studies have investigated the influence of epistemic cognition on argumentation, and even though they have varied with respect to which epistemic cognition framework they depended on, the findings have been remarkably consistent. Overall, this work suggests that more sophisticated epistemic beliefs relate to better argumentative reasoning skills (Weinstock, 2005, 2011; Weinstock & Cronin, 2003). Specifically, epistemic beliefs influence the reading strategies enacted (Kardash & Howell, 2000), overall comprehension of argumentative (Mason & Boscolo, 2004) and refutation (Kendeou, Muis, & Fulton, 2011) texts, as well as the conclusions drawn from such texts (Kardash & Scholes, 1996; Schommer, 1990). Also, there is strong evidence that mature epistemic beliefs are associated with better understanding of the purpose and value of argumentative discourse in enhancing understanding (Kuhn, Wang, & Li, 2010). Further, epistemic beliefs predict the extent to which readers will detect argumentation reasoning fallacies, such as "ad ignorantiam," what is known as the argument from ignorance fallacy (Weinstock, Neuman, & Glassner, 2006). Finally, epistemic beliefs predict engagement in meta-level processing while reading a text (Iordanou et al., submitted).

Besides the relation between epistemic beliefs and evaluation of arguments, a relation between epistemic beliefs and argumentation skills has also been observed. In particular, Mason and Scirica (2006) found that epistemic understanding was a significant predictor of the production of an argument, counterargument, and rebuttal after reading a text on a controversial topic. Participants with evaluativist epistemic understanding, who appreciated both the subjective and objective dimensions of knowledge, generated arguments, counterarguments, and rebuttals of a higher quality than participants with multiplist epistemic understanding, who overemphasized the uncertain and subjective dimension of knowledge. Nussbaum et al. (2008) also found differences in argumentative reasoning between students with different epistemic understandings. Specifically, students with evaluativist epistemic understanding tended to disagree with their interlocutor, cite contradictory facts, and point out the need for more information in argumentation, while students with multiplist epistemic understanding interacted less with their interlocutors and were less critical of arguments offered by their discussion partner. Further, there is evidence for the relation between certain dimensions of epistemic cognition and argumentation, such as (a) justification of knowledge, which predicts the quality of written argumentative texts (Bråten, Anmarkrud, Brandmo, & Strømsø, 2014; Bråten, Ferguson, Strømsø, & Anmarkrud, 2013; Ferguson & Bråten, 2013; Mason & Scirica, 2006; Nussbaum, Sinatra, & Poliquin, 2008), and (b) certainty of knowledge, which negatively predicts resolving global ambiguities (Kardash & Howell, 2000) and willingness to engage in argumentation (Bell & Linn, 2000; Nussbaum & Bendixen, 2003).

## IMPROVING EPISTEMIC COGNITION VIA ARGUMENTATION

The research we have reviewed thus far suggests that that there is an intimate relationship between epistemic understanding and argumentative reasoning. Both skilled evaluation and production of arguments are related to advanced epistemic understanding. Thus, the question of how researchers and educators can support the development of epistemic understanding is a central one for argumentative reasoning. The position that we propose here is that epistemic understanding develops *in sync* with argumentative reasoning. We further suggest that the context of dialogic argumentation that proved to be a productive condition for developing argumentative reasoning, even for very young children, can also be a promising vehicle for developing epistemic understanding.

Iordanou and Constantinou's (2015) work offered some suggestive data regarding the facilitative role of dialogic argumentation in promoting epistemic understanding. In this study, eleventh graders engaged in collaborative dialogic argumentation, in the context of the SOCRATES web-based learning environment, on the topic of climate change. The SOCRATES learning environment included a knowledge base on the topic of climate change, a chat tool that was used for conducting argumentation, and reflective templates where students were asked to construct evidence-based arguments and reflect on the arguments they produced while they were engaging in dialogic argumentation. Students working with a partner engaged in electronic argumentative dialogues with classmates who held an opposing view on the topic, and in evidence-focused reflective activities based on transcriptions of their dialogues. The findings showed an increase in the use of scientific data to support students' arguments, a decrease in the use of personal opinions, and an increase in citation of the source of the data used. These findings suggest that students developed, at least implicitly, an advanced epistemic understanding. Students exhibited a shift from presenting their "correct," self-evident theories without providing any data to support their arguments, to employing data to support their positions and offering alternative interpretations for a particular piece of evidence. Kuhn et al. (2013) also reported gains in epistemic understanding for students who engaged in prolonged dialogic argumentation. In particular, they observed gains in epistemic understanding of the norms that govern argumentation in terms of what constitutes acceptable claims of knowledge and acceptable forms in which to advance them in discourse.

Consistent with these findings, Ryu and Sandoval (2012) also obtained evidence for children's understanding and application of epistemic criteria (i.e. criteria regarding the production of coherent claims and the explicit justification of such claims with appropriate evidence) of scientific arguments as a result of instruction focusing on argumentation. In this study, children's appropriation of four epistemic criteria were examined: (a) causal structure, (b) causal coherence, (c) citation of evidence, and (d) employment of warrants for proposed relations between claims and data. The findings showed that children improved in their ability to both construct and evaluate arguments, especially in the ways children met evidentiary criteria.

Iordanou (2010) directly assessed participants' epistemic understanding before and after their engagement in an argumentative-based intervention. Findings showed that engagement in the argumentative intervention supported participants' development of a more evaluativist epistemic understanding. The improvement observed in epistemic understanding was domain specific. This finding is consistent with the view that there are qualitatively different challenges in the development of epistemic understanding across domains (Kuhn, Iordanou, Pease, & Wirkala, 2008). Specifically, the major challenge in the social domain is to overcome the view that human interpretation plays an unmanageable, overpowering role, whereas the major challenge in the science domain is to recognize that human interpretation plays any role at all.

In summary, there are some preliminary findings, from observational and experimental studies, showing that sustained engagement in argumentation supports the development of some aspects of epistemic cognition. Yet, given the complexity of epistemic cognition, there is a need for further research in this area. We discuss specific ideas for future research next.

## IMPLICATIONS AND FUTURE DIRECTIONS

As we mentioned above, argumentative reasoning has been researched in different fields and with very different lenses and approaches. One line of research has focused on the construction of arguments, and how to support the development of argument skills, while another line has focused on the comprehension and evaluation of arguments in the context of reading. We believe that building bridges between these two lines is important for acquiring a more comprehensive understanding of argumentative reasoning. A related issue pertains to the much-needed cross talk among these different areas and the establishment of a common language to facilitate better communication and collaboration.

The distinction in the literature between argument construction on the one hand, and argument evaluation and comprehension on the other hand, does not necessarily imply that different skills are involved for construction versus comprehension of arguments. The evidence of transfer of gains in argument skills, for example from dialogic argumentation to evaluation of arguments at the individual level (Kuhn et al., 2013; Ryu & Sandoval, 2012), suggests that there is a core set of skills that supports both argument construction and evaluation. More work is needed to identify this core set of skills and provide insights regarding whether, and if so to what degree, argumentative reasoning is task specific.

Another question that is still open is the issue of domain-specificity versus domain-generality of argument skills. The evidence of transfer of argument skills across modes, topics, and domains suggests the generality of these skills. Yet, evidence for asymmetric transfer of argument skills across domains (Iordanou, 2010) suggests that there are also domain-specific components in argumentative reasoning. To address this issue we think it is important to approach argumentative reasoning as a multifaceted construct (Kuhn et al., 2013; Duschl, 2008). Besides cognitive skills, argumentative reasoning also involves meta-strategic understanding and understanding of the epistemic norms of argumentation (Iordanou & Constantinou, 2014, 2015; Kuhn, Goh et al., 2008; Ryu & Sandoval, 2012). The findings of Kuhn, Iordanou et al., (2008) suggesting that there are specific epistemic challenges that need to be addressed for developing epistemic understanding in a particular domain offer at least a partial explanation of the asymmetric transfer observed in argumentation skills across domains. What constitutes evidence in one domain differs from what is considered evidence in another domain. Development of the epistemic norms of argumentation in a particular domain might be required for skilled argumentation in a particular domain. Further research is required to illuminate the field's understanding of how epistemic cognition influences argumentative reasoning.

Another question that remains open is whether an intervention that promotes the development of epistemic cognition would also support the development of argumentative reasoning. Studies that examined the reverse relationship, that is, the effect of interventions that promote argumentative reasoning on epistemic cognition, yielded some promising findings. First, these studies (Iordanou & Constantinou, 2015; Kuhn et al., 2013) showed that argumentation is a prominent arena for studying and understanding individuals' epistemic beliefs. Specifically, dialogic argumentation offers a window to students' epistemic beliefs and to what Chinn and colleagues (2011) refer to as students' epistemic aims and values. Thus, studying students engaged in dialogic argumentation over time could be a promising way to respond to the call by Sandoval (2014) for more research employing the microgenetic method in order to develop a comprehensive understanding of epistemic development (Iordanou & Constantinou, 2015). Second, the findings of the studies that involved argumentative, collaborative dialogues suggest that argumentation might be a promising vehicle for supporting the development of epistemic understanding. Given the complexity of epistemic cognition, future research needs to examine how argumentation influences the development of different components of epistemic cognition, such as epistemic values and justification of knowledge (Greene, Muis, & Pieschl, 2010), and how domain or task specific this development is.

## CONCLUDING REMARKS

To conclude, our review of the literature on argumentative reasoning, including both construction and comprehension of arguments, and epistemic cognition, suggests that argumentative reasoning and epistemic cognition are closely intertwined. In this chapter, we have highlighted evidence showing that engagement in dialogic argumentation appears to be a promising vehicle for supporting both argumentative reasoning and epistemic cognition. We suggest that further research is required to provide insights regarding the development of epistemic cognition and its interconnection with argumentative reasoning.

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# 4

# LOGICAL AND CAUSAL REASONING

*David Moshman and Pina Tarricone*

Reasoning is perhaps best defined in relation to thinking and inference (Moshman, 2011, 2015). *Inference,* the broadest of these three terms, typically refers to the generation of new knowledge through a variety of processes, often without the intent or awareness of the knower. *Thinking* involves the metacognitive self-regulation of inferences. In thinking, one deliberately controls one's inferences on the basis of one's knowledge about inference in general and awareness of one's own inferences. Nevertheless, thinking is often more concerned with success than with generating new knowledge or better understanding. Faced with a problem, for example, one tries to think of a solution. If the problem is solved, the thinking is successful. Similarly, in making decisions, rendering judgments, or formulating plans, people make and coordinate inferences in order to serve their purposes. Thinking, in other words, is deliberate but often just pragmatic.

Sometimes, however, the concern is with knowledge. If I am concerned with knowledge I am concerned with what I *should* believe, which requires me to consider the truth, or at least the justification, of my various beliefs and of various alternatives. When people regulate their inferential processes in order to maximize the truth and justification of their beliefs, their thinking is epistemologically self-regulated and thus qualifies as reasoning. *Reasoning*, in other words, refers to forms or aspects of thinking that are reflectively oriented toward epistemological considerations of justification and truth. Reasoning, in short, is epistemologically self-regulated thinking (Moshman, 2011, 2015).

In this chapter we consider two forms of reasoning: logical and causal. These are not the only forms of reasoning, but they are fundamental. In the next section we consider the epistemological basis for distinguishing forms of reasoning. We then turn to more detailed coverage of the two forms of reasoning central to this chapter, beginning with logical reasoning and concluding with causal reasoning. For each form of reasoning we consider its nature and functioning, its epistemological foundation, and its development. Logical and causal reasoning and their associated epistemologies, it will be clear, are central both to individual cognition and to the conceptualization of academic disciplines such as logic, mathematics, and science.

## EPISTEMIC DOMAINS OF REASONING

Consider the following three propositions concerning a switch (which can only be up or down) connected to a light bulb (which can only be on or off):

1. If the switch is moved up, the light bulb will go on.
2. Moving the switch up causes the light bulb to go on.
3. If the light bulb is on, then it is not off.

All three propositions appear to be justified and true. But most adults would recognize, at least upon reflection, an important difference between the third proposition and the first two. The first two are scientific propositions that can be tested by getting evidence and could turn out to be false. The first is an empirical claim that could be true or false. The second is a causal explanation that could be true or false. The third, in contrast, is a logical proposition that is necessarily true. Given that the light bulb must be on or off, we can infer from it being on that it is not off. Thus the third proposition is not just true; it is logically necessary.

Beyond early childhood, people readily distinguish causal explanations and associated empirical regularities from logical necessities and associated proofs (Moshman, 2015; more on this in a subsequent section). Causal and logical explanations are understood to rely on different conceptions of justification and truth. Such understanding concerns matters of epistemology and is thus part of epistemic cognition—that is, knowledge about the justification and truth of beliefs. Epistemic development—the development of epistemic cognition—is in part an increasingly explicit understanding of the distinction between (a) the explanatory and causal nature of the empirical sciences and (b) the formal necessities of logic and mathematics.

Because epistemic domains rely on distinct conceptions of justification and/or truth, they support correspondingly distinct forms of reasoning. As discussed in this chapter, logic and causality are epistemologically distinct domains that ground logical and causal reasoning respectively. Other potential epistemic domains include morality, social convention, history, and identity (Moshman, 2015).

Morality is commonly recognized as a distinct epistemic domain involving knowledge of how people ought to treat each other. Principled reasoning provides forms of justification and truth distinct from both logic and science. Moral principles are neither empirical generalizations nor causal theories. They are concerned with determining how things *ought* to be, not with describing or explaining how things *are*. Because morality is normative rather than empirical it can be said to resemble logic more than science. But moral principles are not logical rules. Principled reasoning, unlike deductive reasoning, is often a matter of judgment, yielding conclusions about which people can reasonably disagree, even if some conclusions cannot be justified or are less defensible than others.

Social convention is commonly distinguished from morality and is arguably an epistemic domain of its own. Precedent-based reasoning, central to social conventions such as law, is a type of case-based reasoning constrained on the basis of previous cases. Respect for precedent has no clear counterpart in logical, causal, or moral reasoning and appears irrelevant or antithetical to each, suggesting it differs from each in its conception of justification and truth.

Other potential domains include history and identity, which are closely interrelated and are addressed at individual, social, and academic levels. These may involve narrative forms of reasoning and epistemological issues of what it means to be true to oneself. Keeping in mind this larger picture, we focus this chapter on the logicomathematical and causal/scientific domains and highlight the forms of reasoning associated with each.

## LOGICAL REASONING

From very early ages, children make inferences that can be recognized by logicians and psychologists as logical (Braine & O'Brien, 1998; Scholnick & Wing, 1995). The children themselves, however, do not recognize their inferences as logical or even recognize that they have made inferences (Moshman, 1990; Sodian & Wimmer, 1987; more on this in a subsequent section). Rather than deny that children are logical, it seems most illuminating to describe this situation by saying that very young children engage in logical inference (i.e. inferences in accord with what logicians and cognitive psychologists recognize as rules of logic) but not in logical reasoning (i.e. inferences that are deliberately applied and coordinated by children for the purpose of reaching what they understand to be logically necessary conclusions). Thinking can be seen as the metacognitive self-regulation of inferences; logical reasoning, more specifically, is the *metalogical* self-regulation of inferences.

Logical reasoning, at least in its prototypical forms, is rule based. Provided one follows the rules, truth is guaranteed and justification is absolute. Unlike scientific reasoning, logical reasoning is not a matter of getting empirical evidence and is not contingent on such evidence. Logic is a realm of possibilities, impossibilities, necessities, and proof (Gauffroy & Barrouillet, 2011; Piaget, 1987; Ricco, 2015).

Ricco and Overton (2011; see also Ricco, 2015) provided what they call a *Competence<—>Procedural processing model* of deductive reasoning that draws on recent dual-process models of cognition (Evans, 2007; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 2011). System 1 in their model is domain specific and involves "heuristic, implicit, automatized processes" that operate in "real time" on "contextual representations heavily dependent on problem content" (Ricco & Overton, 2011, p. 124). System 2 is domain general and involves "universal, enduring, organized operations of mind" that operate on "de-contextualized, de-coupled, secondary and metarepresentations" (Ricco & Overton, 2011, p. 124). Following Stanovich (2011) they distinguish two subsystems within System 2 competence: an algorithmic subsystem and a reflective subsystem. The algorithmic subsystem of rules or operations provides a mental logic or natural deduction system "while the reflective system is the seat of practical and epistemic self-regulation, including emergent epistemic and metalogical norms" (Ricco & Overton, 2011, p. 119). Developmental progress in metalogical understanding is central to the development of the reflective subsystem.

Markovits et al. (2015) provided evidence consistent with a dual-process perspective in a series of two studies investigating people's confidence in their logical reasoning. A total of 354 college students were presented with written conditional reasoning ("If … then") problems. Some of the problems were "abstract" and others were "concrete." Some of the concrete problems involved premises with many potential alternative antecedents, which has been associated with responses consistent with conditional logic; others involved premises with few potential alternative antecedents, which leads people to respond as if the conditional relationship were biconditional (i.e. reversible). Students' confidence was significantly correlated with their logical performance in the abstract condition. In the second (i.e. few alternatives) concrete condition, by contrast, their confidence ratings were higher, on average, but were unrelated to their actual performance. Markovits et al. (2015) concluded that people have a "metacognitive representation of abstract validity" (p. 681) that they can use for abstract reasoning, but also that they are often systematically misled by content in cases of concrete reasoning.

Using a very different methodological approach, DeWall et al. (2008) provided, to quote their title, "evidence that logical reasoning depends on conscious processing." Their evidence was the performance of 366 college students on a variety of logical reasoning tasks under a variety of conditions designed to influence their conscious or nonconscious processing. As predicted, logical reasoning was enhanced in conditions that engaged and stimulated conscious processing and was impeded in alternative conditions that encumbered or preoccupied conscious processing. Corresponding manipulations of nonconscious processing, in contrast, had no effect. Without denying that automatic and intuitive inferences may be logical, DeWall et al. (2008) concluded that the controlled and reflective processes associated with consciousness contribute importantly to logic, consistent with a dual-process approach to logical reasoning.

Consistent with these findings, research on collaborative reasoning under conditions of free discussion shows that groups achieve higher levels of logical performance than individuals (Moshman & Geil, 1998). More generally, as seen in the next two sections, research on logic, like research in most areas of cognition, consistently shows the importance of metacognition (Tarricone, 2011).

### *Understanding the Epistemology of Logic*

Logical reasoning requires conceptual knowledge about the nature of logic, especially with regard to its role in justification and its relation to truth. This has been termed *metalogical understanding* (Moshman, 1990). Metalogical understanding includes at least four components: (1) awareness of inference as a process that generates conclusions from premises; (2) understanding that some inferences and conclusions are more justifiable than others; (3) knowledge about the logical properties of propositions, inferences, and arguments, including the logical necessity of deductive inference; and (4) conceptualizations of logic as an epistemic domain in relation to other domains such as empirical science. Research shows systematic developmental progress in metalogical understanding over the course of childhood and sometimes beyond (Moshman, 1990, 2015; more on this in the next section). Even adults, however, often fail to apply their most advanced metalogical knowledge. Instead, consistent with dual-process theories, people rely largely on intuitions and automatic processes, which are usually adaptive, and often fail to override those processes even when they know better, or would have known better had they reflected on what they were doing (Evans, 2007; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 2011).

Deduction is generally considered the core of logic. In a deductive argument, the conclusion follows necessarily from the premises and thus preserves truth. If the premises are true then the conclusion must be true. Even if the premises are uncertain, deduction generates a conclusion that would be true *if* the premises were true and thus provides a basis for hypothetical propositions that are *necessarily* true. Here is such a proposition: *If a light bulb can only be on or off, and it is not on, then it is off.* One cannot know whether the light bulb is on or off without empirical evidence about its state, but there is no need for empirical research to test the truth of the hypothetical proposition. It is true regardless of evidence.

As discussed in the next section, children need not know any of this to make deductive inferences in the sense of reaching conclusions that logicians deem logically necessary. Knowledge about the nature of deduction, however, enables people to distinguish deductive from nondeductive inferences. The developing consciousness of logical necessity is central to Piaget's developmental epistemology (Smith, 1993) and much of his research on cognitive development was driven by this concern (Inhelder & Piaget, 1958, 1964; Piaget, 1941/1965, 1987; see also related research discussed in the next section).

The term logic is often used more broadly to include nondeductive inferences in which the conclusion is justifiable but not logically necessary. Inductive logic generalizes beyond the cases at hand to yield conclusions that are reasonable but could be disconfirmed by future evidence and thus turn out to be false. Informal logic is concerned with the quality of argumentation and the avoidance of fallacies but does not rely on logical form and thus cannot provide logical necessity. Even if we define logic broadly, understanding the logical necessity of deduction, as distinct from the fallibility of nondeductive inference, is central to understanding the epistemology of logic.

### *Development of Logical Reasoning*

The development of logical reasoning has been a major topic of empirical research and active theorizing since Inhelder and Piaget's (1958) *The growth of logical thinking*. An excellent overview of the state of the art has been provided by Ricco (2015; see also Barrouillet & Gauffroy, 2013; Ricco & Overton, 2011).

Research on infants has demonstrated the sequential emergence of an increasingly coordinated sensorimotor logic over the first 18 to 24 months of life (Langer, 1980, 1986; Piaget, 1936/1963). As inferences become increasingly visible with the development of language over the preschool years, it becomes clear that preschool children routinely make a variety of inductive and deductive inferences (Braine & O'Brien, 1998; Scholnick & Wing, 1995). Such inferences, however, are automatic and intuitive. Preschoolers show no awareness of the process of inference—a lack of metacognition. Thus, they can have no knowledge about the logic that is often implicit in their cognition—no metalogical understanding.

Automatic and intuitive inferences are not just found in young children. Dual processing theories have indicated that adults engage regularly in automatic and intuitive inferential processes, often the same processes seen in children of all ages. People have knowledge inferred from other knowledge via a variety of inferential processes and lose track of what they have inferred from what (Evans, 2007; Evans & Stanovich, 2013; Kahneman, 2011; Stanovich, 2011).

Unlike preschool children, however, adults are potentially aware of their inferences. They may be unaware of a particular inference but they know that they make inferences and they can identify and reflect on some of them. Adults, moreover, understand the difference between premises and conclusions, even though they often fail to make that distinction. Preschool children, in contrast, are unaware not only of particular inferences but of inference itself. Adults may lose track of what has been inferred from what, but preschool children are unaware that anything is ever inferred from anything else and make no distinction between premises and conclusions. Despite some claims of earlier competence (Keenan, Ruffman, & Olson, 1994; but see Pillow, 1999), there appears to be a consensus that children become aware of inference as a source of knowledge at about age 6 years (Miller, Hardin, & Montgomery, 2003; Pillow, 2002; Pillow, Hill, Boyce, & Stein, 2000; Rai & Mitchell, 2006; Sodian & Wimmer, 1987).

The classic demonstration of children's developing awareness of inference as a source of knowledge was provided by Sodian and Wimmer (1987) in a study of children ages 4 to 6 years. The core of the study was as follows: Imagine you are presented with a container of red balls. One of the balls is removed and placed in an opaque bag, but you do not see which one. When asked the color of the ball in the bag you respond that it is red. When asked whether another person observing what you did would also know the color of the ball in the bag, you respond that the person would also know it to be red. You understand that, even though the other person cannot see what is in the opaque bag, that person can and will make the same inference you did. You also understand that the color of the ball in the bag could not be inferred if the original container contained balls of more than one color. Sodian and Wimmer found that 6-year-olds responded to their tasks just like adults and seemed to have the same basic understanding of inference. The 4-year-olds, in contrast, though equally able to infer that the ball in the bag would be red, seemed unable to grasp that another person could make that inference, presumably because they were unaware that their own response was the result of an inference. It appears, then, that although humans make inferences throughout the preschool years, it is only at about age 6 years that people become aware of those inferences.

Awareness of inference allows people to reflect on its characteristics and on the justifiability of its results. This includes reflection on the strict logic of deductive inferences. Extensive research has shown that children have some understanding of logical necessity, consistency, and impossibility beginning at about age 6 years (Miller, 1986; Miller, Custer, & Nassau, 2000; Ruffman, 1999; Somerville, Hadkinson, & Greenberg, 1979; Tunmer, Nesdale, & Pratt, 1983), with ongoing development of metalogical understanding in later childhood (Byrnes & Beilin, 1991; Galotti, Komatsu, & Voeltz, 1997; Markovits, 2013; Morris & Sloutsky, 2001; Moshman, 1990, 2011, 2015; Piaget, 1987; Piéraut-Le Bonniec, 1980; Pillow, 2002, 2012; Pillow & Anderson, 2006; Pillow, & Pearson, 2012; Pillow et al., 2000; Ricco, 1997; Ricco, McCollum, & Wang, 1997). Education may promote such development but there appear to be age-related constraints on the ability to learn metalogical concepts (Klahr & Chen, 2003). Studies by Pillow (2002) and Miller et al. (2000) illustrate the nature of this research and the typical pattern of findings.

Pillow (2002) presented inference-related tasks to 112 children ranging in age from 5 to 10 years, plus 16 college undergraduates. The tasks included deductive inference, inductive inference, informed guessing based on partial information, and pure guessing. Participants of all ages were highly certain of their conclusions in the case of deductive inferences and less certain in all other cases. Even the youngest children (ages 5–6) had significantly more confidence in deductions than in guesses and justified their deductive conclusions by referring to relevant premises. By age 8–10 years, children had significantly more confidence in deduction than induction and, in turn, significantly more confidence in induction than in pure guessing. Adults showed a perfect hierarchy of certainty, with deduction deemed most certain followed by induction, informed guesses, and pure guesses.

Miller et al. (2000) interviewed a hundred children of ages 7, 9, and 11 years about logical necessities (e.g. a light must be on or not on), mathematical necessities (e.g. 3 is bigger than 2), definitional necessities (e.g. triangles have three sides), physical laws (e.g. letting a pencil go will result in its falling), and an arbitrary fact (whether there was chalk in a designated box). Children were asked whether each of the various true statements was true everywhere (i.e. spatial universality) and whether these truths ever could change (i.e. changeability). They were also asked whether any alternative could even be imagined. For some items they were invited to draw an alternative such as "a triangle that does not have three sides." Even the younger children showed some awareness that logical, mathematical, and definitional necessities are universal and unchangeable. With increasing age, children increasingly recognized that violations of such necessary truths are literally unimaginable and increasingly distinguished such necessities from other sorts of knowledge.

Development continues beyond childhood. For example, Moshman and Franks (1986) assessed the ability of fourth graders (ages 9 or 10 years), seventh graders (ages 12 or 13 years), and college students to distinguish the validity of a deductive argument (i.e. whether the conclusion follows necessarily from the premises) from the truth or falsity of its premises and conclusions. Across a series of three studies, 197 participants sorted and evaluated arguments varying in (a) inferential validity, (b) truth of the premises, (c) truth of the conclusion, (d) form of argument, and (e) content of premises and conclusions. These tasks were performed under conditions that varied systematically with regard to providing definitions, explanations, and/or feedback. Regardless of condition, a substantial majority of college students showed clear understanding of the concept of inferential validity whereas virtually no fourth graders showed such understanding. Seventh graders were highly variable in their spontaneous performance, with some reasoning at the level of the best college students and others at the level of the fourth graders. Under facilitative circumstances of explanation and/or feedback, seventh grade performance improved to nearly the level of the college students (the remaining differences were not statistically significant), whereas fourth graders failed to profit.

Metalogical understanding concerning the validity of hypothetical inferences can be seen beginning at about age 11 years (Efklides, Demetriou, & Metallidou, 1994; Markovits & Bouffard-Bouchard, 1992; Markovits & Nantel, 1989; Markovits & Vachon, 1989; Moshman, 1990). Morris (2000) had some success in improving performance among children of ages 8–11 years by setting up an elaborate fantasy context and repeatedly directing children's attention to key structural relationships, but even under these favorable conditions most children, regardless of age, still failed to distinguish valid from invalid arguments. Other research also shows the extended developmental course of counterfactual reasoning (Amsel & Moshman, 2015; Amsel, Trionfi, & Campbell, 2005; Rafetseder, Schwitalla, & Perner, 2013). Such reasoning is seen by dual-process theorists as central to the reflective mental processes associated with System 2 (Evans, 2007; Evans & Stanovich, 2013; Stanovich, 2011).

In summary, thinking can be conceptualized as the metacognitive self-regulation of inferences. To the extent that such regulation is guided by epistemic cognition, and is thus aimed at justification and/or truth, people may be said to be reasoning. To the extent that epistemic cognition includes metalogical understanding, reasoning includes logical reasoning. Metalogical understanding shows substantial progress over the course of childhood and beyond, which enables progress in logical reasoning. Logical reasoning is not the only kind of reasoning but it plays a unique role with regard to the justification of inferences, the truth of conclusions, and the coherence of knowledge.

## CAUSAL REASONING

Causality is a complex and subtle matter that has been of great concern to philosophers of science, cognitive developmentalists, scientists, historians, educators, and people of all ages (Hewitson, 2014; Koslowski, 1996; Piaget, 1974; Rosenberg, 2012; Sandoval, Sodian, Koerber, & Wong, 2014; Witherington, 2011). Recall the three propositions from the beginning of the chapter:

1. If the switch is moved up, the light bulb will go on.
2. Moving the switch up causes the light bulb to go on.
3. If the light bulb is on, then it is not off.

Unlike the third proposition, the first is an empirical claim that is presumably based on past observations. It provides a prediction that can be tested against new evidence. The second proposition is a causal explanation for the empirical observations that led to the empirical claim. The first two propositions fall in the realm of science, which is concerned with organizing and explaining observations of the world. This concern for organization and explanation leads scientists, and people in general, to notice causal relations and provide causal explanations.

Now consider three more propositions:

4. Smoking tobacco causes lung cancer.
5. Violent video games cause violent behavior.
6. Ethnic oppression causes group violence.

Does smoking tobacco cause lung cancer? Certainly the two are correlated. Correlation does not entail causality but in this case there appears to be a scientific consensus that the relation is causal. But smoking does not cause cancer in anything like the sense that switching on a light causes it to go on. Rather scientists say smoking plays a causal role in cancer or increases the likelihood of cancer to indicate that the relation, though causal, is statistical rather than absolute. In the cases of individual and group violence, questions of causality are even more complex and subtle with regard to both empirical evidence and the nature of whatever causal relations exist.

A reductionist conception of the sciences suggests that all causal relations are ultimately reducible to the billiard-ball causality of mechanics. Societal phenomena such as ethnic oppression may temporarily require sociological explanations, but at least in principle such explanations can ultimately be reduced to psychological explanations of the behavior of all the individuals involved, which in turn can be reduced to biological explanations of the underlying anatomy and physiology, which in turn can be reduced to organic chemistry and eventually to elementary physical causality.

An emergentist conception of the sciences reveals important distinctions in the nature of causal relations across the transition from the physical sciences to the biological sciences to the behavioral sciences to the social sciences, while acknowledging the concern with causality that all sciences share. Biological systems show self-regulatory forms of causation not seen in physics. In homeostasis, for example, the system reacts to external pressures in such a way as to maintain its equilibrium. Such emergent self-regulation is compatible with the laws of physics but not reducible to them. At higher levels of emergence, behavior and social organization further complicate causal explanation. Dynamic systems manifest complex and circular forms of causality in which the systems themselves are causal agents (Witherington, 2011).

Questions of causality are further complicated by the fact that the nineteenth-century billiard-ball causality of classical mechanics no longer reigns in physics. In the twentieth century, the probabilistic metaphysics of quantum mechanics raised profound questions about the nature and existence of causal relations. Nevertheless, causality remains central to scientific understanding for scientists across all disciplines and people of all ages. Beyond the micro-level phenomena of quantum mechanics, the concept of causality appears indispensable, at least for human minds (Rosenberg, 2012).

In fact, concern with causality goes beyond science. History is generally seen as more descriptive than theoretical. Historians provide rich narratives about what happened but, unlike scientists, they do not usually seek to provide a general theory that explains it all nor do they usually make predictions about the future. Nevertheless, most historians are concerned with causality, engage in causal reasoning, and provide causal accounts of history (for a systematic overview and analysis of the role of causality in the study of history, see Hewitson, 2014).

### *Understanding the Epistemology of Science*

Causal reasoning, or more generally scientific reasoning, requires understanding the epistemology of science, including the empirical basis of scientific knowledge. Perception is crucial to science. For knowledge claims to be scientific they must be subject to empirical tests that yield empirical evidence that comes to us through perception. Scientific theories are also evaluated with respect to nonempirical standards such as coherence and parsimony. But empirical evidence plays a special role as a source of scientific justification and thus of scientific knowledge (Rosenberg, 2012; Sandoval, 2005; Sandoval et al., 2014; Sinatra & Chinn, 2012).

Scientists seek *knowledge*, which entails justification and truth, not just *belief*. They generally assume there is a reality sufficiently distinct from their theories of it that those theories could be false. But scientists are not satisfied to describe reality as accurately as they can and justify their descriptions. Science aims to explain, and the ideal of scientific explanation is causal explanation (Koslowski, 1996, 2013; Koslowski, Marasia, Chelenza, & Dublin, 2008; Rosenberg, 2012; Sandoval et al., 2014; Zimmerman, 2000). Causal explanation, moreover, is theoretical explanation. The most fundamental explanations provided by science are its causal theories.

This focus on empirical evidence and causal relations does not disparage the importance of logical reasoning, which is undoubtedly crucial. Because adolescents and adults can recognize and evaluate logical interconnections among hypothetical propositions, they can consider the potential interrelations of multiple possibilities and thus formulate and test explicit hypotheses (Inhelder & Piaget, 1958; Kuhn, Amsel, & O'Loughlin, 1988; Moshman, 2011; Zimmerman, 2000). But there is more to science than logic (Carey & Smith, 1993; Koslowski, 1996, 2013; Rosenberg, 2012). Scientific reasoning is not the application of logic to empirical evidence; it reaches conclusions that are not logically necessary. Theories, moreover, are not simply hypotheses, and they are not immediately abandoned if they lead to a hypothesis that is not confirmed (Chinn & Brewer, 1993; Koslowski, 2013; Rosenberg, 2012).

Chinn and Brewer (1993) distinguished seven ways people, including scientists, respond to data that seemingly contradict their theories. First, they may ignore the data.

Second, they may find methodological or other bases for rejecting the data. Third, they may deem the data to fall outside the domain of their theory. Fourth, they may hold the data in abeyance pending further evidence. Fifth, they may reinterpret the data to render it consistent with theory. Sixth, they may modify peripheral aspects of the theory. And finally, when all else fails, they may reject or radically modify a disconfirmed theory. Although protecting theories from data sometimes hinders scientific progress, it is often rational to maintain a theory despite empirical anomalies until the pattern of evidence is clear and theoretical alternatives have been fully explored. Thus science involves a dialectical coordination of theory and evidence rather than a simple application of logic.

D. Kuhn (1989, 2005, 2009; Kuhn et al., 1988) has long maintained that the differentiation and coordination of theories and evidence are central to scientific reasoning. Even children have theories and even children change their theories on the basis of evidence. Development in Kuhn's (1989) view is largely metacognitive, toward "thinking about theories, rather than merely with them, and thinking about evidence, rather than merely being influenced by it" (p. 688). Such progress enables more rigorously logical hypothesis testing, but logical rigor in hypothesis testing is not sufficient. Science involves the ongoing reflective coordination of theory and evidence, which inevitably raises issues of epistemology. Thus epistemic cognition is crucial, Kuhn (2005, 2009) insists, to scientific reasoning.

Koslowski (1996; Koslowski et al., 2008) drew directly on philosophy of science to extend the scope of research on scientific hypothesis testing. She found that adolescents and college students routinely interpreted hypotheses as causal. Scientific reasoning is thus, at its core, causal hypothesis testing. The plausibility of data depends on the possibility of postulating a causal mechanism. Thus causal hypothesis testing is guided in reasonable ways by theoretical expectations rather than proceeding only on the basis of logic. There is no algorithm for extracting scientific truth from data. Scientific reasoning is a bootstrapping process that involves both theory and data and requires clear recognition of their interdependence. The scientific thinker must understand that "considerations of theory or mechanism constrain data, and data in turn constrain, refine, and elaborate theory" (Koslowski, 1996, p. 86).

Empirical hypothesis testing is the form of reasoning most central to science. Causal hypothesis testing is the form of empirical hypothesis testing most central to scientific explanation. Scientists use many other forms of reasoning too but hypothesis testing is central to their empirical aim of truth. The testing of causal hypotheses, moreover, is central to their theoretical aims of explanation and understanding. Thus, causal hypothesis testing is central to scientific reasoning. Causal reasoning is often seen as a matter of *abduction*, rather than deduction or induction (Koslowski, 2013). Deduction is logical, and induction has a logic too. Abduction, also known as *inference to the best explanation,* does not follow logical rules but is nonetheless rational. Even if no explanation can be proven true, an explanation may reasonably be deemed superior to any apparent alternative, in part on the basis of its consistency with related explanatory networks.

The history of the philosophy of science over the past century can be seen in broad overview as a transition from (1) the logical positivist conceptions that dominated the early twentieth century to (2) the subjectivist conceptions that flourished in the 1960s and 1970s following Thomas Kuhn's groundbreaking *The Structure of Scientific Revolutions* (T. S. Kuhn, 1962/1996) to (3) post-Kuhnian conceptions of scientific rationality and progress that reflect further on subjectivity and its relation to objectivity (Rosenberg, 2012). Thus the epistemology of science has shown the same trend from objectivist to subjectivist to metasubjectivist conceptions that has been seen repeatedly in individual development (Moshman, 2015).

### *Development of Causal Reasoning*

Beginning in the first few months of life, infants increasingly experience causal agency in their power to control their sensorimotor relations with the world and increasingly construe relations they observe in the world outside them in causal terms (Piaget, 1937/1954). The earliest causal inferences are likely sensorimotor, however, and causal inferences throughout life remain in large part automatic and intuitive. This is not to say they are wrong or maladaptive. On the contrary, the causal inferences that come naturally to humans are largely adaptive, presumably because they are a genuine source of knowledge about the world. But very young children are not aware of their causal inferences and have no control over them. Thus, they are entirely at the mercy of whatever inferences are set in motion during their ongoing interactions with and observations of their environments.

By the age of 3 or 4 years, children show what some have deemed causal reasoning, albeit in very simple situations. Frye et al. (1996) studied 80 North American children of ages 3 and 4 years in a series of two experiments. The task involved predicting whether a marble would take a straight or diagonal path on the basis of whether a light was on or off, using a rule stated by the experimenter. Even 3-year-olds could do this if there was just one possible starting point; 4-year-olds succeeded in more complex versions of the task requiring embedded conditional rules. A cross-cultural replication and extension of this research in China by Hong et al. (2005) confirmed the causal competence of preschool children and the substantial developmental progress between ages 3 and 4 years.

What remains to develop? It appears that the development of causal reasoning beyond early childhood is in large part the development of (a) the metacognitive self-regulation of causal inferences and (b) the epistemic self-regulation of theoretical knowledge and associated inferences. Automatic inferences do not always lead to accurate causal theories. With increasing metacognition, including epistemic cognition, knowledge about matters of justification and truth increasingly guides and coordinates causal inferences. Causal reasoning develops throughout childhood and often beyond; the causal reasoning of adults, however, remains far from perfect (Inhelder & Piaget, 1958; Koslowski, 1996, 2013; Koslowski et al., 2008; Kuhn, 1989, 2005, 2009; Kuhn et al., 1988; Sandoval et al., 2014).

Causal reasoning, like logical reasoning, develops through the metacognitive awareness and control of inferences, including the application of epistemic cognition concerning scientific justification and empirical truth. Inference is elementary; automatic and intuitive inferences are important throughout people's lives. In the domain of science, as in the domain of logic, what develops is metacognitive self-regulation of inferences, including epistemic self-regulation on the basis of increasing knowledge about the nature of justification and truth.

## CONCLUSIONS

Much of cognition is automatic, intuitive, and practical. Thinking is deliberate and metacognitive, but it may nonetheless be entirely practical, aimed at overcoming an immediate problem. Only if people seek justification and truth does their thinking qualify as reasoning. Only on a foundation of epistemic cognition can humans reason.

Future research on reasoning faces the ongoing challenge of maintaining an epistemic perspective. Research on logical and causal reasoning must consider people's developing understanding of the epistemological basis for each, including the developing understanding of the distinction between them in conceptions of truth and justification. Epistemic development, moreover, occurs at both individual and societal levels, with ongoing interaction between these (Kitchener, 1986). The study of epistemic cognition and its development thus requires transdisciplinary perspectives.

An epistemological perspective on logical and causal reasoning has important practical applications, especially for education. It is not enough to get students to make the correct inferences. Educators must help them understand the epistemological bases for their inferences and for the resulting knowledge. Students must reflectively coordinate their inferences on the basis of their epistemic cognition. By doing so, they simultaneously engage in reasoning and contribute to the epistemic development that will improve their future reasoning. Ongoing efforts to engage students in active and broad-ranging inquiry and argumentation (Kuhn, 2005; Kuhn, Hemberger, & Khait, 2016; Sandoval et al., 2014) may be expected to promote epistemic cognition, including causal and logical reasoning.

## ACKNOWLEDGMENT

We are grateful to Barbara Koslowski and Jeff Greene for helpful comments on the manuscript.

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# 5

# THEORY OF MIND

*Beate Sodian and Susanne Kristen*

## INTRODUCTION

Theory of Mind is the ability to attribute mental states to oneself and others. Premack and Woodruff (1978) argued that such commonsense mentalism requires theoretical knowledge because mental states are unobservable and inferred like theoretical terms in the sciences. Mental state attribution improves the everyday explanations and predictions of human behavior, therefore the conceptual system underlying these attributions has the explanatory power of a theory. However, the term "theory" is often used loosely, in the sense of a coherent body of knowledge. Theory of Mind research has been an extraordinarily productive area of conceptual development since the 1980s (see Astington, Harris, & Olson, 1988; Baron-Cohen, Tager-Flusberg, & Cohen, 1994; Carpendale & Lewis, 2004; Flavell, 2000; Lewis & Mitchell, 1994; Perner, 1991; Sodian, 2005; Wellman, 1990, 2011, 2014 for books and review chapters).

The core concepts of commonsense mentalism are desires and beliefs (Bartsch & Wellman, 1995). Developmentally, desire reasoning precedes full belief-desire reasoning by about two years (Wellman, 2011). While 2- and 3-year-old children understand the relation between an agent's desire and an agent's action (e.g. that people who find their desired object will stop searching, whereas people who find another object will continue their search; Wellman & Wolley, 1990), only 4- to 5-year-old children understand that an agent's beliefs can be false and that agents act on their beliefs, not on the state of reality (Perner, 1991; Wimmer & Perner, 1983). Belief attribution involves an understanding of propositional attitudes. A propositional attitude indicates the psychological relation between an individual and the world. The key to false belief understanding is to recognize that propositions can be evaluated in different ways by different individuals (e.g. Maxi believes that the proposition "the chocolate is in the blue cupboard" is true, whereas I know that this proposition is false). Thus, false belief understanding requires an understanding of the representational relation between mind and world, that is, metarepresentation (Perner, 1991). In order to infer others' beliefs, one has to track their sources of information: Maxi, who was outside while his mother transferred the chocolate from the blue to the green cupboard, does not *know* where the chocolate is now, and falsely *believes* that it is still in its original location.

To understand another person's false belief one has to understand the causal relation between access to information and knowledge or belief. Thus, Theory of Mind research addresses the developmental origins of epistemic cognition.

While Theory of Mind research in the 1980s and 90s mainly focused on the acquisition of the concept of belief, and related concepts, in the age range between 3 and 6 years, recent research has increasingly addressed the origins of implicit epistemic concepts (e.g. the seeing–knowing relation, belief-based action prediction) in infancy. This chapter presents a brief overview of Theory of Mind development from infancy to the elementary school years, with a focus on children's developing understanding of knowledge and belief. Conceptually, Theory of Mind research is closely related to work in epistemic cognition (i.e. epistemological beliefs, personal epistemology), which concerns "the beliefs we hold about knowledge and knowing" (Hofer, 2002, p. 3; see also Chandler, Hallett, & Sokol, 2002). While Theory of Mind addresses the origins of epistemic concepts in young children, work on epistemic cognition tends to focus on explicit beliefs about epistemological issues (i.e. certainty and simplicity of knowledge) and their role in learning among older children, adolescents, and adults (Chinn, Buckland, & Samarapungavan, 2011; Greene, Azevedo, & Torney-Purta, 2008). To date, little research has explicitly addressed the relations between personal epistemology and Theory of Mind (Burr & Hofer, 2002).

## INFANCY AND TODDLERHOOD

The study of the origins of psychological reasoning in infancy has made major progress in the last 20 years (see Poulin-Dubois, Brooker, & Chow, 2009; Wellman, 2014 for reviews). Now there is solid evidence for the view that infants, in their first year of life, conceive of others' actions as intentional, in the sense that they represent actions in terms of relations between agents and their goals, rather than in terms of physical m ovements (see Woodward, 2009). Furthermore, recent research has revealed a remarkable ability in infants in the first and second years of life to keep track of what others have perceived or experienced at a given moment, and to form psychologically plausible action expectations based on their representations of others' goals and experiences. There is an ongoing debate about whether and to what extent these psychological reasoning abilities involve an understanding of epistemic states, that is, an understanding of the conditions for knowing (see Apperly & Butterfill 2009; Baillargeon, Scott, & He, 2010; Perner & Roessler, 2012; Sodian, 2011; Sodian (in press)).

### *Understanding Goals and Intentions*

Imagine a human hand reaching towards and grasping one of two toys. Do infants perceive this event in terms of spatiotemporal properties of movements of arms and hands or do they interpret it as a goal-directed action? Woodward (1998) habituated infants to a hand reaching to and grasping one of two toys. Then the locations of the two toys were switched and infants saw two types of test events. In the new goal event condition the hand reached to the old location and thus grasped the new toy, not the one it had grasped during habituation. In the old goal event condition the hand grasped the same toy as in habituation, but approached it by a different path, since it was in a new location. Five- and 9-month-old infants looked longer at the new goal event, indicating that they had encoded the event in terms of an action directed towards a goal and thus dishabituated more strongly to the novelty of the goal, rather than to the novelty of the motion path. Infants do not show this looking-time pattern when they see a mechanical rod or claw, instead of an agent approaching the goal-object, or when the action is ambiguous (Woodward, 2009), indicating that the findings cannot be explained by infants' low-level associations between agents and objects. Moreover, 7-month-old infants also show selective attention to others' goals in their own actions. When they see an adult reach toward one of two toys, they tend to subsequently select that toy themselves, whereas they choose randomly between the two toys if they see an adult direct an ambiguous back-of-hand touch toward the toy (Hamlin, Hallinan, & Woodward, 2008). Performance in the visual habituation task was found to be correlated with performance in the selective imitation task in 7-month-olds, independent of performance in a working memory task (Thoermer, Woodward, Sodian, Perst, & Kristen, 2013), indicating that a conceptual understanding of action goals underlies infants' performance on these superficially quite different tasks.

Evidence for an abstract, generalized representation of actions in terms of their goals comes from a large number of studies by Gergely et al. (1995), Csibra (2008), and their collaborators, indicating that infants from 6 months of age form teleological action representations, guided by the principle of efficiency. If infants are habituated, for instance, to an animated circle "jumping" over a barrier to reach its goal-object, they subsequently look longer at indirect (i.e. jumping) test events in test trials, once the barrier is removed, rather than direct (i.e. efficient, straight path) test events. Thus, infants are already able to form rational expectations (i.e. based on efficacy) in regard to human agents' action goals. This was not only shown for animated geometrical shapes, moving in an agent-like way, but also for videotaped human agents (Sodian, Schoeppner, & Metz, 2004).

Does infants' ability to infer action goals depend on having produced similar actions themselves? Sommerville et al. (2005) gave one group of 3-month-old (i.e. prereaching) infants practice with Velcro mittens immediately prior to a habituation session assessing their encoding of another agent's goal-directed reaching, while a control group received no such training. The infants in the training group showed a selective novelty response on goal change trials, while the control group did not, and there was a significant correlation between the extent to which infants in the training group engaged in object directed actions with the mittens and their selective response on goal-change trials in the habituation task. Skerry et al. (2013) found a similar training effect in prereaching infants, but also showed that infants exhibited expectations about action efficiency that went beyond what could be learned from the training, suggesting that some knowledge of goal-directed action precedes this first-person motoric experience.

Is infants' understanding of goal-directed action purely behavioral or does it indicate an understanding of mental states? There is ample evidence that infants take the intentional stance in the second year of life, distinguishing between accidental and intentional actions (Carpenter, Akhtar, & Tomasello, 1998; Olineck & Poulin-Dubois, 2005), and imitating the intended action after having observed a failed attempt (Meltzoff, 1995). But even 10- to 12-month-olds reason about the goal of a failed action (Brandone & Wellman, 2009), and 7-month-olds analyze the goals of uncompleted actions (Hamlin et al., 2008), indicating that infants, in the second half of the first year, make abstractions from specific, physical connections when inferring action goals. Moreover, they appear to understand goals as residing in the person, not as properties of events (Buresh & Woodward, 2007). By the age of 9 months, infants react differently in live social interaction with experimenters, depending on whether they are unwilling or unable to give infants a toy (Behne, Carpenter, Call, & Tomasello, 2005), and they positively evaluate those who have helped versus hindered third parties (Hamlin, Wynn, & Bloom, 2007). In fact, social evaluation processes have been demonstrated in infants as young as 3 months (Hamlin & Wynn, 2011). Hamlin et al. (2013) were able to rule out a number of lower-level (i.e. nonmentalistic) interpretations of 10-month-olds' social evaluations and conclude that social evaluation processes are driven by mental state attributions at that age.

In sum, there is evidence for goal representation in infants as young as 3 months, and for a mentalistic understanding of goals and intentions beginning in the second half of the first year of life. Furthermore, goal-encoding in infancy, from 6 to 12 months, has been shown in longitudinal studies to be continuous with Theory of Mind abilities between 4 and 5 years of age, independent of language abilities and IQ, thus suggesting a conceptual relation between infants' and preschoolers' psychological reasoning (Aschersleben, Hofer, & Jovanovic, 2008; Wellman, Lopez-Duran, LaBounty, & Hamilton, 2008).

### *Understanding Perception, Knowledge, and Belief*

When reasoning about an agent's goals, infants above the age of 6 months take into account what another person can and cannot see, thus demonstrating Level 1 visual perspective taking (i.e. children's understanding that another person does not see an object that they can see or vice versa; Luo & Johnson, 2009; Sodian, Thoermer, & Metz, 2007). By 12 to 14 months infants follow an adult's gaze around a barrier, coupled with visual checking back and forth to verify that the infant and the adult are seeing the same thing, which suggests that they have some understanding of the importance of the visual experience in joint attention (Dunphy-Lelii & Wellman, 2004; Moll & Tomasello, 2004). Meltzoff and Brooks (2008) gave 12- and 18-month-olds experience with blindfolds. After such experience they were less likely to gaze-follow a blindfolded adult, indicating that gaze following was guided by their sense of what an adult can see. Furthermore, 18-month-olds did follow a blindfolded adult when they were given experience with a special blindfold that looked opaque but was transparent when worn. Thus, by the age of 18 months it is most likely the sense of the agent's visual experience and not just overt eye or head directedness that controls gaze following.

Do infants understand the relation between seeing (i.e. witnessing an event) and knowing? In an early study, O'Neill (1996) found that toddlers communicated with their parents differently if the parent had or had not been present. For example, children specifically pointed to the relevant location much more if their mother had not witnessed the toy's original placement at that location than if she had been present, and they also provided more location specific verbalizations. More recently, a basic ability to track an agent's past engagement and to infer the agent's awareness was shown in infants as young as 12 months. Tomasello and Haberl (2003) presented 12- and 18-month-old infants with three unusual objects; an experimenter joined these interactions for two objects but not the third one. Later on, infants of both age groups gave the experimenter the toy that was new to the experimenter, showing some evidence for tracking the adult's experiences. Moll and Tomasello (2007) showed that infants determined what others knew, or had experienced, based on their interactions with them, not based on the adults's visual experience as onlookers alone. Furthermore, infants by the age of 12 months adapt their communicative behaviors to their partner's knowledge state (Liszkowski, Carpenter, Striano, & Tomasello, 2006; Liszkowski, Carpenter, & Tomasello, 2008).

While these findings are consistent with the idea that infants understand the relation between information access (e.g. visual perception, communication) and knowledge (e.g. of the contents of a box), very few studies have critically tested this claim. Dunham, Dunham, & O'Keefe (2000) studied 27- to 33-month-old children's ability to tailor their communicative behaviors to the knowledge state of their partner. An experimenter placed a desirable object (e.g. a sticker) into one of two opaque containers. The child was then required to ask for the parent's assistance in retrieving the object. In one condition, the parent covered her or his eyes during the hiding of the sticker (i.e. parent ignorant condition); in a second condition, the parent's eyes were open during the hiding of the sticker (i.e. parent knowledgeable condition); and in a third condition, the parent first covered her or his eyes but then opened them during the hiding of the sticker (i.e. sham ignorant condition). Children at both ages appropriately informed the parent by employing a pointing gesture more often in the parent ignorant condition than in the parent knowledgeable condition. However, the younger age group did not differentiate between the sham condition and the parent ignorant condition, thus failing to show an understanding of the seeing–knowing relation, whereas the older children appropriately gestured less in the sham condition than in the parent ignorant condition. Similarly, Sodian and Thoermer (2008) found that 16-month-olds did not differentiate in their looking times between ignorance and sham-ignorance conditions in which the agent was absent before or after a hiding event, but witnessed the event itself. Thus, infants and toddlers may be tracking knowledge-like experiences (Wellman, 2014), based on a representation of other agents' past engagement, rather than an analysis of the agents's access to information.

A similar argument can be advanced with respect to false belief understanding in infancy. In a pioneering study with 15-month-old infants, Onishi and Baillargeon (2005) used a violation-of-expectation paradigm to test for false belief understanding in infants. The procedure had a familiarization phase, a belief induction trial, and a test trial. In the familiarization phase, infants first saw an agent place an object in box A, and then reach for the object in box A on two subsequent trials. In the belief induction trial, the object was moved from box A to box B. In the false belief condition, the agent was unable to observe this transfer, while in the true belief condition the transfer was done in the agent's presence. In the test phase, the agent reached either into box A or box B without retrieving the object. An agent, who had been unable to watch the transfer, would be expected to reach for the object in box A, while an agent who saw the transfer would be expected to search in box B. Fifteen-month-olds' looking times indicated that they shared these expectations. They looked reliably longer (i.e. indicating a violation of expectation) at belief-incongruent outcome events, that is, a knowledgeable agent searching in box A, or an ignorant agent searching in box B, than at the corresponding belief-congruent outcome events. Since then, about 25 experimental studies have been published, using looking-time (Baillargeon et al., 2010), anticipatory looking (Southgate, Senju, & Csibra, 2007), and prompted action (Buttelmann, Carpenter, & Tomasello, 2009) methods, with findings indicating a remarkable sensitivity to agents' beliefs or belief-like states in infants at or below the age of 24 months (see Sodian, in press, for a review). However, only one study by Stack and Lewis (2011, as cited by Wellman, 2014, p. 191) employed a control condition for infants' understanding of belief formation. While the false belief condition was almost identical to the one employed by Onishi and Baillargeon (2005), the ignorance false positive condition showed an agent who was absent for an identical amount of time, but at a different, noncritical part of the transfer sequence. Since the agent was not ignorant in this condition in regard to the object location, infants should look equally long at the agent searching in either one of the two locations. However, infants' responses to the false belief and the ignorance false positive conditions were identical, indicating that infants may have been responding to the agent's engagement with the situation, not to his or her access to information. To gather more empirical evidence relevant to rich versus lower-level interpretations of infants' Theory of Mind, more studies employing such controls are necessary to determine the scope and limitations of infants' understanding of beliefs or belief-like states.

While rich interpretations of the infant false belief studies (Baillargeon et al., 2010) assume that infants possess a concept of belief that is masked in traditional (e.g. elicited response) tasks by processing demands (i.e. language, working memory, inhibition), leaner accounts distinguish between a fast and automatic "minimal" Theory of Mind (Butterfill & Apperly, 2013) in infancy, based on Level 1 perspective taking, and a later explicit Theory of Mind, characterized by an understanding of propositional attitudes. Infants' responses in looking-time and anticipatory looking tasks are explained by their ability to calculate an agent's behavior based on a representation of the facts that the agent registered (Apperly & Butterfill, 2009) or their ability to keep an "experiential record" of what an agent did and did not perceptually track, which is likely to be evoked upon the agent's return (Perner & Roessler, 2012). To date, one longitudinal study found evidence for conceptual continuity between implicit false belief understanding at 18 months in an anticipatory looking task and explicit false belief competence at 48 months, independently of IQ (Thoermer, Sodian, Vuori, Perst, & Kristen, 2012). This finding is compatible with both rich and leaner accounts of infant false belief understanding, but speaks against an extreme low-level account in terms of perceptual novelty (Heyes, 2014). In sum, a cautious interpretation of the infant findings is that infants do not yet possess true epistemic concepts, that is an understanding of the conditions for knowing (e.g. visual access or communication), but that their ability to track perspectives and to keep records of an agent's experience may facilitate the acquisition of epistemic concepts.

### *Mental State Language*

In the second year of life, children across languages and cultures acquire the verbal means to talk about their own and others's inner emotional and mental world, which is the first evidence for explicit mental state attribution (Bretherton & Beeghly, 1982). Their growing mental state vocabulary enables children to engage in meaningful conversations with others, which in turn, fuel their comprehension of the underlying mental concepts (Harris, de Rosnay, & Pons, 2005; Olineck & Poulin-Dubois, 2007). In support of a stepwise development across cultures and languages in regard to the developmental trajectory of mental state language, there seem to be more cross-lingustic developmental consistencies than differences. When compared to children's vocabulary for emotions and desires, there seems to be a cross-linguistic developmental delay in children's development of a vocabulary for thoughts and beliefs (e.g. Kristen et al., 2014). More specifically, while at as early as 18 months children have acquired a differentiated vocabulary for negative emotions (e.g. “sad”), their references to epistemic states such as “knowing” and “thinking” do not become more diverse until around 30 months of age (e.g. Kristen, Sodian, Licata, Thoermer, & Poulin-Dubois, 2012). Further, Bartsch and Wellman (1995) found that at around 2 years of age, children first primarily refer to their own and others’ desires and emotions (“I like something and you don’t”), while they come to contrast their own and others’ thoughts and beliefs considerably later, at around 3 to 4 years of age. Finally, while preschoolers’ production of epistemic terms is related to their comprehension of the underlying concepts, it is not before 4 to 5 years of age that children come to understand the difference between “know,” “think,” and “guess” (Moore, Furrow, Chiasson, & Patriquin, 1994).

Given that recent infant research has suggested an earlier onset of mental state understanding than was previously thought, Harris (2014) reanalyzed the speech samples used by Bartsch and Wellman (1995) and found that at as early as 2 years of age children begin to show first, but limited, explicit signs of an understanding of knowledge and belief. Toddlers comment upon knowing certain things, and not knowing others, and they also comment about the knowledge and ignorance of a conversational partner. However, 2-year-olds do not appear to contrast their own knowledge with that of a conversational partner or their own past ignorance or false belief with their newly acquired knowledge. Also, they do not seem to comment on the sources of their knowledge. The third year of life is an important transitional period between an implicit and an explicit Theory of Mind and toddlers’ productive and receptive understanding of mental state language deserves further attention.

## THREE TO SIX YEARS

Children have been theorized to progress through the following developmental sequence between 3 and about 6 years of age (Wellman & Liu, 2004): Diverse Desires (i.e. one person can like something, whereas the other person does not like it; average age of mastery: 3.5 years), Diverse Beliefs (i.e. people can have different beliefs about the same situation; average age of mastery: 4.0 years), Knowledge Access (i.e. people may not know something because they do not have access to information; average age of mastery: 3.9 years), False Belief (i.e. another person may have a belief about a state of affairs that the participant knows to be false; average age of mastery: 4.6 years), and Hidden Emotion (i.e. someone can feel a certain way, but hide this emotion and thereby induce a false belief in another person; average age of mastery: 5.4 years). This theory has been tested with a Theory of Mind scale (Wellman & Liu, 2004) and the tasks were found to form a strict Guttman scale, with more than 80 percent of the children conforming to the canonical order. Further empirical results have shown that the same developmental sequence as found in the United States was observed in Australia (Peterson, Wellman, & Liu, 2005) and in Germany (Kristen, Thoermer, Hofer, Aschersleben, & Sodian, 2006). A similar developmental sequence, with Knowledge Access preceding Diverse Beliefs, was found in China (Wellman, Fang, Liu, Zhu, & Liu, 2006), and Iran (Shahaeian, Peterson, Slaughter, & Wellman, 2011). Moreover, longitudinal research has not only indicated that early concepts precede later concepts, but also that individual differences in the mastery of earlier concepts predict individual differences in the mastery of later concepts (Wellman, Fang, & Peterson, 2011).

### *Knowledge*

The research reported in this section is most directly relevant to the early development of epistemic cognition. When do children begin to explicitly understand the relation between access to information and knowledge? In simple forced choice paradigms, such as the Knowledge Access task of the Theory of Mind scale, children associate informational access with knowledge and lack of informational access with ignorance (Pratt & Bryant, 1990) by the age of 3 years. Similarly, children master a choice task that avoids the use of epistemic language (i.e. "Who can help you find the sticker?" with the choice being between a person who saw it being hidden and a person who did not see the hiding event) only around the age of 3 years, whereas 2-year-olds pass a parallel nonepistemic choice task (Sodian, Thoermer, & Dietrich, 2006). However, typically only 4-year-olds respond correctly to "How do you know?" questions (Wimmer, Hogrefe, & Perner, 1988), although 3-year-olds are able to answer parallel "Why?" questions about nonepistemic internal states, such as the causes of being hungry (Perner & Ogden, 1988). Four-year-olds understand that knowledge can be acquired through perception and verbal communication. However, like 3-year-olds, they often fail to distinguish between the kinds of information acquired through different sensory modalities that leads to knowledge about different object properties (e.g. that touching an object leads to knowledge about its texture, whereas seeing an object leads to knowledge about its color; O'Neill, Astington, & Flavell, 1992). These tasks are very similar to tasks used to assess epistemic cognition by Burr and Hofer (2002).

Furthermore, 3- and 4-year-olds have difficulty distinguishing between knowledge that they acquired through communication with others, and self-generated knowledge acquired by perceptual access or inferential reasoning (Gopnik & Graf, 1988). Marked improvement in free recall as well as in source monitoring, and decreased suggestibility, have been related to children's conceptual understanding of sources of knowledge (Perner, 2000). Although preschoolers can memorize facts, they often fail to represent the temporal and situational context features of learning events; only around the age of 5 years do children retrieve such context information correctly, whereas younger children often claim that they knew the facts they were taught during the experiment all along (Taylor, Esbensen, & Bennett, 1994).

Once children understand the causal relation between information access and knowledge in principle, they still have marked difficulty with understanding cases of partial information. Recent research by Rohwer et al. (2012) on children's metacognitive understanding of their own ignorance has shown that children below the age of 5 years have difficulty assessing their own epistemic state when exposed to partial information (e.g. when presented with two objects, one of which was subsequently hidden in a box). While even 3-year-olds were able to assess their own ignorance when presented with *no* information, and their own knowledge when presented with *full* information, only children above the age of 5 years passed the *partial* ignorance task. One interpretation of this finding is that young children rely on a feeling of competence, generated through their access to some relevant information, when answering the knowledge assessment question. In contrast, few 4-year-olds, and no 5- and 6-year-olds, committed such an error in conditions where *another* person had access to partial information (Pillow, Hill, Boyce, & Stein, 2000; Sodian & Wimmer, 1987).

When judging *others'* knowledge, however, 4- and 5-year-old children employ the oversimplified rule that people know a fact if and only if they had direct perceptual or communicative access to that fact, thereby neglecting inference as a source of knowledge (Ruffman, 1996; Sodian & Wimmer, 1987). While children themselves can generate a response by drawing the relevant inference and thereby assess themselves as knowledgeable even when lacking direct perceptual access to information, children below the age of 6 years do not attribute inferentially acquired knowledge to others.

In sum, these findings indicate that young children's epistemological understanding is limited, both with respect to assessing their own and others' knowledge, even after they have mastered simple knowledge-access and false-belief tasks. This conclusion is also supported by findings from the literature on children's trust in testimony and their choice of informants. Even 4- and 5-year-olds monitor an informant's access to information. Thereby, they prefer a knowledgeable informant to an ignorant one and trust previously inaccurate informants if their inaccuracies stem from ignorance or false beliefs, rather than dishonesty or other negative personality traits (Nurmsoo & Robinson, 2009). However, only children above the age of 5 years old selectively attribute knowledge to a negative-trait protagonist (e.g. a "mean" puppet) if this character had access to information, whereas younger children attribute knowledge to a "nice" protagonist even in the absence of access to information, and subsequently endorse the nice protagonist's testimony, while ignoring the "mean" character's (Lane, Wellman, & Gelman, 2013). Furthermore, while young children understand in principle that one should choose a knowledgeable informant to learn from, only 7- to 8-year-olds appear to understand that an ignorant, rather than a knowledgeable character, ought to be taught (Kim & Spelke, 2013). The implications of this research for the development of epistemological beliefs have not yet been explicitly addressed.

### *False Belief*

The ability to distinguish beliefs from reality is seen as the litmus test for a Theory of Mind, because a false belief is a misrepresentation of reality. Therefore, an understanding of false belief indicates the ability to reason about mental constructs independently of reality. In the first systematic investigation of children's understanding of false belief, Wimmer and Perner (1983) found that 40 percent of 4-year-olds and 90 percent of 6- and 7-year-old children correctly predicted a story protagonist's action based on his or her false belief. Importantly, when the protagonist's informational access, or lack thereof, was made salient, even 50 percent of the older 3-year-olds gave belief-based answers to the test question. However, children below the age of 3.5 years did not benefit from the salience of information access.

Since this pioneering study, many attempts have been made to reduce the information processing demands of false belief tasks, and to demonstrate explicit false belief understanding in 3-year-olds and younger children (see Sodian, 2005, for a review). A metaanalysis of more than 500 studies of false belief understanding in young children by Wellman et al. (2001) clearly showed that despite facilitating effects of several task manipulations, there is a robust developmental trend in false belief understanding: while 2.5- and young 3-year-old children tend to give reality-based responses, an increase in the proportion of correct (i.e. belief-based) answers is found above the age of 3.5 years. This developmental trend was independent of whether the test question referred to mental states or to behavior, or whether the protagonist was a story figure, a person in a video, a doll, a child, or an adult. These findings clearly support the view that an explicit understanding of false belief develops as a result of conceptual restructuring. Interestingly, the onset of false belief competence on the behavioral level is related to a specific pattern of neural activation that is not found in same-aged children who fail the false belief task (Liu, Sabbagh, Gehring, & Wellman, 2009).

However, the recent demonstrations of implicit false belief understanding in infancy have refueled the debate about conceptual continuity or conceptual change in the development of false belief understanding. Rubio-Fernandez and Geurts (2012) recently found competence in young 3-year-olds in a verbal false belief task that carefully avoided disruptions in perspective tracking, and Setoh et al. (2011) reported success with 2.5-year-olds in a low-demand elicited response task. These findings have been taken to indicate conceptual continuity in false belief understanding from infancy to the preschool years, with 2- and 3-year-olds' competence being masked, due to task demands, in traditional false belief tasks (Baillargeon et al., 2010). It should be noted, however, that success on false belief tasks in children below the age of 4 years is exclusively based on Level 1 perspective taking (i.e. understanding that another person can see something that one cannot see, and vice versa). One study of false belief understanding in infancy involving Level 2 perspective taking (i.e. understanding that people can differ in *how* they perceive an object or event) by Scott and Baillargeon (2009) has been criticized on the grounds that infants can solve the task based on Level 1 understanding (Butterfill & Apperly, 2013).

Level 2 perspective taking is conceptually related to false belief understanding because it involves an understanding of mental representation (Perner, 1991). Similarly, the appearance–reality distinction requires metarepresentational understanding, and is closely related to the development of belief understanding around the age of 4 years (Flavell, Flavell, Flavell, & Green, 1987; Slaughter & Gopnik, 1996). It has been argued that pretend play is also a metarepresentational activity, but develops much earlier, around the age of 2 years (Leslie, 1994). However, understanding another person's false belief requires an understanding that the other person misrepresents reality, whereas pretend play merely requires the child to distinguish between reality and fiction, rather than representing the representational relation between the two (Perner, 1991). Recent research on the neural underpinnings of pretense and false belief in adults and children has indicated that pretense and false belief reasoning are subserved by distinct neurocognitive mechanisms, thus supporting the view that these are not functionally equivalent metarepresentational activities (Kühn-Popp, Sodian, Sommer, Döhnel, & Meinhardt, 2013; Meinhardt, Kühn-Popp, Sommer, & Sodian, 2012).

One argument against the view that false belief understanding emerges around the age of 4 years as part of one's coherent conceptual understanding of the representational mind is that a full or explicit understanding of mental representation is acquired much later than first-order false belief understanding. Even 6-year-olds have a limited understanding of knowledge representation in the human mind, because they fail to understand aspectuality, or referential opacity (Apperly & Robinson, 2003; Hulme, Mitchell, & Wood, 2003), that is, they tend to believe that a person who knows a description X of an object also knows the object under the description Y (e.g. if Max knows that his dog barked at a postman and the postman is 35 years old, young children would tend to assume that Max knows that his dog barked at a 35-year-old man). However, a recent study by Rakoczy et al. (2015) showed that 4-year-olds can understand aspectuality in a simplified task and that this ability is highly correlated with performance in the false belief task, thus supporting the view of a unified conceptual capacity emerging around the age of 4 years.

Is Theory of Mind development driven by domain-specific mechanisms of conceptual change or is it driven by more general cognitive changes occurring in the same age range? Close relations have been found between language and Theory of Mind development (Astington & Baird, 2005), as well as between executive functions, especially inhibitory control, and Theory of Mind (Perner & Lang, 2002). It is unlikely that these relationships merely reflect task demands, because similar associations have been found for nonverbal Theory of Mind tasks and for Theory of Mind tasks with varying executive demands (see Sodian, 2005). Rather, shared conceptual abilities may underlie the observed relationships. de Villiers and de Villiers (2000) proposed that linguistic complement structures (i.e. complement syntax, as in "Paul say, the key is in the box") form the general representational structure for an understanding of embedded propositions such as "Max believes that the chocolate is in the cupboard." Moses et al. (2005) have argued for a conceptual relation between executive functions and Theory of Mind. Bischof-Köhler (2000) proposed that the notion of a frame of reference (i.e. the child's developing ability to reflect on frames of reference) is the general metarepresentational ability that underlies Theory of Mind development, as well as related changes in other domains, such as time representation, which, in turn, enables action planning. Recently, Perner et al. (2011) tested a theory about shared conceptual abilities between belief and identity, arguing that both understanding belief and understanding identity statements depend on the common ability to separate sense from reference. They showed that both capacities emerge between 3 and 5 years of age and are interrelated. Thus, there is support for the view that deep conceptual structures underlie metarepresentational development.

## SECOND ORDER AND ADVANCED THEORY OF MIND

While first-order false belief reasoning is reasoning about someone's belief about a state of the world, second-order false belief reasoning concerns A's beliefs about B's belief about a state of the world. Perner and Wimmer (1985) found competence in second-order false belief attribution only in 7- to 8-year-old children, whereas Sullivan et al. (1994) found evidence of second-order false belief attribution with simplified tasks with 5- and 6-year-olds. Nonetheless, first-order reasoning precedes second-order reasoning developmentally. There is an ongoing debate about whether second-order Theory of Mind reasoning involves conceptual change or whether its complexity, compared to first-order Theory of Mind reasoning, just requires more cognitive resources (see Miller, 2009, for a review).

Second-order mental state understanding is necessary for understanding complex speech acts, such as irony, which, like a lie, is an intentionally false utterance. But irony differs from a lie in that the speaker does not intend the listener to believe it. There is protracted development in understanding the social cognitive aspects of irony. While 7-year-olds achieve a basic understanding of the speaker's intention, even 9-year-olds do not reach adults' level of understanding (Filippova & Astington, 2010). Assessment procedures for the study of second-order Theory of Mind reasoning have been developed primarily in autism research and include various types of nonliteral speech, such as sarcasm, white lies, metaphors (Happé 1994; Kaland et al., 2002), cases of faux pas in which the participant is supposed to identify and explain (Baron-Cohen, Ring, Wheelwright, Bullmore, Brammer, Simmons, & Williams, 1999), and measures of empathic role taking and conceptual perspective taking in ambiguous social situations

(Bosacki & Astington, 1999). In all of these tasks, developmental progress has been found in elementary and secondary school-aged children.

Higher-order perspective taking is related to a deepened metaconceptual understanding of the knowing process (Carpendale & Chandler, 1996). While 4-year-olds understand that misinterpretation arises from insufficient information (Perner & Davies, 1991), young elementary school children begin to understand interpretive diversity in everyday situations such as cases of social prejudices or stereotypes in the classroom (Pillow, 1991, Pillow & Weed, 1995). Similarly, 7- to 10-year-old children are able to conceive of alternatives to their own theory about a complex social phenomenon such as aggression in children (Sodian & Barchfeld, 2011), which indicates that their epistemological stance is not profoundly absolutist; however, they are extrememly poor at generating evidence relevant to evaluating their own or an alternative causal theory (see Kuhn, 1991; 2001). The view that children of elementary school age possess some understanding of mental construction and interpretation is also supported by Flavell et al.'s (1995) research on children's understanding of mental activity: while preschoolers conceived of thinking as a momentary activity that is under voluntary control, 8-year-olds articulated the idea of a continuous and partly uncontrollable mental activity, in the sense of a stream of consciousness. In sum, Theory of Mind research has indicated a higher level of epistemological understanding at elementary school age than other research traditions in the field (see Chandler et al., 2002 for a review of conflicting descriptions of epistemological development). However, the processes of conceptual change occurring in epistemological concepts from preschool age to adulthood are poorly understood.

Is advanced Theory of Mind a coherent conceptual structure? Very little research has addressed this issue, and findings are conflicting and hard to interpret because they were gathered in atypical populations (e.g. Meristo, Falkman, Hjelmquist, Tedoldi, Surian, & Siegal, 2007; Sobel, Capps, & Gopnik, 2005). Some evidence for conceptual coherence in typically developing children's advanced Theory of Mind comes from studies showing theoretically expected links between second-order belief understanding and scientific reasoning (Astington, Pelletier, & Homer, 2002), between Theory of Mind and metamemory (Lockl & Schneider, 2007), between mental state knowledge and metaknowledge about reading (Lecce, Zocchi, Pagnin, Palladino, & Taumoepeau, 2010), and, in the social cognitive domain, between second-order belief understanding and reasoning about display rules (Naito & Seki, 2009). However, advanced Theory of Mind is unlikely to be unidimensional. In a paper-and pencil assessment of a large sample of 8- to 10-year-old children on higher-order false belief understanding, social understanding, emotion recognition, and perspective-taking abilities, Osterhaus et al. (2014) found evidence for three distinct factors underlying advanced Theory of Mind reasoning: social monitoring, social reasoning, and metaconceptual understanding of the knowing process (i.e. epistemological understanding). Further research is needed to better understand the interplay between epistemological and social understanding in advanced Theory of Mind development.

## CONCLUSIONS

Humans' capacity for mental state attribution develops earlier than was previously thought: infants take the intentional stance by the end of the first year of life, and by tracking others' perspective they arrive at representations of what others experienced.

There is an ongoing debate about whether these "experiential records" (Perner & Roessler, 2012) reflect an implicit knowledge of epistemic states. Consequently, it is controversial whether an explicit, verbal understanding of epistemic states at preschool age is conceptually continuous with infants' implicit understanding or whether an explicit Theory of Mind emerges as a result of conceptual change processes. Microgenetic research testing for implicit and explicit skills within the same children and training studies are needed to shed light on the exact nature of these developmental mechanisms. Progress has been made in characterizing the conceptual structures underlying a representational Theory of Mind. These may not be narrowly domain specific, but shared with other domains that share deep conceptual structures with Theory of Mind. With respect to epistemic cognition, Theory of Mind research has found evidence of a constructivist understanding of the mind as an active interpreter of information in the preschool and early elementary school years, which is considerably earlier than most theories of epistemological development suggest. Thus, Theory of Mind research provides exciting new perspectives for research on the development of epistemic cognition.

## ACKNOWLEDGMENT

Preparation of the present chapter was supported by grant number DFG SO 213/27-2, 3.

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# 6

# SOCIAL COGNITION

*Fabrice Clément*



## THE MULTIPLE MEANINGS OF SOCIAL COGNITION

"Social cognition" is a term that is employed without much precaution in psychology even though it is used to mean different things. The first definition refers to the cognitive processes involved in the understanding of other people, social relations, and social institutions, as distinct from cognition about biological, physical, or logico-mathematical entities. Most often, this kind of social cognition is reduced to the inferences performed about others' mental states (i.e. desires, beliefs), notably to anticipate and interpret their behaviours. This perspective is usually associated with Theory of Mind or Folk Psychology, i.e. "the construal of persons as psychological beings, interactors, and selves" (Wellman, Cross, & Watson, 2001, p. 655). This view has recently been questioned because it is more and more accepted that, besides this "mentalizing" strategy, there is also room for a more sociological understanding of other people (Clément, Bernard, & Kaufmann, 2011; Hirschfeld, 2001; Kaufmann & Clément, 2014; Spelke & Kinzler, 2007). By detecting hierarchical relationships, for instance, social observers can anticipate how a social interaction is most likely to unfold (Charafeddine et al., 2015; Cummins, 1996; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011).

This first sense of social cognition is therefore cognition *about* the social (i.e. persons and social entities) and it should not be confused with two other meanings. Social cognition can also refer to the knowledge obtained *via* others (i.e. persons or institutions). Social epistemologists tend to call this acquisition process *testimony* (Chinn, Buckland, & Samarapungavan, 2011; Coady, 1995; Fricker, 1995), a term that is now widely used in developmental psychology since the pioneering work of Paul Harris and colleagues (Clément, 2010; Harris, 2002, 2012; Koenig, Clément, & Harris, 2004). Finally, social cognition can also be understood as the knowledge acquired thanks to a collective process of *reasoning in a group* (Moshman, 1998).

The primary goal of this chapter is to show that social cognition, which appears to be an oxymoron (i.e. cognition being, as a product of the brain, fundamentally individual), is indeed a pleonasm, because no form of knowledge can be devoid of a social dimension. It will also be shown that, from a developmental perspective, the influence of the social environment on epistemology takes the form of a progressive awareness of the normative procedures linked with knowledge acquisition. In other words, it is very likely that learners do not initially possess epistemic beliefs (Schommer-Aikins, 2002), but instead that they possess epistemic *cognitions*: in a first step, children's control of the informational acquisition process is mainly procedural and they are not yet able to think reflexively about how knowledge is, or ought to be, acquired. With experience and more contact with different sources of knowledge, they progressively develop a more reflexive understanding of the different processes, individual or collective, involved in the acquisition of justified information. In a sense, students are endowed from a very early age with what could be called a *naïve epistemology*; with time, this competence develops into a more sophisticated and explicit set of *epistemic beliefs*, which may also be influenced by the cultural form of thinking about knowledge acquisition and justification (i.e. *folk epistemologies*).

## THE SOCIAL DIMENSION OF INDIVIDUAL COGNITION

Including a chapter on social cognition in a handbook on epistemic cognition may seem paradoxical. Epistemic cognition is generally considered as a "personal matter," as an individual quest towards finer and more justified beliefs (Stein, 1996). As cognition is understood to be an inferential process, because it goes "beyond the information given," as in the title of Jerome Bruner's (1973) famous book, epistemic cognition tends to be understood as an individual endeavour, a path to improving coordinated and reflexive inferences (Moshman, 1998). In a nutshell, epistemic cognition is often described as the main path from inherited preconceptions to knowledge and a way to achieve, thanks to critical thinking, better control of one's life (Kuhn, 1999). From this perspective, it is hard to see how something "social" could be of any use to these essentially reflexive cognitive processes.

Of course, it is hard to deny that at least some of people's knowledge originates from their social environment. The human species is characterized by a very long maturation and, without constant care from their significant others, it would be impossible for humans to become adults. As children are embedded within speaking communities, which share norms, values, and beliefs, at least part of this heritage is transmitted from generation to generation. However, even if that fact of nature is acknowledged, such inherited information is often not recognized as true knowledge. The founder of child psychology, Jean Piaget, insisted for instance on the fact that it is not because young children can reproduce a number sequence correctly that they understand quantity; in a way, they could be compared to parrots, able to mimic sounds without any conceptual hold on what they refer to (Harris, 2012).

Since Piaget, the way scholars have conceived of children's understanding has considerably changed. To continue using the same example, it is increasingly accepted that even 3-month-olds have some understanding of small numbers, or a "naive arithmetic" (Simon, Hespos, & Rochat, 1995; Spelke, 2000; Wynn, 1992). Indeed, numerous researchers have shown that infants build knowledge very early and spontaneously, not only about small numbers but also about their physical environment (i.e. naïve physics; Baillargeon, 1987; Spelke, 1994), about living beings (i.e. naïve biology; Atran, 1998; Springer & Keil, 1998), about others' mental states (i.e. naïve psychology; Baron-Cohen, Leslie, & Frith, 1985; Wellman, 1990), about rules of welfare and justice (i.e. naïve morality; Nucci, 2001; Turiel, 1983), and about social entities such as social groups, norms, and relationships (i.e. naïve sociology; Cummins, 1999; Hirschfeld, 1995, 2001; Jackendoff, 1994; Kaufmann & Clément, 2014). Of course, this knowledge is not reflective, but the surprise displayed by infants when one of the rules belonging to one of these different domains is violated constitutes proof that their cognitive system is already making inferences and predictions about *what should happen* in these different environments (Baillargeon, Scott, & He, 2010). However, children are dependent on adults for the acquisition of many beliefs. For instance, how could they learn by themselves that the Earth is round, that germs cause illness, or that thoughts are dependent on brain activity (Clément, 2010; Harris, 2012)? But does this imply that these beliefs that they acquire from others, these *testimonies* that they subsequently take for granted, are not justified and that they cannot be considered as knowledge?

From an epistemological perspective, where a mental representation can be considered as knowledge if and only if it is (1) justified, (2) true, and (3) believed by the person (Greene, Azevedo, & Torney-Purta, 2008), both naïve theories and testimonies seem to be beyond the scope of justified and true beliefs that are socially transmitted. On the one hand, core knowledge (e.g. expecting that objects maintain their identity through time) appears to emerge from encounters between individual modular cognitive systems and their environments, which are not dependent on others' teaching (Hirschfeld & Gelman, 1994). In other words, it does not seem to be a matter of *social* cognition. On the other hand, testimonies rely on the transfer of knowledge, the reliability of which does not rely on the receiver; in this sense, testimony would not qualify as social *cognition* either.

My objectives on the following pages are to show that (1) even the cognitive operations underlying the acquisition of core knowledge have a *social* dimension, and (2) the acquisition of knowledge via testimony involves, from a very young age, *cognitive* operations in order to "filter" the incoming information.

## THE SOCIAL DIMENSIONS OF CORE KNOWLEDGE

The research on core knowledge systems has predominantly focused on the internal mechanisms that enable infants to represent and make sense of ecologically relevant entities and events (Spelke, 2000). However, even if humans are genetically "equipped" to process certain kinds of information and generate specific inferences, this process does not happen in a social void. First of all, these systems need inputs to function and, given the state of children's helplessness, the stimulation required to activate their potential capabilities would be limited to what happens in close proximity. Fortunately for them, babies are not only fed but also "transported" to many different sites and confronted with numerous situations by their caregivers. This social support enables them to accumulate sufficient elements to train their competences and develop representations about the different domains that are specific to their environment (Carey & Spelke, 1996).

However, the importance of others in the development of naïve theories is not limited to this basic "life support." In particular, adults do not interact with these very young learners as they do with their peers. Brand and her colleagues (2002) showed, for instance, that mothers' demonstrations to infants, compared to demonstrations to adults, are higher in interactiveness, enthusiasm, repetitiveness, and simplicity (i.e. *motherese*). More recently, Csibra and Gergely (2009) even proposed a *natural pedagogy* hypothesis, stating that humans have so much general knowledge to acquire from bits of episodic information that infants are able to rapidly generalize a piece of information proposed ostensively by experts, and that experts are prone to ostensively communicate information that is generalizable.

Moreover, the development of knowledge is not linear and solipsistic. As Piaget has already shown, some notions are not easy to assimilate (Piaget, 1937), and social interactions with individuals that have already mastered a notion or an ability can be crucial. This is notably the case when core knowledge produces predictions that differ from what is factually deducible. In such cases, children progress faster when they are confronted with other children exhibiting different cognitive strategies (Doise, Mugny, & Perret-Clermont, 1975; Perret-Clermont, 1980). A classical example is liquid conservation, a task that has often been used to trigger a socio-cognitive conflict by putting a child who already masters liquid conservation in the company of a child who does not. In these interactional contexts, "the subject comes to reorganize and restructure cognitions as a result of confrontation with opposing points of view" (Bell, Grossen, & Perret-Clermont, 1985, p. 42).

More recently, the idea that knowledge is a personal endeavour obtained by progressively refined coordination of inferences and by the improvement of reasoning abilities has been challenged by a radical perspective whose nature is fundamentally *social*. This new perspective demonstrates that the goal of reasoning, individually or collectively, is not to improve knowledge and make better decisions, but rather that its function is argumentative and that it has been designed by evolution to persuade others or to avoid being manipulated by others (Mercier & Sperber, 2011). This hypothesis, which could be considered an "epistemic sacrilege" because it attacks the traditional association between truth and reasoning, seems to account for a wide range of poor rational performances that have always been problematic for more standard theories. The plausibility of this idea again underlines how the improvement of knowledge is embedded in interactional social contexts, as is more and more accepted by social epistemologists (Goldman, 1999).

In summary, even if it is taken for granted that there are some parts of knowledge acquisition that rely on systems of core knowledge with principles that enable people to individuate and support inferences of certain kinds of entities (Spelke & Kinzler, 2007), this does not mean that these processes are devoid of any social dimension. Without others, (1) newborns would never be able to access the information necessary to trigger their naive theories, (2) children would not make important epistemic progress when confronted with others' opinions, and (3) individuals would not benefit from the refinement of knowledge through argumentation.

## THE COGNITIVE DIMENSION OF SOCIALLY ACQUIRED KNOWLEDGE

After insisting on the *social* dimension of personally acquired knowledge, it is important to insist on the *cognitive* aspect of socially acquired knowledge. A very important part of what people consider to be true has not been acquired through personal observations or inferences, but by testimony. Indeed, the importance of others' inputs in knowledge acquisition is now realized by philosophers. Social epistemologists admit that their discipline has long been "individualistic, focusing on mental operations of cognitive agents in isolation or abstraction from other persons" (Goldman, 1999, p. 4). In fact, even the more sophisticated discoveries of science are dependent on a refined division of cognitive labour where trust in others is absolutely essential (Kitcher, 1995). From a cognitive point of view, the difficulty is to assess the way people incorporate others' testimony in their own knowledge. In philosophy, this debate is known as the conflict between *reductionists*, who think testimony by itself is not sufficient to legitimate any acquired knowledge (Fricker, 1995), and *non-reductionists*, who claim that beliefs acquired merely on the basis of a speaker's testimony can be justified without other positive reasons (Burge, 1993; Coady, 1995; Goldman, 1999). Developmental psychology could play an important role in this debate. If children are, from the beginning, like the parrots that Piaget talked about, simply repeating what someone told them without any understanding of its content, it would indeed be hard to describe such information as "knowledge." However, if people have, from an early age, some cognitive means to filter the communicated information, then it may be appropriate to describe such acquisition as "epistemic" in nature (Clément, 2010).

Recent research in developmental psychology seems to indicate that even young children are not passive when confronted with others' testimony; a sort of "filtering" of communicated information seems to be in place even at a very young age, enabling children to evaluate the epistemic qualities of their sources (Sperber, 2001). This is compatible with what is called the "epistemic vigilance hypothesis," based on the nature of communicated information (Sperber et al., 2010). Communication is extremely important for humans as it serves to enrich their knowledge about relevant aspects of their environment without incurring the risks associated with perceptual acquisition of information. In a way, language and communication enable people to "have more eyes to see" (Quine & Ullman, 1978, p. 50). However, the risk of getting deceived, intentionally or not, is particularly high. This is notably the case because the interests of others and people's own interests do not always coincide. Indeed, in a variety of situations, people's interests are best served by misleading or deceiving others. For the communication to remain advantageous, it is therefore crucial that people do not indiscriminately accept everything that they are told.

Evidence of such basic filtering mechanisms has been highlighted by developmental research on *testimony*. Contrary to what would have been expected if children were completely credulous, it has been shown that they choose their informants according to multiple criteria based on properties of the source and of the message (Clément, Koenig, & Harris, 2004; Harris, 2012). For instance, when preschoolers could choose between two informants, of whom one has been unreliable in the past, 4-year-olds, and sometimes even 3-year-olds, were able to put their trust in the more reliable source. This was particularly true when one of the informants constantly gave wrong labels for known objects; when children had to decide who was giving the right name for unknown objects, they chose the source which had previously been reliable (Jaswal & Neely, 2006; Koenig et al., 2004; Koenig & Harris, 2005). Moreover, this epistemic preference is stable across time: one week after having observed that one informant was more reliable than another, 3- and 4-year-olds were more likely to trust the source that had been reliable in the past (Corriveau & Harris, 2009).

Preschoolers are also able to evaluate which of two informants has better access to certain information. For instance, when 3-year-olds observed that one source had perceptual access to a given content, while the other source did not, they were able say who was the better informed (Pillow, 1989; Robinson, Champion, & Mitchell, 1999). Some research seems to indicate that even younger children are able to discriminate between informants. For instance, experiments related to social referencing showed that 12- to 18-month-olds were influenced by the relevant emotional reaction of an adult who could see the same ambiguous toy as the infant, but not by the emotional reaction of an adult who could not see the toy (Moses, Baldwin, Rosicky, & Tidball, 2001). More recently, it has been shown that even 8-month-olds who were familiarized with two female faces, one systematically looking at a box which happened to contain something interesting (i.e. an animation), the other at a box which contained an animation only 25 percent of the time, trusted the reliable face more (Tummeltshammer, Wu, Sobel, & Kirkham, 2014).

In summary, when children do not have any prior information about certain states of the world, they are prone to evaluate who, between conflicting informants, is better informed, and they have more faith in such reliable sources.

The level of agreement triggered by a statement is another important cue when it comes to making a decision about whom to trust. Here again, it has been shown that even young children are able to take this kind of epistemic cue into account. For instance, when two adult bystanders consistently signalled assent (i.e. via nods and smiles) to the claims of one informant, and dissent (i.e. via head shakes and frowns) from the claims of the other informant, 4-year-olds subsequently trusted the informant who had received more bystander assents (Fusaro & Harris, 2008). Even younger children are able to use adults' nonverbal expression of agreement and disagreement with a speaker's claims. In Fusaro and Harris's (2013) study, 24-month-olds observed an adult nodding or shaking his head after two conflicting statements about the location or identity of an object by a speaker; the children were then able to use this cue to infer the correct name and location of the object.

Even without any sign of confirmation from an audience, detecting which direction a majority is "leaning towards" is often a good way to choose between conflicting statements. Interestingly, children take into account consensus when they have to evaluate contradictory statements. For instance, when 3- and 4-year-olds were shown unfamiliar objects and had to decide which one was the "modi" (i.e. an invented label), they chose the object that had been pointed at by three adults, and not the one pointed at by only one adult (Corriveau, Fusaro, & Harris, 2009). Even 2-year-old children give priority to information delivered by a consensus. When they had to decide how to use an unknown box to get a reward, they were more likely to imitate three demonstrators doing one action than a single demonstrator doing the same action three times (Haun, Rekers, & Tomasello, 2012). The level of consensus is therefore an important dimension that is detected by children early in their development, and is used to evaluate the epistemic reliability of a claim.

In the absence of any direct evidence about the level of informativeness or unanimity of their sources, children are not completely caught off guard. First, they are able to take into account the benevolence of the sources. Mascaro and Sperber (2009), for instance, showed that 3-year-olds trusted a source that had been nice toward the experimenter and rejected a source that had been nasty. Even when the only distinction between two informants was their emotional expression (i.e. anger versus happiness), children were more likely to trust the apparently benevolent informant (Clément, Bernard, Grandjean, & Sander, 2013).

In general, it also seems reasonable that people listen to those who they trust in their daily lives and with whom they are familiar. For most children, it would be expected that caregivers would be given a kind of epistemic priority. This has indeed been demonstrated for children as young as 4 years old who enjoy a secure affective bond with their mother: when the testimony of their mother conflicted with the testimony of an unknown adult, they preferentially chose their mother's assessment (Corriveau et al., 2009). Similarly, children from 3 years of age gave more weight to information transmitted by people with whom they are familiar. Corriveau and Harris (2009) showed, for instance, that preschoolers trusted a familiar teacher more than an unfamiliar teacher. Familiarity seems to extend to much wider social circles, including unknown people who possess some cues of group membership. Although race does not seem to trigger preference at an early age (Hirschfeld, 1996; Kinzler, Shutts, Dejesus, & Spelke, 2009; Kinzler & Spelke, 2011), accent is an important cue for in-group membership and children rapidly recruit it for epistemic decisions. For instance, after having seen videos of a native- and a foreign-accented speaker of English who each spoke for 10 seconds, and then silently demonstrated different functions with novel objects, 4- and 5-year-olds chose to select the nonverbal information given by the native speaker and imitated her action (Kinzler, Corriveau, & Harris, 2011).

When no cue about the potential reliability of the source is available, it is still possible to check the coherence of the communicated message itself. For example, if people contradict themselves, or if a message contains contradictions, it is probably good to be sceptical about its content, as a precautionary measure. Detecting such contradictions seems to be a complex task but, again, evidence shows that even preschoolers are able to conduct such epistemic evaluations. For instance, my colleagues and I have shown that children as young as 3 years of age seem to favour an opinion supported by a strong argument over an opinion supported by a circular argument (Mercier, Bernard, & Clément, 2014). Similar results have been obtained by Corriveau and Kurkul (2014), who showed that 5-year-olds, and in simpler conditions, 3-year-olds, demonstrated a selective preference for noncircular over circular explanations. It is worth highlighting that this evaluation of consistency is also done through the detection of logical connectors. When 4- and 5-year-old children had to choose between two statements differing only by the presence of the connector "because" (i.e. "The ball is in the green box, Jane always puts her ball in the green box" versus "The ball is in the green box because Jane always puts her ball in the green box"), they selected the statement containing the "because," even if its use did not add anything to the explanation (Bernard, Mercier, & Clément, 2012).

To sum up, from a very early age, individuals do not unconditionally accept the different testimonies that may enrich their knowledge. Even preschoolers are able to evaluate the reliability of their informants, judging that certain sources are more knowledgeable than others. They are able to decide which of two informants has had better informational access to a given fact and, as a consequence, to judge which is therefore more trustworthy. Also, children track past reliability and use it to decide whom to trust in the future. Humans seem to be "equipped" to take into account the degree of agreement on a given statement, granting greater epistemic value when a consensus has been reached. The benevolence of the source is also taken into account and, from a similar perspective, group membership; these cues are related to the level of cooperativeness of the informants and they are also detected at a very early age. As the children get older, the coherence of the message is also evaluated and they are ready to discard statements that are circular. With time, students learn to evaluate the level of trust that they can accord different sources of knowledge, given their perceived expertise (Bråten, Strømsø, & Britt, 2009) and benevolence. This sensitivity to others' accuracy is in line with the overall move toward an evaluativist epistemology (Kuhn, 2001), where arguments are evaluated as being more or less reliable judgments.

Given such diversity in evaluative processes, and its precocity, it would seem strange to discredit *a priori* the epistemic nature of socially acquired knowledge. But it is nonetheless legitimate to wonder to what extent these kinds of evaluative processes are *epistemic* in nature. In particular, it is widely admitted that epistemic cognition requires metacognition (for a subtle discussion, see Barzilai & Zohar, 2014); can the basic evaluative processes that were described previously be considered metacognitive?

## SOCIAL COGNITION, METACOGNITION, AND EPISTEMIC COGNITION

Contemporary theories about epistemic cognition tend to be rather demanding about what qualifies as an epistemic belief. In philosophy, epistemology is essentially concerned with the *justification* of knowledge and is therefore related to rationality, to *explicit* conceptions about the reasons that enable us to consider any given belief as true. This perspective tends to give a certain prevalence to the individual level of justification, although it does allow for the justification of knowledge to come from external sources such as testimony (Greene et al., 2008). However, this implies that individuals are able to take a step back in order to consider the evidence for a particular belief. It is in this sense that metacognition is generally related to epistemic cognition, as a "cognition that reflects on, monitors, or regulates first-order cognition" (Kuhn, 2000, p. 178). In other words, epistemic beliefs are often thought of as being *metarepresentational*, i.e. representations whose content is *about* other representations (Sperber, 2000). In the case of social cognition in general, and for beliefs acquired via testimony in particular, the same requirements seem necessary. For example, if someone told you that eating cranberries is good for your health, you should not only be able to recall this content but also retrieve who, and in which context, this advice had been given to you. If the source was your family doctor, for instance, or a recent paper in a prestigious scientific journal, your belief would be quite justified (Burge, 1993).

Taken seriously, this metacognitive perspective is cognitively demanding and it is interesting to consider whether most of people's beliefs could really be explicitly justified. Indeed, even if there is no machine monitoring what people consider to be true, it is a safe bet that people would not be able to systematically explain the reasons that lead them to believe what they now take for granted. Even if children's minds are less crowded by beliefs than adults, this is even more the case for children. For instance, young children are not even very good at remembering the sources of their beliefs: Gopnik and Graf (1988) showed that 3-year-olds could remember the contents of a drawer but were not able to remember if they had seen it, if someone had said it, or if they had inferred it from a cue. Moreover, metacognition is generally conceived as being inextricably linked to theory of mind (Kitchener, 2002), and young children are known for their very partial mastery of second-order representations, i.e. they have difficulty in attributing intentions and beliefs to others (for a review, see Wellman et al., 2001; Sodian, this volume). In adopting a cognitively demanding conception of epistemic cognition then, it seems impossible in general terms to speak of epistemic beliefs in young children, and it follows that this would also be the case for social cognition.

There are, however, an increasing number of experiments that seem to show that children are able to evaluate their own level of certainty in order to decide whether to update their belief according to the "quality" of the communicated information. Everything happens as if "epistemic measuring scales" enable children, from a very early age, to weigh the different available evidential cues. On these scales, information obtained via *perception* weighs most heavily. For example, when a statement given by someone who has been reliable in the past conflicts with a perceptual belief, preschoolers cease to follow the source and stick to what they have observed in the recent past (Clément et al., 2004). This is also the case when a consensus's statement conflicts with a perceptual belief (Corriveau & Harris, 2010; Bernard, Harris, Terrier, & Clément, 2015). More generally, representations that have already been determined to be true seem to be used automatically to filter the newly communicated information. This can be illustrated by two different sets of studies. Pea (1982) showed that 2- to 3-year-old children spontaneously corrected false statements. More recently, Koenig and Echols (2003) demonstrated that even 16-month-old infants looked longer at people who incorrectly labelled objects that were already familiar to the infants. Infants even tended to correct the false labels when the person produced them. Such results indicate that children possess, from an early age, a way to automatically filter incoming information with representations already taken to be true. The presence of these mechanisms is in line with the epistemic vigilance hypothesis, i.e. the idea that humans are biologically equipped with a suite of cognitive mechanisms to filter communicated information (Sperber et al., 2010).

People even seem to be sensitive from an early age to the level of knowledge possessed by others and to take it into account when deciding whether to "update" their beliefs. For instance, when 3- and 4-year-old children were presented with two informants, one being an expert on dogs and another not, they trusted the expert more when it came to naming new unknown dogs, but not when naming unknown artefacts (Koenig & Jaswal, 2011). From 3 years of age, children take into account the level of knowledge that is associated with familiar experts, demonstrating a certain understanding of the division of cognitive labour (Lutz & Keil, 2002). Even more interestingly, when choosing between two informants, infants as young as 24 months old are able to take into account nonverbal expressions of level of confidence (Brosseau-Liard & Poulin-Dubois, 2014). Everything happens as if the infants are able to detect another person's level of trust in their own epistemic states; in other words, at 2 years of age, children seem to be able to use certain cues (e.g. the person shrugging, palms up) to detect procedural metacognition.

These recent results could dramatically change the way scholars look at metacognition and at its role in social cognition. Indeed, metacognition is usually conceived as inseparable from theory of mind (Carruthers, 1999; but see Proust, 2007, 2013). However, this cognitive ability to represent mental representations, of others or oneself, is far from completely acquired by children as young as 2 or 3 years of age (Sodian, this volume; Wellman et al., 2001). Nevertheless, young children are capable, to a certain extent, of evaluating their own, and other people's, level of confidence in their epistemic states. To explain the different results mentioned in this chapter, one has to posit that metacognition is not entirely explicable through metarepresentational abilities. This is compatible with a conception of metacognition as *procedural*, i.e. a form of dynamic control of the "informational quality" of one's epistemic state that relies on some feelings, in particular of fluency (Koriat, 2000; Proust, 2013). This form of metacognition has been detected even in nonhuman primates, who are able to skip a task when they evaluate that they are too uncertain of being able to complete it successfully (Beran, Smith, Redford, & Washburn, 2006). Similar results have been obtained with 3.5-year-olds (Balcomb & Gerken, 2008), and Lyons and Ghetti (2011) showed that even 3-year-olds, probably relying on response latency, could reflect on their sense of certainty about the likely accuracy of their decisions.

Given all these findings, I propose that a basic form of metacognition exists from an early age and most likely continues to function throughout the entire lifespan. It enables people to monitor their epistemic states and to evaluate the different "epistemic weights" of different sources of information, including testimony. Given that children are unable to access these evaluative procedures explicitly (i.e. via second-order representations), it does not seem appropriate to speak in such cases of *epistemic beliefs*. Indeed this is often the situation for adults too. However, it seems appropriate, given the rather sophisticated evaluation documented by many experiments in developmental psychology, to speak of *epistemic cognition*.[1] More specifically, I propose that individuals are biologically equipped to evaluate the content of their epistemic state (i.e. trusting oneself) and the reliability of information communicated by others (i.e. trusting others). In other words, humans are endowed, from an early age, with a *naïve epistemology*.

## CONCLUSION: FROM NAÏVE EPISTEMOLOGY TO FOLK EPISTEMOLOGY

Even if I were to admit that there is something like a naïve epistemology that plays a crucial role in social cognition, this does not dismiss the fact that personal epistemologies undergo profound modifications during childhood and adolescence (Hofer & Pintrich, 1997; Moshman, 1998). In particular, individuals develop *epistemological beliefs*, i.e. conceptions about the definition of knowledge, about the way it is constructed, how knowledge is evaluated and how knowing occurs (Kitchener, 2002). These beliefs are obviously metarepresentational and they correspond to what is most often considered as "folk epistemology." Individuals become able to justify their knowledge; they can, for instance, provide evidence in support of what they consider to be true, or mention authority and expertise in defending their beliefs (Hofer & Pintrich, 1997). In a sense, this move from tacit commitments (Chinn & Brewer, 1993) to explicit epistemic belief is akin to the contemporary distinction between cognitive processes belonging to System 1 (i.e. automatic and tacit, or *heuristic*) and System 2 (i.e. reflexive and controlled, or *analytic*; Evans, 1984; Kahneman, 2011). This "royal path" to critical thinking (i.e. the process by which one revises and improves, individually or collectively, the reliability of one's beliefs) is often considered an individual endeavour (Kuhn, 1999), with individuals becoming increasingly successful at organizing their thinking in a more and more rational way (Moshman, 1998; Moshman & Geil, 1998).

This individual dimension is undoubtedly important but there is clearly also a significant social dimension to epistemological beliefs. In every human group, there are epistemological folk theories, cultural traditions that help individuals to be attentive to certain dimensions of the knowledge acquisition process and that propose different strategies to improve knowledge. This sociocultural dimension of epistemology, which corresponds to what could be called a "folk epistemology," is a very interesting aspect of epistemic cognition that requires further research (Nisbett, 2003). For instance, it is possible that the basic factors underlying naïve epistemology (e.g. accuracy, reliability, consensus, coherence, expertise) are shaped differently according to specific cultures and socializations. It could be true that, in similar contexts, individuals from different cultures give more weight to certain cues than others. It may be the case, for example, that in small communities, where social cohesion is crucial for the wellbeing of everyone, consensus could often predominate over accuracy or coherence. On the contrary, one can expect that the multiplication of potentially conflicting sources of information in the modern environment favours the emergence of individual and collective epistemic inquiries, notably to separate the epistemic wheat from the deceptive chaff (Bråten, Britt, Strømsø, & Rouet, 2011). It is, however, far from obvious how to foresee the potential consequences of such an intense and potentially disturbing circulation of opinions. It could lead to a more distanced view on social conventions and profound discussions about people's common humanity (Gabbenech, 2007; Habermas, 1999). But such a profusion of ideas could also generate a sort of epistemic panic and an intellectual retrenchment on a set of cultural, notably religious, beliefs judged as immovable and irrefutable. To explore these paths, a close collaboration between philosophers, psychologists, and anthropologists is more than ever required; this constitutes in itself an appealing invitation for a new epistemological journey.

## NOTE

1 Therefore, I use this notion in a slightly different way from Karen Kitchener (1983). For her, epistemic cognition refers to the individual's reflection "on the limits of knowing, the certainty of knowing, and criteria of knowing" (Kitchener, 1983, p. 222). In my sense, it is not required to be reflective for epistemic cognition because it is possible to monitor epistemic states without "reflecting" on them.

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# 7

# THE ARGUMENTS FOR AND THE REASONING ABOUT EPISTEMIC COGNITION

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Let me begin this response to the diverse and informative chapters that populate the section of the *Handbook on Epistemic Cognition* (Greene, Sandoval, & Bråten, 2016/this volume) entitled "Psychological Perspectives on Epistemic Cognition" by taking as a given (at least for the moment) that the pursuit of knowledge and the act of knowing often require individuals to engage in reflective and effortful thought. Moreover, such reflective and effortful thought may well entail some manner of logical or causal reasoning, the weighing of evidence and claims, the contemplation or construction of arguments, and a judgment as to the intentions and goals of self and others. Moreover, let me acknowledge that, at present, the rich and expanding literature pertaining to epistemic beliefs, values, or goals is truly in need of more coherence and consistency in the language employed to signify those aforementioned aspects of knowledge pursuit and knowledge justification. If those were the sole objectives or claims forwarded in the contributions populating this section then my response would be done. I would have nothing further to question, nothing more to argue.

Yet, within these chapters, the overall portrait of human cognition as routinely a reflective, effortful, reasoned pursuit of knowledge or "justified true beliefs" demands critical analysis. Is this a portrayal that can be regarded as a realistic representation of human cognition or a more idealized depiction? How does the answer to this question about cognitive reality versus cognitive idealism reflect on the images of epistemic cognition that are concurrently displayed within the pages of this Handbook? Are they similarly fair and accurate representations of individuals' "explicit or tacit cognitions related to epistemic or epistemological matters" (Chinn, Buckland, & Samarapungavan, 2011, p. 141), or somewhat airbrushed or doctored images of what truly exists in the harsh light of reality?

These are the questions I seek to explore in this response and I do so without raising the specter of doubt as to the valued insights offered by each contribution in this section. Those contributions begin with an overview of the literature on personal epistemology and epistemic cognition expertly crafted by Hofer (2016/this volume), which is followed by treatises on particular, associated constructs: argumentative reasoning, logical and causal reasoning, theory of mind, and social cognition. Specifically, my purposes in this response are twofold. The first is to perhaps forestall tendencies to exhibit human cognition in only favorable light or to expand the boundaries of epistemic cognition to encompass any and all fleeting thoughts or associates that occur in mind or brain. More to the point, my approach herein is to weigh certain claims that were either expressly *plena voce* or *sotto voce* within the preceding chapters and to pursue counterarguments that might cast a shadow of doubt on that specific portrayal. More particularly, I interrogate five perceptions that arise within the preceding chapters, specifically that:

1. Thinking is synonymous with reasoning.
2. Thinking is intentional.
3. Humans are routinely engaged in the pursuit of knowledge or the act of knowing.
4. Epistemic cognition encompasses the expanse of human mental activity.
5. There are specific psychological-cognitive constructs to which epistemic cognition pertains.

My second purpose is to focus on the potential and promises of epistemic cognition to bring greater precision and unity to the expanding literature on knowledge and knowing, as expressed eloquently by Hofer (2016/this volume) in the opening chapter. In this instance, I will consider whether I find the arguments offered compelling and the justifications convincing to the point that I would set aside my own epistemic lexicon in favor of the über-construct of epistemic cognition.

## THINKING, REASONING, AND EPISTEMIC COGNITION

### *Thinking as Reasoning?*

In the opening paragraphs of their exploration of argumentative reasoning, Iordanou, Kendeou, and Beker (2016/this volume, p. 39) stated that "argumentative reasoning lies at the heart of thinking." I concur with the authors that the reasoning involved in the evaluation, construction, and comprehension of arguments is a foundational aspect of human learning and development. Yet, while this may have not been the intention of these authors or others in this section (Moshman & Tarricone, 2016/this volume), I wish to use the opportunity to interrogate the potential conflation of reasoning and thinking that seemingly arises within the broader literature.

Let me begin that interrogation with my own statement of principle: *The activities of the human mind are incessant.* Whether individuals are awake or asleep, and whether they are expressly aware of their thoughts and perceptions or not, mental processing continues unabated. Even though humankind would like to assume that the activities of their minds are routinely within their awareness or control and the consequence of serious reflection, I would counter that many thoughts are spontaneous, unregulated, and *not* the byproduct of reasoning or reasoned behavior.

This precisely is the argument underlying Kahneman's (2011) notion of "Thinking, Fast and Slow." As Kahneman contends:

> You believe you know what goes on in your mind, which often consists of one conscious thought leading in an orderly way to another. But that is not the only way the mind works, nor indeed is that the typical way. Most impressions and thoughts arise in your conscious experience without your knowing how they got there. (p. 4)

This conveyance of fast and slow thinking corresponds to Stanovich and West's (2000) dual processing theory of human cognition. Building on decades of empirical research, Stanovich and colleagues (Evans & Stanovich, 2013; Stanovich, 2009; Stanovich & West, 2008) have professed the existence of two systems of thinking: System 1 and System 2. Indeed, the recognition of such a dual system was expressly acknowledged by several authors within this section (e.g. Moshman & Tarricone, 2016/this volume; Sodian & Kristen, 2016/this volume). The processing that occurs in System 1 is characterized as automatic, relatively fast, cognitively undemanding, and holistic, whereas System 2 is depicted as analytic, relatively slow, and effortful. If the evidence forwarded for a dual processing model of human cognitive is deemed viable, then it requires the disentanglement of thinking and reasoning. That is, I cannot simply accept the position that reasoning is at the *heart* of thinking.

A dual model of cognition also counters Moshman and Tarricone's (2016/this volume) claim that "thinking involves metacognitive self-regulation" (p. 54). Even the authors' addition of the qualifying phrase, "but is often more concerned with success than with knowledge," (p. 54) does not serve to move the possibility of thought to the realm of System 1. Here again, while it is certainly desirable for individuals to engage in thinking that entails metacognition or self-regulation—terms which are often conflated (see Dinsmore, Alexander, & Loughlin, 2008)—it is presumptuous to assume that thinking is routinely or predominantly so. There is simply too much evidence to the contrary. Moshman and Tarricone (2016/this volume) likewise acknowledged that children may not even realize that they have made inferences or that those inferences were logical or causal in nature. Referencing the work of Barzilai and Zohar (2014) by these authors and others in this volume represents an important step in the right direction by recognizing that metacognition may be necessary but not sufficient for forms of human thought to rise to the level of System 2 thinking and reasoning. However, the language in the chapters remains equivocal in terms of the potential for thinking that is not monitored or unregulated.

So, what can be said about the relation to thinking and reasoning? In both the case of argumentative or logical/causal reasoning, I think it is more defensible to argue that they are key abilities within the realm of System 2. That is, both argumentative reasoning and logical/causal reasoning are means of reflecting on or interrogating ideas and, therefore, have value in achieving deeper and more evidenced understandings. But, it cannot be claimed that these forms of reasoning occupy the universe of human thought.

### *Thinking as Intentional?*

One of the notions that threads through this section of the Handbook, especially the contributions dealing with Theory of Mind (ToM; Sodian & Kristen, 2016/this volume) and social cognition (Clément, 2016/this volume), is that epistemic thinking and judgments require ascertaining the intentions of self and others. But, are such notions not only indicative of human thought, but also foundational to epistemic cognition? That is the claim I wish to interrogate here.

At its core, ToM has been described as the ability to attribute mental states (e.g. beliefs, intentions, or knowledge) to self and others or to ascertain how individuals' mental states can vary across individuals and across situations, or be used to predict others' actions or assertions (Astington, Harris, & Olson, 1988; Sodian, 2011). In some ways, ToM answers the base question: "What was I (that person) thinking?" The theoretical and empirical foundations of ToM reach well back to developmental psychologists, notably Piaget (1954), Flavell (2004), and Wellman (2002). I have no intention to distract from the importance of putting oneself in the perspective or mindset of another. Even understanding the simplest of human message or action necessitates a presumption of speakers' or doers' purposes or goals. Yet, how does such a critical mental process relate to epistemic cognition specifically rather than to cognition more generally?

To Sodian and Kristen, (2016/this volume), ToM "addresses the developmental origins of epistemic cognition" (p. 69), and they supported this contention through a detailed summary of the relevant literature. The studies they referenced point to the cognitive capacity of even young children to make judgments about the certainty or potential source of their knowledge or that of another, along with the limitations of such determinations. As these authors state:

> Even 4- and 5-year-olds monitor an informant's access to information. Thereby, they prefer a knowledgeable informant to an ignorant one and trust previously inaccurate informants if their inaccuracies stem from ignorance or false beliefs, rather than dishonesty or other negative personality traits. (p. 76)

One problem for me in positioning this enlightening discussion within the goals of the Handbook was ascertaining the boundaries between metacognition and epistemic cognition, which I perceive as tenuous or underspecified. Some of this concern, of course, harkens back to the prior discussion of System 1 versus System 2 thinking. I am not alone in this regard, as evidenced by the writings of Barzilai and Zohar (2014) who have sought to bring the relation between metacognition and epistemic cognition into clearer focus. Minimally, it seems difficult, if not impossible, to delve into System 2 processing without some manner of "meta" or executive functioning.

Young children, as well as older children or adults, may well offer a statement as to the certainty of their understanding or ascribe greater credibility to one source over another when asked expressly to do so, as has been evidenced in ToM experiments. But, the question remains whether such an utterance signifies some automatic, holistic, and non-explicated response (System 1) or is indicative of deeper, analytic, and effortful consideration of the data or situation (System 2)? That is, do they simply offer a response to a direct question without deep reflection or evaluation, or does that response, in fact, signify some critical, justified examination of the question asked? Having witnessed undergraduates quickly offer an unsubstantiated opinion to a question intended to provoke evaluative, epistemic thinking (e.g. List, Grossnickle, & Alexander, 2014), I cannot help but ask whether Sodian and Kristen's (2016/this volume) attribution of outcomes to epistemic cognition is truly justified. If I grant that epistemic cognition is not simply metacognition or its various manifestations (e.g. metacognitive knowledge, metacognitive awareness, or metacognitive strategies), then perhaps it might be thought of as thinking that entails not only metacognition or executive monitoring but also critical-analytic thought (e.g. the weighing of arguments and evidence for the purpose achieving a best response or action; Alexander, 2014a). This is a point I will return to later in this response.

### *The Pursuit of Knowledge?*

Recently, I have been attempting to reconcile cognitive pursuits that can occur both in System 1 and System 2: information management and knowledge building (Alexander, 2013, 2014b; Alexander, Winters, Loughlin, & Grossnickle, 2012).

Information management can be understood as more task-driven engagement that generally entails the manipulation of data from multiple sources and the potential organization, regulation, and communication of that data to multiple audiences in multiple forms and for some rather specific purpose or relatively short-term goal. As such, information management can be characterized as more externally motivated and more temporally constrained. When individuals click on the first piece of information that comes up in an online search that appears to correspond to the question asked, but feel no compulsion to check the accuracy or suitability of that data, they are information managing. When students memorize content to pass a test or a class without the goal of making that content an enduring part of their knowledge base or without the need to ensure the veracity of that information (other than the teacher deems it test worthy), they are information managing.

By contrast, there are times when "just getting it" is not sufficient and when "getting it right" becomes important. At such times, individuals do more than manage information. They seek to link that content to their personal goals or connect it meaningfully to their lives; they find some emotional valence in what is being learned and attempt to retain it—make it part of their long-term memory. Most importantly from the standpoint of epistemic cognition, they seek to ascertain the veracity, accuracy, or "truthfulness" of that information—their goals are at least partially epistemic in nature (Pluta, Chinn, & Duncan, 2011). When such a shift in the goals of knowing occur, these individuals manifest the attributes of knowledge building rather than solely information management.

I offer this contrast between information management and knowledge building for the purpose of raising the issue of how epistemic cognition comes into play in the more pedestrian engagement with information; that is, is there any epistemic value or criteria applied to interaction with information (Chinn et al., 2011)? If individuals are not concerned with the truthfulness or veracity of information, if they really do not care if what they are learning is accurate provided it seemingly serves the task at hand, and if there is no effort to further justify or substantiate the information encountered, does epistemic cognition enter into the equation?

As with others (e.g. Chinn et al., 2011; List et al., 2014), I think the response to the previous provocative question is "no." That is to say, every encounter with information and every response to information does not necessarily rise to the level of epistemic. Given that the construct of epistemic cognition is framed in terms of the philosophical domain of epistemology, it would seem to require something more than simply the processing or managing of information. But what that something may be has not been fully articulated, although attempts have been made (Chinn et al., 2011). The argument I forward nonetheless is that it should not be presumed that every human act of cognition—conscious or unconscious; System 1 or System 2; information management or knowledge building—serves as an occasion for or evidence of epistemic cognition. Rather, the pursuit of knowledge or the act of knowing should minimally be implicated.

### *Epistemic Inclusiveness or Incompatibility?*

The prior discussion pertaining to the boundaries of epistemic cognition raises related questions about what constitutes epistemic vis-à-vis non-epistemic cognition. If I am to truly grasp the nature of the construct "epistemic cognition," then it is essential for me to reason antinomously; that is, to also ascertain what non-epistemic cognition means. Regrettably, my efforts to reason antinomously about what *is* and what *is not* epistemic cognition were not well served by the chapters included herein. Within this section, there were certainly attempts to be precise as to the definition of epistemic cognition (Hofer, 2016/this volume), but the efforts to clearly distinguish what is *not* epistemic were found wanting overall. Two possible explanations for this seem feasible. The first is that authors of the more particular chapters were tasked with bringing their specific constructs to those invested in epistemic cognition. Therefore, the focus was not directly or expressly on epistemic cognition. The second is that these authors may have been operating under the assumption that the meaning of epistemic cognition is rather apparent—a misguided assumption, I venture to say.

In terms of expressed definitions, for instance, Moshman and Tarricone (2016/this volume) stated that understandings concerned with matters of epistemology are "part of epistemic cognition" (p. 55), and then proceeded to discuss epistemic development. Similarly, Sodian and Kristen's (2016/this volume) treatise on theory of mind cited Chinn et al. (2011) to establish their definition of epistemic cognition, as did Iordanou et al. (2016/this volume). Further, Iordanou et al. (2016/this volume) spoke about shared components of epistemic cognition and argumentative reasoning, such as justification and certainty of knowledge.

In his treatment of social cognition, Clément (2016/this volume) offered a general definition of epistemic cognition as encompassing "an individual quest towards finer and more justified beliefs" (p. 84). Further, in a footnote, Clément (2016/this volume) went on to mention that his conceptualization of epistemic cognition differed from that of Karen Kitchener's (1983), which entailed individuals' reflection on the "limits of knowing, the certainty of knowing, and criteria of knowing" (p. 93). In effect, Clément eliminated any requirement for reflection from his definition, arguing that it is possible for individuals to monitor their epistemic state without reflecting upon it. Whether I find Clément's argument convincing or not, I appreciated the effort to explicate the meaning of epistemic cognition. That being said, the aforementioned conceptualizations leave me to question what would fall outside this notion; that is, what would be antinomous to such a sweeping view of epistemic cognition?

Whether it was the intention of the current editors of this Handbook or not, I was hoping that outcomes of this undertaking might encompass movement toward a more definitive conceptualization of epistemic cognition than currently populates the literature or to the identification of various schools of thought that might exist within the theoretical and empirical literature on epistemic cognition. Of course, I cannot make any definitive claims for what may transpire across the entire volume, only this collective of writings. Certainly, when reading Hofer's (2016/this volume) opening chapter, the hope for conceptual clarity was amplified. Nonetheless, I remain unconvinced that the goal of clearer explication was, in fact, progressed throughout the remainder of this section of the Handbook. I further remain adamant that it is not sufficient to merely describe what epistemic cognition *is*. It is also critically important to make it evident what epistemic cognition *is not*.

### *General Habit or Situated Enactment?*

To this point, I have focused my comments and concerns on individual issues or particular constructs. Yet, it is not possible to look critically or analytically at this section of the *Handbook on Epistemic Cognition* pertaining to psychological perspectives without asking how this array of topics—argumentative reasoning, causal/logical reasoning, theory of mind, or social cognition—coalesce as a system of cognitive behaviors or habits of mind ultimately associated with epistemic cognition. Perhaps this issue I am posing should be directed as much to the editors of this volume as to the authors of these chapters. Of all the multitude of psychological constructs that could have populated this particular section of the Handbook, why were these specific ones deemed most relevant? What is it about the underlying natures of argumentative reasoning, logical/causal reasoning, theory of mind, and social cognition that make them most suitable for explicating the nature of epistemic cognition? Once again thinking antinomously, are there cognitive behaviors or habits of mind that should be purposefully excluded?

As someone prone to think globally or to perceive things as gestalts, I tried to find the conceptual or procedural "glue" that bound this set of writings together. The challenge was significant and the outcome was not entirely satisfying. As I noted, the chapters do speak to mechanisms by which individuals are able to or motivated to delve into their own thoughts or actions or those of others. Further, they all touch on important psychological areas of study within human learning and development. But are these observations sufficient to justify their individual and collective place within epistemic cognition? I am skeptical. From where I stand, more evidence is required for me to reach a viable conclusion that these particular works—among all possibilities—capture the psychological perspectives foundational to epistemic cognition. I remain open to persuasion or convincing, however, not only as to why these individual pieces are part of the epistemic cognition puzzle, but also what the assemblage ultimately looks like. What is the picture being constructed here? What are communities of research and practice hoping to envision about epistemic cognition once this mélange finally comes together?

## EPISTEMIC COGNITION AS UNIFYING CONSTRUCT

Initiating this section of the Handbook on psychological perspectives with a chapter that nested epistemic cognition within a rich historical frame was, in my judgment, a wise decision. Having a more global orientation to epistemic cognition did, in fact, position the more particular chapters that ensued nicely and outlined certain underlying issues and threads that bind these contributions together. That judgment would seem applicable whether readers are new to or long invested in the philosophical and psychological literatures on epistemology and epistemic beliefs. As someone who would count herself among the more invested readers, this treatise laid bare one overarching conundrum for me, along with several associated puzzlements. That overarching conundrum pertained to whether I was duly convinced that epistemic cognition "might now serve to unite a somewhat disparate field of scholarship" (Hofer, 2016/this volume, p. 20) pertaining to epistemic beliefs.

### *Why Terminology Varies*

The language that populates professional and everyday discourse has long captivated me. I have been fascinated by what people mean when they evoke psychological words like *knowledge*, *beliefs*, *information*, *truth*, *learning*, and *motivation*, for instance (Alexander & Dochy, 1995; Alexander, Schallert, & Hare, 1991; Alexander, Schallert, & Reynolds, 2009; Murphy & Alexander, 2000). What these conceptual forays have taught me is that the use of different words by those within communities of practice can arise for many reasons. For one, those evokers may simply fail to be precise or explicit in their word choices, or they may operate under the mistaken notion that commonplace terms are commonly understood. For another, those employing particular concepts or constructs may come from diverse traditions and, thus, use different terms for the same or similar construct. Such lexical disparities could seemingly be rectified with thoughtful reflection, adequate care, and consensual agreement as to word choices and definitional attributes. This is one approach foreshadowed by Hofer (2016/this volume) in her survey of the language of personal epistemology and epistemic cognition.

However, there is another reason why individuals appropriate different terms for what appears on the surface to be the same or related phenomena. That is, these individuals want to pinpoint potentially subtle, yet important, distinctions that would be lost or masked by the use of other terminology. For instance, there was a clear intention by some within the literature to denote that what was often espoused by individuals regarding the knowledge and knowing did not arise from any systematic or examined understanding of these notions (R. Kitchener, 2002). For that reason, these researchers chose to speak about *epistemic beliefs* rather than *personal* or *individual epistemology*. For example, as Maggioni and Parkinson (2008) stated in their review of teacher epistemic cognition, epistemic beliefs, and calibration:

> Overall, although researchers focusing on epistemic cognition tend to view individual epistemology as a unified set of ideas about the nature of knowledge and knowing that develop in time, researchers studying epistemic beliefs hypothesize that individual epistemology is composed of different, quite stable, semi-independent dimensions (e.g. certainty of knowledge and simplicity of knowledge). (p. 447)

More recently, as individuals adding to the lexicon within the literatures on knowledge and knowing, my colleagues and I have spoken and written about *epistemic competence* (Alexander, 2014b; Alexander & The Disciplined Reading and Learning Research Laboratory, 2012). Our purpose in adding yet another term to an already-laden vocabulary was to address a critical pattern in individuals' justification of beliefs and pursuit of evidence—their inevitably contextual and situational nature. For us, what matures is not simply individuals' generic ability and willingness to be more reflective and evaluative in their judgments or to be more open and reasonably skeptical in the acceptance of evidence or evidentiary sources. What also develops is individuals' understanding that what constitutes viable and sufficient evidence for a given situation is determined by many factors, including the nature and complexity of the problem per se, its domain and disciplinary roots and associated communities of practice, and its value or relevance to self or others (Murphy, Alexander, & Muis, 2012b). I will not belabor this discussion of epistemic competence here. I only offer it as evidence of the fact that areas of inquiry as multidisciplinary and as multifaceted as those pertaining to knowledge and knowing are unlikely to be captured or unified under any one term—even one as promising as epistemic cognition.

### *Precursory Distinctions*

Earlier, when discussing distinctions between information management and knowledge building, I voiced concern that perhaps not all human interactions with information could or should fall under the banner of epistemic. In reading Hofer's (2016/this volume) historical overview in juxtaposition to Iordanou et al.'s (2016/this volume) exploration of argumentative reasoning, yet another relevant distinction presented itself—psychological versus philosophical notions of knowledge. Specifically, at points in their examination of argumentative reasoning, Iordanou et al. refer to the construct of *prior knowledge.* Consistent with the cognitive psychological and text-based literatures, prior knowledge entails all that is stored in memory whether such knowledge is accurate or inaccurate, justified or unjustified (Alexander et al., 1991). This is quite a different conception than the "justified true beliefs" designation that has marked the more philosophical writings on knowledge and knowing. Thus, the question naturally arises: How does the conception of knowledge guiding the work on epistemic cognition contrast to the notion of prior knowledge and other associated terms, including learning and memory, that likewise populate this collection of chapters? Before there can be any consistency in terminology within the epistemic cognition, it seems important to ensure that basic words like knowledge are well understood.

From the reading of this set of chapters, it would appear that the editors of the current volume understandably allowed insights and understanding about epistemic cognition to arise organically from the individual contributions. Nonetheless, I am left with various unanswered questions, such as: Will there be a more comprehensive and evidence-based definition of epistemic cognition that emerges from this amalgam? Are there critical interrelations between epistemic cognition and other psychological constructs pertaining to the pursuit of knowledge and knowing that will ultimately surface in the future?

Beyond these conceptual boundaries and parameters, there is another enigma that remains to be resolved within the literature on epistemic cognition, in my judgment. That issue relates to the important difference between beliefs espoused and beliefs enacted. Shadows of this issue came forth in Hofer's discussion of research methodology and the recognition that much of the research on knowledge and knowing, especially within psychology, has rested on self-reported data. However, the concern is not simply in the problems associated with measurement; it goes deeper. There is little cost or consequences for voicing certain beliefs about knowledge and knowing in general or within domain/disciplinary communities. The question is whether such beliefs actually manifest in the actions of respondents, be they students, teachers, or "just-plain-folks." This is a serious question that Murphy and colleagues (e.g. Murphy, 2007; Murphy, Alexander, Greene, & Hennessey, 2012a) have voiced in their examination of epistemic framing. And, it is a question that merits reconsideration in this psychological exploration. Is there something inherently different about the beliefs that are and are not evident in individuals' words and deeds outside of psychological assessments (Sandoval, 2005)?

As with my prior query about the boundaries and parameters of epistemic versus non-epistemic aspects of human learning and development, I must be patient. I must wait to see how this set of psychologically oriented chapters, this Handbook overall, or future contributions on knowledge and knowing resolve such lingering issues. Without question, when weighing the potential insights and value to be garnered for this endeavor, it is well worth the wait.

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# Section II

## Disciplinary Perspectives on Epistemic Cognition

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# 8

# EPISTEMIC COGNITION IN SCIENCE

*Andrew Elby, Chris Macrander, and David Hammer*



## INTRODUCTION

This chapter introduces research on epistemic cognition—people's thinking about knowledge and knowing—in science. Science education researchers and practitioners have attended to this topic largely for two reasons: sophisticated understanding of the epistemic nature of science is an educational goal in itself, and sophisticated epistemic cognition connects to productive approaches to learning the concepts and practices of science.

Research in this field over the past decade has generally continued earlier themes. Most research continues to view as "sophisticated" the beliefs that scientific knowledge is tentative and evolving rather than certain and fixed, complex and interconnected rather than piecemeal, justified by appeals to evidence and coherence rather than authority, and constructed by people rather than perceived in nature. Most research continues to use surveys and interviews to sort participants into categories of greater versus lesser sophistication along predefined epistemological dimensions. Finally, most research continues to conceptualize epistemic cognition as the enactment of beliefs that are fairly robust and context-independent, at least within a given discipline.

In this chapter, we review how these trends emerged from earlier intellectual currents, and how other recent work challenges them, offering new, productive approaches to conceptualizing and studying epistemic cognition in science.

## EPISTEMIC COGNITION IN SCIENCE: AN ORIGIN STORY

Current work on epistemic cognition in science largely stems from two threads of research: *personal epistemology* and *nature of science* (NOS). Personal epistemology is a person's views about the nature of knowledge and knowing, particularly her own. NOS concerns beliefs and knowledge about the nature and generation of scientific knowledge.

### *The Origins of Research on Personal Epistemologies of Science*

The "personal epistemology" thread (Hofer & Pintrich, 1997) goes back to Perry (1970) and subsequent Piagetian-inspired studies (Belenky, Clinchy, Goldberger, & Tarule, 1986; Kitchener & King, 1981; Kuhn, Cheney, & Weinstock, 2000). Researchers fit participants' epistemological beliefs into progressions of increasingly sophisticated stages, generally as follows: children begin in an absolutist stage, seeing knowledge claims as right or wrong, verified through authority and/or direct experience. Then, through effective schooling, students progress to a multiplist stage, understanding knowledge as a subjective construction, allowing multiple valid perspectives. Some progress further to an "evaluativist" stage (Kuhn et al., 2000), understanding knowledge as constructed but affirming criteria by which competing claims can be debated and judged. Much current work continues to assume some version of this developmental progression.

Two facets of early work from this tradition, however, are mostly missing from current studies. First, Perry (1970) and Belenky et al. (1986) treated personal epistemologies as entangled with identities and emotions. For example, students in the bottommost of Perry's three "commitment within relativism" (roughly corresponding to evaluativist) stages were typically college seniors or juniors thinking about future careers, coming to terms with their choices of ways of being and knowing, while acknowledging the validity of others' different choices. Perry's description of this stage entangles identity (the student has settled into one), affect (the student is comfortable with the choice), and epistemology (making a reasoned but subjective choice about what ways of knowing to adopt). Belenky et al. (1986), who studied women's ways of knowing in contrast to Perry's focus on men, described an initial stage of "silence": the individual feels at the mercy of authority in what to do and to think, a matter both of identity and epistemology. At a later stage, "connected knowers" seek empathetic (as opposed to detached) understanding of others' perspectives. By contrast, most current research separates the notion of personal epistemology from matters of identity and affect, to keep the construct strictly defined as "views about knowledge and knowing."

A second facet of early personal epistemology research mostly missing from current work is accounting for *how* a new stage is constructed from the previous one. Perry, for instance, discussed how students in a dualistic (absolutist) stage become keenly aware of the multiplicity of views about an epistemic problem, such as how to interpret a historical event. This awareness, Perry theorized, is a building block for a multiplist epistemology. By contrast, little current work focuses on identifying mechanisms by which seeds present in an earlier stage play into the construction of the next.

In the 1990s, personal epistemology research introduced multiple dimensions of belief, largely driven by Schommer's (1990) model. Hofer and Pintrich (1997) synthesized the variety of multidimensional schemes in play into four dimensions:

1. Simplicity versus complexity of knowledge: is knowledge a piecemeal collection of bits or an interconnected web of ideas?
2. Certainty versus tentativeness of knowledge: is knowledge fixed and absolute or tentative and evolving?
3. External versus internal source of knowledge: is knowledge merely perceived from the world and/or accepted from authority, or does it originate inside the knower through their own meaning making?

4. Multifaceted versus simplistic justification for knowing: does the knower evaluate knowledge claims superficially or use multiple criteria, such as fit with evidence, coherence with other knowledge, or credibility of experts?

Hofer and Pintrich's synthesis retains a developmental flavor in assuming learners progress from less to more sophisticated views within each dimension.

Also in the 1990s, research on epistemologies became more common in specific disciplines, including science (e.g. Grosslight, Unger, Jay, & Smith, 1991; Hammer, 1994; Songer & Linn, 1991). Most recent theory building (Buehl & Alexander, 2006; Muis, Bendixen, & Haerle, 2006) and much empirical work (Muis et al., 2006) suggests that epistemological views are at least partly tied to specific domains of thought/activity such as science or history. Other work identifies variations in students' epistemologies across the sciences (e.g. physics and biology; Stahl & Bromme, 2007; Gouvea, Sawtelle, Geller, & Turpen, 2013).

In summary, current work on students' epistemic cognition in science stems in part from studies of personal epistemologies. The stage-like progressions assumed in this early work persist: epistemological "progress" is generally assumed to consist of moving from naive to sophisticated stages or beliefs within multiple dimensions. However, most current research reflects the assumption that the epistemological views expressed and enacted in a science context are at least partly views about science in particular as opposed to domain-independent epistemological views that happen to be on display in a science context.

### *The Origins of Research on Views about the Nature of Science*

The second research tradition feeding into current work on epistemic cognition in science concerns the nature of science (NOS). NOS research emerged primarily from debates about the goals of science education as informed by the philosophy and sociology of science. This has led to a perennially renewed consensus that students should learn NOS (Central Association of Science and Mathematics Teachers, 1907; Hurd, 1960; NRC, 1996).

A long history of debate about the definition of NOS (Lederman, 2007), which may refer broadly to a description of science as an endeavor (NSTA, 2000), has concerned whether "NOS" also includes attitudes about science and issues of personal identity (Wilson, 1954; Mead & Metraux, 1957). However, just as epistemology researchers stripped identity and affect off of early conceptualizations of "epistemology," NOS researchers largely stripped identity and affect off of early conceptualizations of NOS. Most pertinent to this chapter is the definition of NOS as "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, 1992). The characteristic values and beliefs of NOS most generally agreed upon are: (i) observation and inference are distinct, as are (ii) laws and theories; (iii) science is culturally embedded; (iv) scientific knowledge is both empirical and creative; (v) is subjective; and (vi) is tentative (NSTA, 2000; Lederman, 2007).

Early research developed surveys to probe NOS understandings in both students (Cooley & Klopfer, 1961) and teachers (Behnke, 1961; Kimball, 1968). More recent efforts have added qualitative methods such as interviews and case studies (Aguirre, Haggarty, & Linder, 1990; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Researchers consistently find that both students and teachers fail to espouse the value of NOS, instead displaying views that scientific knowledge is objective and absolute (Lederman, 2007).

There is recent debate about whether more desirable conceptions of NOS are best learned through explicit instruction (Abd-El-Khalick & Lederman, 2000) or by immersing students in scientific inquiry (Sandoval, 2005), with concomitant disagreements about the most appropriate conceptual frameworks and measures of outcomes. Sandoval, in particular, calls for study of "practical epistemologies" (*in situ* epistemic cognition) to advance our understanding of how to promote NOS in schools.

### *Epistemic Cognition in Science: Bridging Personal Epistemology and NOS Research*

The different origin stories for NOS and personal epistemology research help to explain their different emphases. Personal epistemology research in science focuses on individuals' views about their own knowledge, which is related but not necessarily identical to their views about NOS as Scientific Knowledge writ large (Hammer, 1994; Hogan, 2000; Sandoval, 2005).

The NOS and personal epistemology literatures overlap substantially; both explore students' views about the tentativeness of knowledge, the extent to which knowledge is constructed and therefore subjective, and whether people distinguish observations/evidence from inference. Yet, the two literatures remain fairly separate in the sense that NOS researchers do not typically build on and add to discussions/debates in the personal epistemology literature, or vice versa.

Still, the idea that science or an individual scientific discipline *has* a particular epistemology, i.e. that science has epistemological entailments, may motivate personal epistemology studies that use bottom-up coding to arrive at dimensions or aspects of epistemology that are not simply science-contextualized versions of Perry-style stages or Hofer and Pintrich's dimensions (Hammer, 1994; Tuminaro & Redish, 2007; Sandoval & Çam, 2011; Russ & Luna, 2013). We see this alertness to the distinctive epistemological character of science, and to the distinct patterns of epistemic cognition that may arise when teaching, learning, or doing science, as a promising direction in this field—a direction set up by the field's dual roots in developmental/educational psychology (via personal epistemology research) and the philosophy/sociology of science (via NOS research).

## CURRENT RESEARCH TRENDS

In this section, we describe several current trends in research on epistemic cognition in science: documenting change in response to interventions, connecting epistemology to other constructs, creating *in situ* case studies of epistemic cognition, and studying epistemic cognition in teachers.

### *Documenting Epistemological Change in Response to Interventions*

Significant progress has been made in designing instruction that attends to students' epistemologies. Many studies document change through pre- and post-intervention surveys or interviews (e.g. Conley, Pintrich, Vekiri, & Harrison, 2004; Lindsey, Hsu, Sadaghiani, Taylor, & Cummings, 2012; Muis & Duffy, 2013; Redish & Hammer, 2009). For example, before and after a high school course in Anatomy and Physiology, Zeidler et al. (2009) conducted Reflective Judgment Interviews (King & Kitchener, 1994), which probe epistemic cognition during consideration of controversial topics. The control group of high school students focused on the scientific content, while the treatment group's class was infused with socioscientific issues such as marijuana use and legality. The treatment group showed significantly greater pre-to-post gains in reflective judgment.

In general, these studies and others like them show that more intensive and longer lasting interventions induce more change (although below we discuss studies that show significant change after minimal intervention). These studies also show that engaging students in explicit discussion and reflection about epistemological issues arising during their scientific inquiry induces more change (in survey or interview-based studies), compared to controls involving only the inquiry itself (Bell, Matkins, & Gansneder, 2011; Elby, 2001). Salter and Atkins (2014), however, problematize this finding, as we discuss below.

Typically, intervention studies of epistemic cognition in science have interpreted positive results as arising from particular features of the intervention, such as specific scaffolds or assignments. However, discipline-based education researchers in mathematics and physics (e.g. Schoenfeld, 1988; Elby, 2001) also document the effects that a more general classroom culture—what Muis, Bendixen, and Haerle (2006) call *epistemic climate*—can have on students' epistemologies and associated approaches to learning (Muis & Duffy, 2013). This more holistic view of learning environments is a promising construct that invites ethnographic research methods not yet common in this field (e.g. Kelly, this volume).

### *Correlating Epistemological Beliefs to Other Constructs*

As epistemic cognition has become more established as a focus of research, more studies have correlated it to other constructs and outcomes, such as achievement measures (Tsai, 1998), conceptual understanding (May & Etkina, 2002; Stathopoulou & Vosniadou, 2007), and self-regulated learning (Muis & Franco, 2009). For instance, Chen and Pajares' (2010) quantitative path analysis showed that sixth-grade students' implicit theories of ability—as fixed or as malleable based on effort (Dweck & Leggett, 1988)—influence their epistemologies, which in turn influence their goal orientations (understanding versus succeeding in school), self-efficacy, and achievement.

A small but growing literature has also been exploring relations between epistemologies and particular scientific practices such as argumentation (Khishfe, 2012; Ryu & Sandoval, 2012). For example, Mason and Scirica (2006) had eighth graders read texts about climate change and genetically modified food. The texts presented both sides of a debate. Then, "students were asked to generate an argument, a counterargument, and a rebuttal for each topic" (492). Controlling for students' knowledge about and interest in the topics, the researchers found that the quality of students' responses correlated with their epistemological sophistication based on Kuhn et al.'s (2000) survey.

### *In Situ Case Studies of Epistemic Cognition*

Chen and Pajares (2010) and Mason and Scirica (2006) reflect a trend of testing specific, theory-driven hypotheses in quantitative studies. There is also a trend toward more qualitative and mixed methods research, including *in situ* case studies (Hammer, 1994; Lising & Elby, 2005; Louca, Elby, Hammer, & Kagey, 2004; Brickhouse, 1990; Tuminaro & Redish, 2007; Fives & Buehl, 2008; Russ & Luna, 2013). As Schraw and Sinatra (2004) note in their introduction to a special issue of *Contemporary Educational Psychology* devoted to personal epistemology, "The studies published here [suggest] a movement toward methodological variety that is healthy for a growing discipline" (98).

For example, Rosenberg et al. (2006) analyzed how eighth graders worked to synthesize "the rock cycle." The students began by finding terminology in worksheets they had previously completed and using those terms to create an ordered list of steps—a mode of epistemic activity the authors described as "cut and paste." The teacher's intervention was entirely epistemological, telling the students it was a mistake to use "a lot of words [when] you don't know what they mean," and "to start with what you know, not with what the paper says." This took no more than 30 seconds, but it prompted a shift in students' epistemic activity to telling a causal story of how one geologic process leads to the next. The authors argued that the students, as a group, were capable of taking multiple epistemological stances; the "cut and paste" mode of activity corresponds to treating knowledge as piecemeal and taken from authority, while the "causal storytelling" mode of activity corresponds to treating knowledge as interconnected and personally constructed. Such case studies both motivate and illustrate alternative conceptualizations of epistemic cognition, as discussed below.

### *Epistemic Cognition of Teachers*

NOS research has long focused as much on teachers as on students (Brickhouse, 1990; Lederman, 1992; Abd-El-Khalick, Bell, & Lederman, 1998). Numerous studies show ways to help teachers develop more sophisticated NOS beliefs. The evidence is much less clear, however, that such interventions affect their teaching (Akerson, Buzzelli, & Donnelly, 2010; Lederman & Zeidler, 1987; Abd-El-Khalick et al., 1998). Research suggests that the scant influence of teachers' NOS knowledge on their teaching stems both from the multiple demands and constraints they face in the classroom, and from the limited connection most professional development makes to teachers' day-to-day experience (Duschl & Wright, 1989; Garet, Porter, Desimone, Birman, & Yoon, 2001). A promising direction for the field is to document changes in teachers' classroom practices over several years of more connected NOS-centered professional development.

Research with origins in personal epistemology research has also begun to focus more on teachers (Russ & Luna, 2013; Schraw & Olafson, 2008; Zangori, Forbes, & Biggers, 2013). A common finding is that the beliefs and vision of teaching and learning expressed through interviews/surveys is more student-centered and epistemologically sophisticated than the beliefs/visions enacted in the teacher's classroom practices (Beyer & Davis, 2008; Bryan, 2003; Tobin & McRobbie, 1997). As the above-cited work shows, this may reflect classroom and curriculum constraints, teachers' lack of confidence or skill in implementing student-centered lessons, or, as we discuss below, contextual sensitivity.

## EMBEDDED ASSUMPTIONS AND ALTERNATIVE PERSPECTIVES

In this section we challenge some assumptions embedded in current trends and describe alternative perspectives researchers have developed.

### *The Form (Ontology) of Epistemic Cognition*

Reflecting the field's origins in developmental psychology and NOS research, most studies use surveys or interviews to probe students' or teachers' epistemological *beliefs* or *stages* and then assume those beliefs are in play when they engage in learning or teaching. A growing body of research shows, however, that the epistemological "beliefs" students display may vary not just across domains but also across activities and contexts, even within a given topic (Leach et al., 2000; Lising & Elby, 2005; Bell & Linn, 2002; Muis & Gierus, 2014). For this and other reasons, some researchers challenge the assumption that epistemic cognition consists of enacting beliefs, on both methodological and theoretical grounds.

Sandoval (2005) and his colleagues (Sandoval & Millwood, 2007; Ryu & Sandoval, 2012) study the *practical epistemologies* students enact and display within epistemic activities in science, such as argumentation or reading. Practical epistemologies, they have shown, may have little to do with the views about professional science that students espouse on NOS surveys. Accordingly, Sandoval and colleagues have explored how students' engagement in argumentation both reflects and indicates students' epistemic cognition. Salter and Atkins (2014) showed discrepancies between the epistemologies that elementary education majors showed during their investigations in a course designed to support their learning science as inquiry versus in their responses to the Views of Nature of Science semi-structured interview protocol (VNOS-C; Lederman et al., 2002). Most participants gave similar responses pre- and post-semester, sometimes almost word for word, suggesting that they were reciting previously learned "answers." Their epistemic cognition while immersed in inquiry was more sophisticated than what they displayed in their VNOS-C responses.

We (Hammer & Elby, 2002; Hammer, Elby, Scherr, & Redish, 2005) have argued for a "resources-based" view, a schema theory of epistemic cognition as involving a rich variety of cognitive resources for understanding knowledge and how it arises. Epistemological resources include, for example, *direct perception, transmission, construction*, and *free invention* as ways of understanding how one comes to know something, and *hypothesis, rule, prediction*, and *assumption* as ways of understanding various forms of knowledge. These resources may be active or not in a given situation, so no single view of knowledge is the individual's "real" epistemology. A student getting a phone number understands knowledge as transmitted by authority; the same student, studying chemical bonding, may understand knowledge as constructed. Similarly, a student's responses to a NOS survey may not align with the student's epistemic cognition during scientific inquiry.

Other researchers conceptualize epistemic cognition as an aspect of social practices (Kelly, this volume; Kelly, McDonald, & Wickman, 2012), "a concept of epistemology that is more social and transactional, one which is more situated as consequences in on-going communication, action, and practice" (Östman & Wickman, 2014, p. 375). Rather than looking inward to cognitive structures within an individual, this view of epistemologies looks outward, with epistemology reflecting membership in a community and participation in its practices. Bang and Medin (2010), for example, discuss the possibly contrasting ways of knowing Native American students' experience as students in school and as young members of their tribes. Both social contexts value knowledge about the natural world, with rich and deep traditions for developing and assessing that knowledge. Native practices, for example, focus more on ecological contexts, grouping organisms by the network of their relationships, while Western practices focus more on evolutionary contexts, grouping organisms by genus, class, and phyla. These authors emphasize the importance of students' learning to navigate and coordinate multiple epistemologies, entangled with their multiple communities.

### *Context Dependence or Independence in Assessing Sophistication*

Almost all studies in this field conceptualize epistemological sophistication as believing that knowledge is tentative rather than certain, constructed rather than transmitted from authority, and subjective rather than objective, as described above. We and others have argued, however, that this is too simplistic; sophistication depends on the situation. For instance, treating Newton's second law of motion ($\mathbf{F} = m\mathbf{a}$) as objectively correct can be productive when trying to make sense of that law, while students treating the law as tentative and subjective may unproductively accept apparent contradictions with common sense rather than working to reconcile those contradictions (Elby & Hammer, 2001).

In a study probing college students' reading about climate change, Bråten et al. (2008) found that "in this complex reading-task context, source [of knowledge] beliefs usually located at the sophisticated ends of epistemic belief continuums turned out to be maladaptive, presumably because they distracted from the building of a high-quality representation of author and text meaning" (814). We have similarly argued it can be productive for students to accept ideas they find in their textbooks, provided they do not conflate *acceptance* with *understanding* (Elby & Hammer, 2001).

Bromme et al. (2008) argued that current assessments of personal epistemology are flawed because they do not acknowledge "division of cognitive labor." Instead, questionnaires often falsely treat the participant as an "independent and active information seeker" (436) operating directly on personal experience. Assessments should therefore recognize that participants operate in communities of inquiry, in which it is not only appropriate but also necessary for members to have different levels of expertise (Kelly, Chen, & Prothero, 2000; Bang & Medin, 2010).

### *Conceptualizations of Progress*

A growing body of literature problematizes the assumption that students' epistemic cognition progresses from "lower" to "higher" stages of development as a succession of belief systems.

One challenge to this assumption is evidence of moment-to-moment dynamics, not only from *in situ* case studies as we noted above, but also in experimental studies. Porsch and Bromme (2011), for example, constructed two texts on the same material, designed to cue different stances toward knowledge: as simple and certain (emphasizing accuracy of predictions), or as evolving and constructed (emphasizing theoretical controversies). Randomly divided subjects showed different epistemologies, not only on a formal instrument but also in their choices and assessment of sources. Other studies have similarly succeeded in cuing epistemological stances (Kienhues, Bromme, & Stahl, 2008; Muis & Gierus, 2014).

Chandler et al. (2002) questioned how it could be that longitudinal studies show a similar developmental pattern of absolutism then relativism then evaluatism, regardless of subjects' ages. One explanation Chandler et al. offered was that development is recursive and that regression to earlier stages is probable. Accordingly, Bendixen and Rule (2004) proposed that epistemological development is spiral-like rather than linear. We further speculate that changes in educational contexts may serve as an impetus for such recursion to occur (see Muis et al., 2006).

Still, the suggestion of spiral-like recursion to rescue a development scheme from empirical challenges reminds us of how Ptolemaic astronomers rescued their model of the solar system. They posited "epicycles," circular orbits nested within circular orbits around the Earth, adding new epicycles as more precise measurements challenged the model. The system could match astronomical observations, but a heliocentric system with elliptical orbits turned out to be simpler and just as accurate.

The appearance of epicycles in a theory alerts us to at least consider a paradigm shift toward a different theoretical framework. To be sure, a number of developmental psychologists have been moving away from simple stage-based accounts of development and toward accounts of emergence from complex dynamics:

> The data … argue for a move away from universalist and comparative approaches and toward approaches that recognize as a central phenomenon the pervasive variability in children's thinking. This variability seems to be present in every area of higher level cognition, just as at all lower levels. (Siegler, 1996, p. 81)

We have proposed a conceptualization of progress toward epistemological sophistication based on growing and refining stabilities in patterns of resource activations (Hammer et al., 2005). Watkins et al. (in press) presented such an account of elementary school teachers' progress over three years of professional development. By the end, the teachers' engagement in inquiry and explicit comments about science evidenced the activation of coherent networks of resources corresponding to sophisticated "beliefs." The authors found similar evidence in the first summer, but only in brief moments. Watkins et al. (in press) argue that the teachers' epistemological progress largely consisted of their becoming more stable in practices of sense making, stability resulting in part from metacognitive awareness.

### *Defining Epistemology*

Early descriptions of epistemological stages mixed views about knowledge and knowing with affective and identity-related aspects of development, as discussed above. As the field evolved, everything except beliefs about knowledge and knowing was stripped away from the construct. Most research in the field follows Hofer and Pintrich's (1997) and Sandoval's (2005) call to restrict "personal epistemology" to views about knowledge and knowing, in order to align with philosophers' definition of "epistemology" and to achieve a clarity and limited scope that enables researchers to communicate effectively and build on each others' work (Sandoval, 2009).

This narrow scope of "epistemology" and the conceptualization of epistemology as *beliefs* has been challenged in two ways. We have argued that the cognitive structure of students' ideas (e.g. whether their views about knowing are inextricably tangled with views about learning) should determine what counts as "epistemology," not philosophers' definitions (Elby, 2009). More powerfully, however, Chinn et al. (2011) argue that restricting epistemology to belief-like views about knowledge and knowing is philosophically out of date; current philosophy literature on epistemology is more inclusive. Chinn et al. argue for expanding epistemology to include dimensions such as what students take to be reliable versus unreliable processes for achieving their epistemic aims. More radically, they argue for including non-belief-like constructs such as epistemic aims (e.g. deep understanding or sufficient knowledge for an exam) and epistemic virtues and vices (roughly, epistemologically productive and unproductive habits of mind).

## FUTURE DIRECTIONS

Usually, a field is seen to be making progress when construct definitions approach consensus and methods coalesce around a few techniques. But given the above challenges to the status quo, along with a healthy proportion of surprising or anomalous results as discussed by Chandler et al. (2002) and Chinn et al. (2011), we think the best way forward is for a significant portion of research to take a step back and treat this field as being in its early childhood. This means embracing theoretical and methodological diversity, not for its own sake but because we honestly do not know which mix of theoretical perspectives and methodological orientations will be most productive.

Furthermore, to make progress toward finding productive constructs and mechanisms around which to organize our work, we—following Sandoval (2005), Muis (2008), Chinn et al. (2011), and our own prior work—advocate a greater focus on documenting epistemologies in action during learning activities. Ideally, some such work would continue to build on pre-existing instruments and constructs. For instance, Muis (2008) administered standard surveys probing mathematics students' epistemologies and learning strategies, but she also engaged participants in problem-solving sessions. Coding for metacognitive and epistemological aspects of students' actual solutions enabled Muis to not only check for consistency with the student profiles gleaned from the surveys, but also to flesh out what those profiles look like in action.

Other studies of epistemic cognition in action, we think, should take a fine-grained, bottom-up look at stabilities and shifts in students' and teachers' epistemological stances and how those stances dynamically interact with students' conceptions, metacognition, and emotional states. By allowing ourselves to take into account multiple aspects of participants' thinking and experience, we increase our chances of finding ecologically valid and generative ways to conceptualize epistemic cognition in science. The Rosenberg et al. (2006) study involving the rock cycle exemplifies such work because the "toy" cognitive models (simplified accounts intended to provide a rudimentary sense of mechanism) of the group's cognition during the "cut and paste" and "storytelling" parts of the episode were based closely on the data rather than fit to pre-existing models.

In such studies, as well as in the type carried out by Muis (2008) described above, the range of contexts over which students' or teachers' epistemologies show theory-like coherence is determined empirically rather than assumed in advance (e.g. Smith & Wenk, 2006; Elby, 2011; Muis & Gierus, 2014). When the field has produced many local models across a range of populations and learning contexts, work toward a global, unified theory of epistemic cognition will be more grounded in the phenomena of interest.

We see the field continuing to make progress toward documenting complexity. Research now takes place at a wide range of scales, both in time and in the units of analysis: it includes studies of moment-to-moment dynamics as well as of beliefs persisting over time, and it includes studies focused on the personal epistemologies of individuals as well as those focused on epistemologies inherent within the social practices of a community. Models of epistemic cognition have progressed from Perry's single dimension of development to multiple dimensions to accounts of manifold resources, practices, and shifting epistemological stances.

We suggest that, in these various ways, and like research on conceptual knowledge (Amin, Smith, & Wiser, 2014), research on epistemic cognition is moving toward and will benefit from complex-systems perspectives and approaches, attending to the dynamics of change and stability at multiple scales. Dynamic systems approaches have been productive in other areas. For instance, early models of infants' development of motor coordination during walking or reaching posited top-down cognitive "controls" that relevant muscles gradually become able to carry out. By contrast, Thelen and Smith's (2007) dynamics systems models show progress from bottom-up local emergent behavior to the formation of stable patterns of feedback and stabilization between brain and body. Similarly, models of development of epistemic cognition were formerly conceptualized in terms of top-down "stages," but now some researchers are taking a dynamic systems approach, modeling "progress" as refinement and stabilization of bottom-up patterns of thought and action.

Writing about research on development more broadly, Thelen and Smith (2007) posited two themes of a dynamic systems approach:

- Development can only be understood as the multiple, mutual, and continuous interaction of all the levels of the developing system, from the molecular to the cultural.
- Development can only be understood as nested processes that unfold over many timescales from milliseconds to years. (Thelen & Smith, 2007, p. 258)

We see these themes as generative for future work in research on epistemic cognition, although perhaps not to the extremes of molecular and millisecond scales. A developmental theory of epistemic cognition should situate such cognition in the settings in which it occurs and explore the consequences of participation in these settings at multiple timescales. It should be usable by educators and researchers both to design productive instruction and document and explain its consequences for individual students. It should span microgenetic, sociogenetic, and ontogenetic scales (Sandoval, 2014).

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# 9

# EPISTEMIC COGNITION IN HISTORY

*Bruce VanSledright and Liliana Maggioni*

## INTRODUCTION

The empirical study of epistemic cognition, and of the beliefs people hold that affect it, spans a relatively long history, beginning perhaps at least with Piaget (1950), who in turn influenced scholars such as Perry (1970) in North America. Systematic work in the domain of epistemic cognition in history is much more recent. In part, the late entry of such studies of discipline-specific epistemic beliefs and cognition might be understood as originating in a renewed, 1980s focus on important differences in how disciplines structure and defend knowledge claims and especially on the roles such differences play in learning (e.g. Alexander et al., 2011; Buehl & Alexander, 2001; Donald, 2002; Gardner & Dyson, 1994).

In this chapter, we steer attention toward theoretical and research work dealing with epistemic cognition and beliefs in and about history. Generally speaking, we leave aside a review of domain-general work (e.g. Baxter-Magolda, 1992; King & Kitchner, 2002; Kuhn & Weinstock, 2002; Perry, 1970). It is treated in other chapters in this volume. Although that line of research has influenced more recent studies of epistemic cognition in history, space limitations prevent us from doing little more than noting its relevance.

Our principal goal is to review what we have learned from studies of epistemic cognition in history to date. In doing so, it will become clear that we align ourselves with the idea that, if we are concerned about improving learning in academic subjects such as history, understanding discipline-specific patterns of epistemic beliefs and cognition matter. They matter because early indications suggest that certain types of epistemic beliefs about what history is, and how its knowledge is created and justified, inhibit the types of historical thinking that research on cognition in the domain have shown to be associated with enhancements in historical understanding. Other types of epistemic beliefs about the domain are more adaptive to advances in understanding. As we proceed, we consider implications for thinking about and understanding history and their relationships to educational practices. We end by building arguments concerning ways we may advance research in this area and why more systematic, empirical research is necessary.

Making sense of the past, or doing history, quickly pushes investigators into a series of relatively unique epistemic problems (e.g. what to do when witnesses from the past tell conflicting stories about the same event). These are not easily resolved because all that remains from the past are accounts, not the witnesses themselves. We cannot ask the dead to "set the record straight" for us, nor can we design controlled experiments to test their claims' trustworthiness.

In working out such problems, an inquirer must engage in heady acts of cognition that in turn depend upon the power of his/her epistemic beliefs. The more finely nuanced, consistent, and coordinated those beliefs, the greater the likelihood the inquirer will be up to the task of successfully addressing history's problems of understanding. Conversely, naïve, inconsistent, uncoordinated beliefs will hinder cognition and grind history to a halt (see Lee, 2004). As a result, noting epistemic cognition-in-action is only part of the story. Researching the beliefs that underpin those acts seems to be another crucial part if educators have any hope of cultivating understandings that allow history to be accomplished. Understanding those beliefs can be difficult, as we will show. Equally problematic is establishing with any precision the nature of their origins and how they develop and change. These difficulties are compounded by the role history plays in shaping putative collective memories and the high stakes people often place on cultivating "the correct" memories (e.g. Lowenthal, 1998; Seixas, 2000).

In what immediately follows, we explore briefly what psychologists have said about the nature of epistemic cognition and development that is relevant to history. We then turn to a similarly brief examination of how selected historians have attempted to wrestle with epistemic problems within the field and over time. Finally, we look at empirical studies in history education that shed some light on both cognition-in-action and its underlying belief frameworks. In this sense, we review work at the crossroads of at least three research and scholarly traditions: psychology, history, and history education.

## AT THE CROSSROADS OF RESEARCH TRADITIONS: A THEORETICAL OVERVIEW

### *The Psychological Literature on Epistemic Cognition Relevant to History*

The psychological literature has explored the trajectory of individual epistemic development and the influence on learning of conceptualizations regarding the nature and justification of knowledge and of ideas about how knowing unfolds. It has done so within different theoretical frameworks, each characterized by its own set of assumptions regarding the nature of the construct investigated and its potential relations with other psychological constructs and cognitive and affective outcomes (see Bendixen & Feucht, 2010; Brownlee, Schraw, & Berthelsen, 2011; Hofer & Pintrich, 2002 for an overview of different research frameworks).

Although we appreciate differences among assumptions that characterize each theoretical model, we focus here on what we believe are a few shared understandings emerging from these diverse research traditions that are salient to the specific domain of history. We do so while using as much as possible the terms used in the original research to refer to the specific constructs investigated to signal the limits of our attempt, since only a partial overlap exists between different theoretical frameworks.

Psychology researchers have quite consistently reported that epistemic development correlates to individuals' increasing capacity to view knowledge as the outcome of the integration of objective and subjective factors (King & Kitchener, 2002; Kuhn & Weinstock, 2002; Perry, 1970). It has also identified the emergence of consistent relations between specific epistemic beliefs (e.g. complexity of knowledge) and adaptive learning goals (e.g. comprehension of single and multiple texts; see Khine, 2008 for an overview and Strømsø & Kammerer, this volume).

From a broader developmental standpoint, epistemic development appears to be closely intertwined with the development of consciousness, that is, with how individuals attribute meaning to and organize their experience (Kegan, 1994; Piaget, 1950). In summarizing the results of her 20-year longitudinal study of young adult development and learning, Baxter-Magolda (2008) described development as a movement from dependence on external authorities in deciding what to believe, toward how to identify one's own voice, and then relate it to others with increased reliance on that internal voice in a process of attaining self-authorship. Belenky et al. (1986) also explored how women came to rely on, develop, and integrate different kinds of voices to understand the world, themselves, and their relationships with others. As Perry (1970) and Kegan (1994) observed, such journeys were not always linear, as suggested by strict stage theories, nor were they painless. Learning to rely on criteria internal to the self to navigate the complexity of knowledge growth was difficult.

Although psychological research on epistemic development has traditionally focused on young adults, researchers studying the epistemic development of young learners have suggested that children also can access a variety of epistemic resources. Despite lacking in consistency across contexts, children form judgments compatible both with a view of knowledge as "propagated stuff" (i.e. transmitted) and with a view of knowledge as constructed (Elby & Hammer, 2010). Children's epistemic beliefs also are amenable to change in relation to a specific knowledge domain when they are exposed to experiences specifically designed to foster epistemic development (De Corte, Op't Eyende, Depaepe, & Verschaffel, 2010; Elby & Hammer, 2010; VanSledright, 2002).

Psychology researchers have consistently found positive relations between individuals' capacity to consider and integrate objective and subjective factors in the process of knowledge building and their learning outcomes. Kuhn and Weinstock (2002) defined this more integrated level of epistemic cognition evaluativism. Yet, defining with precision the set of beliefs that typify the construct of evaluativism has remained a challenge. What does evaluativism look like in students and teachers? How does it get translated in the context of the classroom? What exactly does the integration between the subjective and objective aspects of knowing look like, and what criteria are especially helpful in getting individuals out of the quagmire of purely relativist thinking (Bendixen & Feucht, 2010)?

### *Historians on Theorizing Episteme in the Discipline*

Thucydides' introduction to his history of the Peloponnesian War suggests that historians have confronted epistemic questions and problems all along. However, it is especially with the birth of the discipline of history in the late nineteenth century that historiographers, philosophers of history, and intellectual historians have sought to understand and debate them more explicitly. This work can be thought of as providing some guidance on how to conceptualize epistemic constructs in history.

One of the most notable treatises tracing out the relationships historical inquirers strike between objects from the past and the capability to make sense of what they mean is Peter Novick's (1988) seminal treatment in *That Noble Dream: The "Objectivity Question" and the American Historical Profession*. Although Novick considers almost exclusively a 100-year history of Americanist historians' views, the work is still revealing for the shifting beliefs they have held regarding the roles objectivity and subjectivity play in the interpretive process at the center of historical investigators' efforts.

Novick begins his treatment with a European legacy, that of German historian Leopold von Ranke. Ranke defined the task of historical work as the careful and methodologically strict pursuit of essences of the past, the extraction of pure facts. He argued therefore that, "The spirit from which things come, and the knower, will be one. In this theory of knowledge the most subjective is at the same time the most general truth" (cited in Kreiger, 1977, p. 11). Other German historians thought of such philosophical musings as quintessential German idealist episteme in the tradition of Hegel. American historians at the time heard Ranke pursuing positivistic and empiricist convictions in which the knower's subjectivity was bracketed out (or banished?) by an independent, scientific method's ability to reveal history as it actually was (objective realism). The Americans adopted the epistemic beliefs embedded in this (mis)interpretation of Ranke and built their profession around them (Novick, 1988, pp. 29–31).

With the exception of more pragmatic epistemic digressions of Charles Beard and Carl Becker in the 1920s and 1930s (for more, see Novick, 1988, Chapter 6; Strout, 1958), the objectivist and realist anchors held dominance until the late 1960s. Then they began to give way. The shifts took myriad courses but by the 1980s, following the linguistic turn in philosophy, it "ceased to be axiomatic that the scholar's or scientist's task was to represent accurately what was 'out there'" (Novick, 1988, p. 523). Skepticism followed and relativistic attitudes overtook objectivism. The critique of the objective realist's project suggested that a past revealed in timeless certain truth by a detached knower, who could corral her unwitting subjectivity, had evaporated. The knower's theory-laced interpretive operations, her individual protocols for reading, her investigative values and predispositions now were understood as the decisive measures in determining what was the past. Objects and accounts held no meaning other than what an interpreter gave to them. A wholly accurate, objective account of the past could not be fully researched and written, much less known for certain. Suspicions about the authority of knowers followed and traditionalist backlashes ensued (Novick, 1988).

For researchers interested in studying beliefs about knowledge and its warrants that underpin acts of epistemic cognition among learners in history, the discipline of history and projects of historiography and philosophy of history offer some, but far from precise guidance on defining constructs (and even less help in thinking through how to build measures of them). If there is an objective past, can a knower know it? And if so, how could a knower know himself for sure to be knowing it? What does it mean to believe that one can know an objective past and then warrant that he or she is on to the truth of it? If this position is no longer tenable (as some historians have noted), then is it reasonable to believe that anything goes because it is a subjective free-for-all in the sense we make of the past? Or is there a theoretico-methodological-criterial regulatory process to arbitrate among claims to truth? By whose authority would such a system work? These questions are difficult to resolve, and they anticipate at least some normative judgment from both within the field of history and beyond it. Researchers of epistemic cognition in specific learning contexts, for example, would likely prefer sharper and less tendentious conceptual sticks.

More recently, historian Allan Megill (2007), building off the work of David Hackett Fischer (1970), offered a four-part description of distinctions he believes analysts can make about what he calls "four senses of objectivity" (p. 114). Each presupposes an interconnected disposition toward a knower's subjectivity. Researchers studying epistemic cognition in history through beliefs might imagine these "senses" as clusters of beliefs that individuals tend to favor as they orient themselves to the world and toward the past. Conceived as such, they might provide sharper relief.

The first sense Megill (2007) refers to as *absolute objectivity*. Absolute objectivists believe that a god's-eye view of the world is possible, that epistemic neutrality and aperspectivalism are attainable, and that subjectivity can be bracketed out. A cousin of absolute objectivity is what Megill calls *procedural objectivity*. Procedural objectivists also attempt to exclude subjectivity as a source of error and bias by relying on methodological rigor that stands independent of the inquirer. They share much in common with the absolute objectivists but appear to have relinquished the belief that a god's-eye view is achievable. A third sense is *disciplinary objectivity*, wherein a community of inquirers (a discipline, say, history) holds consensus about what counts as truth and regulates acceptance of claims to know and the warrants that justify them (e.g. evidentiary support). A knower's subjectivity here is bent to the will of the disciplinary community.

Finally, there is *dialectical objectivity*. Dialectical objectivists believe that a measure of objectivity is attainable if enough expertise (both methodological/syntactical and substantive) can be brought to the interaction between knower/subject and objects from the past. Subjectivity here is harnessed to produce "discovery and advance of knowledge" (Megill, 2007, p. 114). Subjectivity by these lights is crucial to how inquirers conceive of objects, perhaps not unlike what his fellow Germans thought Ranke had in mind.

Megill suggests that most current practicing historians adhere to a sense of either disciplinary or dialectical objectivity or some combination of the two.[1] Historian James Kloppenberg (1989) had earlier attempted to describe what he called "a pragmatic hermeneutics that relies on methods of science and the interpretation of meanings" (p. 1028) that describes an objectivist middle ground to which he thinks the disciplinary community of historians should aspire. We take him to be referring to what Megill means by some combination of disciplinary and dialectical objectivity.

In historical cognition and following Kloppenberg's implication, we might think of Megill's four senses of objectivity as laying along a continuum, each valuing objectivism while trying to harness, control and/or eliminate the necessary, but error-prone propensities of subjectivities.[2] However, Megill offers no similar history-specific set of "senses of subjectivity," or "senses of relativity," although one might argue that they are implied by his characterizations of objectivity. These other senses would be potentially useful additions.

Some historians seem to suggest that the subjectivity of the knower, far from being a necessary evil, is the enabling condition of historical knowledge, thus broadening the epistemic landscape to include the role subjectivities play. Marrou (1954/1988), for example, noted that in history, "knowledge of the human being by the human being [involves] perception of the past through…living, effortful, human thought;

it is a synthesis, an unbreakable union of subjects and object" (pp. 119–120). Among other things, such effort entails the critical analysis of the documents (or other traces of the past), illuminated by knowledge of the specific historical context in which they originated, and by understanding the human being and human life in general. Such an approach sheds additional light on the nature of the knower's (subjective and impositional) engagement with the objects from the past and implies useful interpretive criteria. It also mirrors the complex, yet intimate relationship between knowers/subjects and objects of knowledge described in the developmental psychological literature. Nonetheless, defining and assessing such constructs remains a slippery landscape, as psychologists have learned.

The discussion thus far seems to beg the question: What are researchers who are interested in school-aged people's epistemic development in history to do with naïve epistemic belief systems, those held by young learners and historical thinkers who have experienced few opportunities to wrestle with epistemic problems in the field? For example, it is not uncommon for young learners to express a simple faith in the power of objects (e.g. a textbook account) to tell the past as it was, or to become historically and epistemically "stuck" when two or more accounts from the past conflict or contradict (Lee, 2004). In such cases, what might researchers conclude about these learners? Are they absolutists in the naïve sense suggested by Kuhn and Weinstock (2002)? Or do they simply lack the capability to fully engage in epistemic cognition because their belief systems are naïve and/or underdeveloped, and in this way then could be thought of as pre-epistemic? Where along a continuum of beliefs might they be with respect to the relationships between Megill's and Kloppenberg's objectivists and Marrou's subjectivist?

Some might be tempted to equate Megill's (2007) absolute objectivist with the naïve absolutist stance posited by Kuhn and Weinstock (2002), for example. However, Megill offers little to indicate that his version of absolute objectivity is naïve. Unattainable in its fullest sense? Likely, but not naïve. We think Megill is saying that absolute objectivity is a coherent and epistemically reasoned regulative ideal in history, and so he differs here from, say, Kuhn and others in psychology precisely because his kind of objectivity *regulates the relation* between the historian and the objects that provide access to the past. Yet, it is important then to observe that Megill is not a developmental psychologist and appears more interested in describing *coordinated* belief systems utilized by historians. For such characterizations to be useful to developmental researchers would require distinguishing Megill's absolute objectivist, who holds a coordinated, refined belief system, from the naïve and uncoordinated belief "tendencies" of Kuhn and Weinstock's absolutist, thus adding more nuanced sets of epistemic senses along a continuum of characterizations. Such additional senses might help to fill in a broader range of constructs on a beliefs continuum that, in turn, may help researchers better understand steps in the development of epistemic cognition in history. It might also alert developmental researchers and educators that notions of epistemic naïveté and epistemic adaptiveness are intrinsically complex and multifaceted, thus portending methodological approaches in tune with its nature.

These types of considerations mean that answering the sorts of developmental questions we have posed remains a high-inference operation in history education. To lower inference levels, we need additional data on learners' underlying beliefs and systems of beliefs and the sources from which they emerge. Doing so returns us to the problem of operationalizing constructs in ways that enable research. The work in a third line of scholarship shows some initial promise.

## EMPIRICAL STUDIES OF EPISTEMIC COGNITION IN HISTORY

Despite abiding interests in studying historical cognition in history and the epistemic problems that emerge as a means of framing the types of thinking efforts that promote deep historical understandings, history education researchers until more recently have generally bypassed the direct study of epistemic beliefs about history and their influences on learning. We would speculate, as we have been alluding, that part of what might be at issue here is the complex terrain on which the study of underlying epistemic beliefs about history rests.

What we have been arguing is that, in order to develop research constructs and tools to make sense of thinkers' epistemic beliefs and, more importantly, how they impact the ways they understand the past and engage in acts of epistemic cognition in historical study, one must theorize about the range of possible epistemic beliefs people might hold. At first blush this might seem straightforward, as psychologists and historians might imply. There are the *objects* from the past (residua that can be known) in the form of accounts.[3] Then there is a knower or *subject*, who imposes her subjectivity on those objects in order to render them meaningful to her. The knower engages the historical objects in an *interpretive* process, while also being situated in a sociocultural context. Roughly speaking, researchers have at least three initial constructs to study in this conceptual scheme: objects, subjects, and interpretive procedures. A fourth construct may emanate from the sociocultural context in which a community's (potentially multiple) regulative ideals influence interpretive procedures.[4] The difficulty makes itself apparent when researchers attempt to define the constructs and especially to demarcate their borders to keep them relatively distinctive for study purposes.

The trickiest element perhaps is describing and defining the nature of the interpretive process, and deciding if one is even necessary to begin with. Do objects mean exactly what they say or convey? Is their meaning inherent and given in the object itself? If so, then we do not need an interpretive process; the object defines itself to the subject (in school history, this often seems to be the assumption). The subject simply apprehends the object's essential meaning and moves on to the next object. However, if the objects of the past do not speak in their own language, have no essences beyond the ones inquirers into the past attribute to them, the subject, or knower, is actively engaged in making meaning and an interpretive process is undertaken in which meaning is imposed on the objects.

What meanings can a knower impose? Is one meaning of a past object or account as good or useful as any other? If we say no, then some kind of *interpretive criteria* (additional constructs?) are implicated for arbitrating better from less useful impositions. Who decides what these criteria are and who arbitrates them in what context? Here, a justificatory system and who knowers (subjects) are to begin with enter in as at least two more matters for researchers to consider. Research on the development of historical thinking, the third tradition, shows signs of addressing some of these questions and sharpening our understanding of epistemic constructs and theories involved in understanding the roles epistemic beliefs play in history and how they develop.

### *Studies of Epistemic Cognition-in-Action*

Researchers in the United Kingdom (UK) have long sought to understand various aspects of learners' cognition in history and place them on developmental trajectories (see Shemilt, 1980). Doing so has considerable import for history education. Much of the work in the UK has centered on what researchers call second-order procedural concepts such as accounts, evidence, opinion/explanation, and cause (e.g. Lee & Ashby, 2000, Lee & Shemilt, 2003). In Project Chata, UK researchers undertook longitudinal studies of Grade 2 to Grade 8 students in order to understand progression (development) in ideas about such second-order concepts (Lee & Ashby, 2000; Lee, Ashby, & Dickinson, 1997). Two concepts—accounts and evidence—are revealing for what they might suggest about both progressions in historical epistemic cognition and the high-inference work involved in understanding the underlying belief frameworks learners hold, how they change over time, and for what reasons.

Peter Lee and Rosalyn Ashby (2000) drew from Chata's longitudinal data set to generate a sequence of growth in learners' ideas about how to handle the epistemic problems associated with constructing historical understandings from accounts. At the most naïve end of a continuum, learners depicted accounts as stories that basically all said the same thing, and thought that a story about the past corresponded directly to something that happened in the past; it was simply objective information (they seemed to be naïve absolutists, although the researchers did not use that vocabulary). As learners' cognitive capabilities advanced, they shifted to thinking that stories had authors as active contributors, and that differences in stories were therefore attributable to author distortion, bias, and/or dogmatism (movement toward what Kuhn & Weinstock, 2002, referred to as multiplists). Their most cognitively advanced study participants saw accounts as vehicles for allowing a knower to understand and (re)construct answers to her questions in line with criteria for turning such accounts into evidence (much like Megill's disciplinary objectivist, or perhaps the evaluativist of Kuhn & Weinstock).

Unlike the less advanced sets of ideas about accounts, this latter cluster offers the learner an adaptive way out of cognitive impasses because she possesses a stronger toolkit for imagining what to do when accounts are not isomorphic. She no longer is a slave to an account or mere opinion. She can draw from criteria for judging some accounts to be more trustworthy than others as evidence for making claims. As we noted, this perhaps implies the disciplinary sense of objectivity to which Megill (2007) refers. Although Lee and Ashby (2000) identified powerful pedagogical advantages tied to utilizing their research-based theories about cognitive progression regarding accounts, they did not offer data explaining the sources of learners' changing ideas or potential underlying epistemic beliefs forged for example by life and schooling experiences. Knowing the general direction of movement from less to more cognitively adaptive ideas regarding accounts (in the sense that impasses to historical understanding are overcome more easily) appears necessary, but is not fully sufficient for pedagogically accelerating change in epistemic beliefs.

A few years later, building again off Project Chata data, Lee and Denis Shemilt (2003) provided an explanation of progression in learners' ideas regarding the second-order concept of evidence. Evidence is a core epistemic concept in history. In order to make defensible knowledge claims, what is testified or described or argued in accounts must be transformed into evidence to support those claims. Evidence preponderance, at least in the discipline of history, typically provides a warrant for justifying knowledge claims. How learners progress in their ideas about evidence is a crucial understanding with important pedagogical implications. Lee and Shemilt (2003) provide a six-part progression of ideas regarding evidence that appears similar to the list Lee and Ashby (2000) offered regarding accounts. We see epistemic content in their descriptions.

However, we must infer the underlying (and shifting) epistemic beliefs held by participants in Project Chata, and the sources that enable them to respond the way they did to epistemic history problems encountered in the study. We survey three points on their continuum in order to demonstrate the range they suggest.

At the least advanced level, learners (not necessarily the youngest in the study) understand evidence, to the extent that they perceive it as such, as accounts, offering direct access to the past. Such learners did not distinguish the past from the present (all accounts were simply stories), and therefore do not typically ask questions about the nature of historical statements or claims to knowledge. At a middle level, learners have shifted to a realization that evidence can be understood as testimony. Learners begin to understand that doing history involves certain methods for testing truth claims. They tend to arbitrate conflicting testimonies by attempting to tell the difference between truth-telling and lying (an objective truth exists but sometimes witnesses tell lies or exaggerate). This truth–lie dichotomy eventually can evolve toward the idea that, when confronted with the epistemic problem of how to proceed when all witnesses might be thought of as exaggerating or distorting the truth for various, sometimes legitimate reasons, the learner attempts to borrow the most accurate statements of the witnesses and pastes them together in a synthetic move. Sound criteria for knowing the difference between accuracy or the lack thereof, though, are mostly absent. Here, the knower's personal, experience-based opinions tend to rule decision making.

Learners at the most advanced (but not always the oldest students) point on the progression continuum in their study of history came to the conclusion that accounts only yield evidence when they are placed in historical context and contexts can vary across time and place. To extract evidence from accounts, learners noted that authors needed to be questioned about who they were, and to whom they were speaking and why, if a better understanding of situational context was to be achieved. However, learners also thought that it was difficult to fully comprehend contexts, so knowledge claims must be understood as provisional.

Such ideas and cognitive moves suggest some coordination between knower (subject) and what can be known (object) that anticipate or implicate the operation of regulatory criteria, such as realizing that drawing evidence from accounts to make claims depends on historical context, and therefore that many accounts and much critical analysis of them is required with a degree of intervening suspended judgment. Learning progressions may suggest epistemic movement, for example, from absolutist to multiplist to evaluativist in Kuhn and Weinstock's (2002) conceptual scheme. However, Megill's (2007) four senses of objectivity do not seem to overlap as well. Without more direct data on what epistemic beliefs students hold about history (e.g. justificatory systems), why they hold those particular beliefs, and under what circumstances they elect to deploy them, these differing characterizations remain only inferences.

Some of Sam Wineburg's early empirical work involved efforts to understand epistemic cognition among adolescents and historian experts. In one notable study he examined what he called epistemology of text. He explored differences in epistemic attitudes experts and smart adolescents enacted in the reading of historical accounts (Wineburg, 1991). He then speculated about the sources from which differences in epistemic beliefs emerged.

Historians read the accounts in search of subtexts, those that guided the ways in which authors were thought to be generating efforts at meaning with respect to whom they imagined they were speaking at the time. The historians seemed to think of texts as communications between the author and her audience and were therefore sensitive to what the texts were trying to do, beyond what they were saying. Therefore, authors' intentions, purposes, and goals served as the primary foci of the historians. They appeared to read accounts in order to answer their questions, turning accounts into evidence (or not) in the service of making claims that were situated in the historical context in which the texts were originally produced (disciplinary objectivists? evaluativists?). By contrast, the smart high school students, despite knowing much about the past, read the same texts as though they conveyed meaning in a straightforward way. They regularly missed subtextual cues, preferring to think that the texts simply served to forward their search for neutral, objective information about the past that could be used to circle the correct answer on a multiple-choice test (absolutists?). Not only were subtexts invisible, reading the historical context in which authors were situated escaped the students as well.

Wineburg (1991) conjectured that such differences in epistemologies of text can be attributed to education. He argued that, unless readers are taught explicitly to see that texts, especially historical ones (i.e. accounts), contain subtexts that are inextricably linked to the larger historical context in which they appear, they remain invisible. He suggests that the way students learn to read texts in school (e.g. repeated exercises in search of a paragraph's main idea) work against an epistemology of text that cultivates deeper historical thought. Epistemic beliefs that shape impoverished cognition in history, by these lights, are the result of miseducation. Learning to read in school tends to produce and then reinforce naïve objectivist beliefs—that information, rather than a message from an author, is stored in an object—a text—and that if we just look carefully enough we can extract it without much fuss. Though Wineburg is only speculating here, data supporting his contentions can be seen in Paxton (1997, 1999) and Afflerbach and VanSledright (2001).

For these adolescents, and unlike the historians, the role of knower vis-à-vis what could be known did not seem especially well integrated; objects (accounts) overshadowed and displaced the adolescents as subjects. Knowledge was detached from knowing. Even though the adolescents could be thought of as intelligent novices, they appeared more epistemically similar to the students in Project Chata, who were at the beginning levels of progression in the ways they understood accounts and evidence. Yet, without more data about students' specific epistemic beliefs, it is difficult to know with any precision about their sources, and therefore what to do to shift them.

Twenty years after Wineburg's (1991) work with historians and adolescents, Avishag Reisman (2012) reported on a cognitive intervention study called "Reading Like a Historian" (RLH). It involved an effort to shift how high school students dealt with historical texts away from the objectivist stances reported earlier and toward the way historians reported attending to them. In a sense, RLH was designed to move students along the progression in understandings of both accounts and evidence, and therefore held promise for revealing changes in epistemic beliefs. Although the intervention demonstrated a number of successes especially with regard to gains in historical cognition and understanding, Reisman observed, "our measures for capturing historical thinking remain inchoate. Although our Historical Thinking findings suggest that students in treatment classes learned to apply disciplinary reading strategies, this measure did not capture students' understanding of the discipline's epistemology nor any affective or attitudinal shifts that students may have experienced" (p. 103). As she suggests, we are left to infer about epistemic beliefs and how they shift.

Chauncey Monte-Sano (2011) reported a study in which a high school history teacher, who made consistent demands on his students to support their claims about the past with evidence, succeeded in improving those students' writing capabilities, historical understandings, and especially their abilities to think historically. However, Monte-Sano did not document shifts in students' epistemic beliefs that may have occurred through the process of learning to justify historical claims with evidence, a potential core epistemic component of such historical cognition. Readers of the study are left to surmise whether students simply learned a technical process (e.g. supporting claims with evidence), shifted their epistemic beliefs, or both.

In 2002, Bruce VanSledright reported on an intervention among fifth graders who were studying American history. He noted a series of epistemic problems students encountered when they attempted to resolve a series of interpretive issues in which evidence did not appear to preponderate in ways that allowed students to offer convincing explanations. In those circumstances, a number of students insisted on turning to the textbook on the belief that its authoritative status could "fix" their interpretive problems. VanSledright referred to this strategy as reflecting an "encyclopedia epistemology," suggesting that students believed that there were texts available to us that could provide uncontested meaning. However, despite tracking changes in students' cognition-in-action, his study held no direct measures of students' possibly changing epistemic beliefs. Once again, we are left to wonder if the fifth graders learned technical procedures he taught them for managing interpretive problems in history while simultaneously changing their epistemic beliefs, or not.

### *Researching Epistemic Beliefs in History*

Some recent research in history education has worked at the intersection of learning to think historically and the epistemic beliefs that appear to enable or block it. Studies have focused on secondary and college students and history teachers, both prospective and practicing. Throughout these contributions, the definition of the nature of beliefs seems especially useful in generating new understandings. Elements of their developmental trajectory have been studied by drawing from a disciplinary perspective. Researchers have been able to offer a somewhat finer-grained description of such beliefs. This work originated on the assumption that knowledge and the process of knowing (underpinned by epistemic beliefs) cannot be detached. Therefore, the purpose of research has been to more deeply understand the relations between learning to think historically and personal epistemic beliefs about history. The hope was that teachers would use the work to plan educational experiences that fostered historical understanding *and* epistemic development, foresaw and recognized impasses, and located within them useful insights about how to help students along an adaptive developmental path.

Some of the most sustained work in this vein has been conducted by Liliana Maggioni and her colleagues (Maggioni, 2010; Maggioni, Alexander, & VanSledright, 2004; Maggioni, Fox, & Alexander, 2010; Maggioni, VanSledright, & Alexander, 2009a; Maggioni, VanSledright, & Reddy, 2009b; VanSledright, Maggioni, & Reddy, 2012). In 2001, they began studying epistemic beliefs among history teachers in the United States. Their interest was sparked by a hunch that many teachers' epistemic beliefs actually hindered their capability to make sense of the past, and to understand where and under what circumstances historical knowledge was developed and justified. They wanted to see how professional development efforts might shift teachers' beliefs.

To begin, Maggioni designed a set of statements and an accompanying six-point Likert-scale questionnaire to assess teachers' epistemic beliefs. She called it the Beliefs about Learning and Teaching in History Questionnaire (BLTHQ). The BLTHQ's 21 statements were divided among three clusters. One cluster reflected what were termed objectivist beliefs (the past can be objectively known), a second cluster was referred to as subjectivist beliefs (knowing is up to the subject or knower), and a third was termed criterialist beliefs (knower and objects interact to form and justify historical knowledge).[5] Analyses of the factor structure of the BLTHQ showed that it was compatible with its theoretical underpinnings (Maggioni et al., 2004). She and her colleagues also assessed the validity of the BLTHQ by administering it to a group of expert historians (Maggioni et al., 2009a).

They then refined the BLTHQ by retaining only those items that most clearly loaded on the factors identifying the three theoretically derived clusters of beliefs and adding new items on the basis of a study conducted with college students. They called this new measure the Beliefs about History Questionnaire (BHQ). Factor analyses of this new measure also were compatible with the three belief clusters hypothesized.

For 10 years, Maggioni and colleagues gathered and analyzed the data from the instrument. They initially administered it to teachers (N = 325) involved in professional development experiences through a pre–post method that allowed them to examine how beliefs shifted. Maggioni later conducted a study on the development of student epistemic cognition in three high school history classes (Maggioni, 2010; Maggioni et al., 2010).

The researchers had speculated that educational interventions and the professional development efforts would move teachers' and students' beliefs away from an over-reliance on objectivist or subjectivist commitments, and toward more integrated criterialist beliefs. Put in epistemic terms, they assumed that as teachers and students learned more about history, how it works, and how its knowledge claims are justified in the context of development and school programs, they would more frequently disagree with objectivist and subjectivist statements and agree with the criterialist ones on the BHQ. They took their assumptive cue from how historian experts, who validated the original BLTHQ, relied consistently on coordinated criterialist beliefs, agreeing regularly with almost all of those items and disagreeing with most or all of the objectivist and subjectivist statements.

As one gauge of how consistent respondents were with criterialist belief items, Maggioni and colleagues (Maggioni et al., 2009b) developed a consistency score and used it to analyze data collected with the BHQ. They counted each time respondents *agreed* with objectivist or subjectivist statements and *disagreed* with criterialist statements. They then subtracted that number from 22 (total number of statements on the revised BHQ). This gave them a ratio expressed as a percentage. For example, if a respondent *agreed with* 2 objectivist statements and 3 subjectivist statements, and then *disagreed with* 2 criterialist statements, it would total 7 inconsistencies with criterialism.[6] Seven from 22 equals 15, which could be expressed as 15/22, or a consistency score of 68 percent.

Comparisons of pre- and post-BHQ consistency scores among teachers showed that they held beliefs that were transitional, and/or unstable. Some teachers' epistemic beliefs seemed to suggest transition from one position to a more cognitively adaptive one (subjectivism to criterialism), even though they sometimes showed movement toward coordination only later to slide back. Other teachers seemed to hold beliefs from various epistemic orientations simultaneously and wield them in unstable and unpredictable ways. For these teachers, the nature of the development experience seemed to provoke instability. However, data collection methods were insufficient to accurately trace their exact sources.

Overall, the teachers wobbled epistemically, sometimes between objectivist and subjectivist beliefs, and for a few, between subjectivist and criterialist beliefs. Those who were attracted to beliefs in all three epistemic positions simultaneously wobbled their way into impasses. Teachers were observed and overheard struggling with how to achieve successful, consistent beliefs coordination.

Interviews with 12 high school students and their three history teachers who took the BHQ allowed Maggioni (2010) to begin to sort out the nature of and differences between transitional and unstable beliefs. She asked students and teachers in her study to explain the reasons for their choices on BHQ items. The coexistence of objectivist and subjectivist beliefs became evident through utterances that contained both beliefs within the same sentence. She also observed students struggling as they became aware of contradictions in their beliefs. For example, in evaluating whether history is simply a matter of interpretation, Monica said: "I don't know, some of it is interpretive, but a lot of it is facts, I don't know." Jack reached a similar epistemic impasse when considering the justifiability of historical claims: "I somewhat disagree with this, because historical claims [silence].... I somewhat agree with this, because historical claims is pretty much interpretation by historians [more silence].... Ah, I don't know." Students seemed motivated to move to productive epistemic positions but were unclear how to do so. Maggioni also found evidence of such impasses during teacher interviews.

Analysis of students' and teachers' interviews allowed Maggioni (2010; Maggioni et al., 2010) to identify sources that fostered epistemic wobbling. Among these, there was the idea that evidence "always" provides two sides to a story, the conceptualization that evidence can be detached from argument, and a view of perspective as a necessary evil. Quite widespread was the reference to a dichotomy between facts and opinions, with facts perceived as disconnected from any knower's interpretive act and interpretation equated with opinion.

From an affective standpoint, the experience of becoming aware of the epistemic contradictions that existed among personal beliefs raised evident discomfort in students and teachers, echoing the findings reported by psychology researchers (e.g. Baxter-Magolda, 2008; Belenky, Chinchy, Goldberger, & Tarule, 1986). Some students explicitly expressed their unwillingness to take on responsibility in a role as an active knower, and stated their preference for relying on the safe authority of teachers and textbooks. Other students welcomed the sense of empowerment, yet found themselves quickly stuck in a relativistic quagmire, faced by the sudden realization that nothing could be known with certainty.

Consistency scores for the 25 high school students ranged from 35 percent to 91 percent, with average scores around 62 percent (Maggioni, 2010). The increase of average consistency scores during the course of a semester taught by the three high school teachers was not statistically significant, variability across students was very high, and Maggioni could not find any trend that could suggest epistemic development. Rather, she interpreted this result as further evidence for the phenomenon of epistemic inconsistency (wobbling) obtained during the structured interviews. She also noted that what students were doing in their history classes did not seem helpful in fostering transitions toward more adaptive beliefs. History classroom experiences often sent students mixed epistemic messages (e.g. sources needed to be interpreted but the textbook was the "correct" account) that may have enhanced wobbling effects.

Teachers in the professional development programs typically came into them with consistency scores hovering on average around 74–75 percent and left the programs at 76–78 percent. The researchers theorized that to approach the type of epistemic consistency that would reflect adherence to criterialist beliefs, teachers would need to attain a consistency score on the BHQ at or above 90 percent, which very few reached.[7] When they disaggregated the data into beliefs clusters, they observed that the teachers tended to vacillate between over-privileging the objects from the past and over-emphasizing the role of the knower. Teachers had difficulty working out a happy middle ground. Epistemic wobbling appeared to be the norm (cf. Maggioni et al., 2009b; VanSledright, Maggioni, & Reddy, 2011, 2012).

The same picture generally held for a group of 18 college students VanSledright and Reddy (2014) worked with in the United States. They designed a specialized intervention that focused on (a) learning how to do history with a targeted consideration of its epistemic underpinnings and (b) using that knowledge in learning to teach it. Most students were sophomore and junior history majors, but three were freshmen, two were seniors, two were education majors (freshman and a sophomore), and one senior was a geography major.

The average consistency score for the group as they entered the intervention was 75 percent, with a low score of 50 percent (a freshman education major) and a high score of 95 percent (a junior history major). At the end, and despite a concerted effort to shift epistemic beliefs toward criterialism, the average consistency score rose only 3 points to 78 percent. In-depth interviews with four of the students supported characterizations of inconsistent, wobbly epistemic beliefs. It is possible that the intervention may have momentarily destabilized some students' beliefs for reasons that remained unclear. Throughout the intervention and as with the practicing teachers in earlier studies, epistemic beliefs appeared to retain a malleable character in ways that contrasted with the epistemic consistency of the practicing historians who validated the initial BLTHQ.

Iris Tabak, Michael Weinstock, and Hilla Zviling-Beiser (2010) reported a study conducted in Israel that also appeared to suggest the types of epistemic belief wobbling in history found in the work of Maggioni and her colleagues. They presented nine college history majors with conflicting historical cases framed by competing accounts, one with biological, one with judicial, and one with historical content. Students were asked in post-task interviews to discuss the trustworthiness of the sources, the degree to which one could obtain some certainty in interpreting the cases based on the accounts, and how knowledge claims generated about the cases could be justified. The responses to the history case are of most interest here.

Tabak et al. (2010) coded six of the nine history majors to be between primary commitments to subjectivist beliefs, what they called multiplism, and commitments to coordinated ones, what they termed evaluativism. The history students rather immediately recognized the interpretive problems they faced in the history task case. Although the students sought to sort out the problems more definitively by asking questions of the accounts' authors, they eventually deferred on a solution, noting that history could not be understood as an exact science and/or that in history anyone could generate an interpretation, and so competing accounts were the norm. The six who were transitionally coded did not offer criteria for arbitrating among better or less adequate interpretations. This of course does not necessarily mean they held to no such criteria; however, none were forthcoming in the rather pointed post-task interviews the researchers conducted.

There are a few additional studies being undertaken by researchers in the Netherlands, Germany, and Pakistan that attempt to examine epistemic beliefs more closely (several using the BHQ instrument). However, at the point of this writing, these studies are incomplete.

## SUMMARY AND CONCLUSION

The work reviewed here recommends that more research is needed on epistemic cognition in history, and the belief systems that underpin it. The studies we have reviewed indicate fairly consistently that understanding the past in ways that permit the making of defensible claims about what it means depends on knowers' justification schemes. Those schemes are deeply tied to knowers' epistemic beliefs. Some beliefs, as we have tried to show, are far less adaptive and useful in efforts to understand, and can in fact create powerful cognitive impasses.

The absence of capabilities for deeply understanding the past, and to make defensible knowledge claims about it, places democratic deliberation in jeopardy. If access to knowledge about the range of choices humans have made over time, and particularly a significant appreciation of their consequences, is not cultivated, or is otherwise abnegated, citizens cannot make wise choices for the future. Deliberation becomes a relativistic free for all in which two very possible outcomes are unreflective polarization and decision-making paralysis. The epistemic instability unearthed by a number of studies we noted and the cognitive impasses that flowed from them indicate how quickly such polarizations and paralyses can take hold. Healthy democratic deliberation that points to a hopeful future demands educated, thoughtful deliberators who know the past and can draw defensible claims from it. Such capabilities can both inspire and counsel future action.

History, for its very epistemic underpinnings, can educate critical, deliberative thought. It promises to do so in relation to issues that are complex and relevant to us in the present. It also helps to educate our encounters with others on their own terms, without abdication of the self. These aptitudes are valuable for life in the present, with all its pluralisms, complexities, and conflicting messages. Yet, epistemic awareness must be cultivated. As a subject that can foster deep cognition in action, history is a powerful candidate for achieving such ends. However, it must be taught well by those who have wrestled with and made advances in their epistemic awareness. If we take these ideas seriously, where do they lead? From perhaps a much larger cluster of directions, we offer the following.

The extant studies indicate that some epistemic beliefs are linked to impasses in the kinds of historical thinking that lead to growth in understanding. For example, students who persist in the idea that texts are authorless harbor the impression that accounts with omniscient, invisible authors are the most authoritative, thereby constricting broader understanding and potentially reinforcing naïve objectivist beliefs. A learner who commits himself to the belief that history is merely opinion may repeatedly dismiss accounts that do not cohere with his worldview. Such a move often reinforces the idea that a knower's subjectivity should be allowed to trump the potential value of struggling to make sense of particular objects from the past that challenge her existing viewpoint and that evidentiary support is thus little more than a personal choice.

A third example hinges on what sorts of assistance learners may seek when they confront accounts that conflict or contradict one another. Without pursuing interpretive decision criteria (e.g. corroboration, evidence preponderance), learners may draw the conclusion that knowers have license to interpret accounts willy-nilly. Both the latter two examples implicate the role naïve subjectivist beliefs may play in creating impasses. All three examples also likely implicate the types of instabilities and epistemic wobbling observed in several studies.

However, at present, studies show that it remains difficult to talk of one-to-one correspondences between particular epistemic beliefs and impasses to understanding. To reduce speculation, we need studies that show as clearly as possible what kinds of beliefs correspond to those impasses and where those beliefs originate (are they developmental constraints or affordances, or are they cultivated in sociocultural contexts such as classrooms or at home?), as well as how they might be educated. Cross-cultural or comparative studies might be useful in these respects.

To follow this line of research will likely require greater precision in construct definition and in theories about how those constructs are linked. As our discussion of the different ways educational researchers and historians have conceptualized epistemic stances demonstrates, Kuhn and Weinstock's (2002) absolutism and Megill's (2007) absolute objectivity do not seem to be the same construct and likely fall in different places along a continuum of beliefs. The precision we imagine would be history-domain specific.

Finally, we would benefit from additional work on history task development. Tasks must contain opportunities to put claims-to-know *and* knowledge justification schemes on display. It is with the latter that epistemic beliefs emerge, giving researchers greater purchase on them, and providing additional opportunities for inquiring about their origins, thus permitting better theorizing to practice and gathering practice data that would point back to the adequacy of theorizing, in recursive rounds.

Since epistemic development appears to be linked to historical thinking and understanding, it would help to develop more robust assessments at the classroom level. For example, how tasks such as constructed-response or document-based questions are assigned and interpreted, and the ways in which feedback is provided to students, could influence epistemic cognition and affect beliefs. Additional focused research on these efforts and their various outcomes might be deeply beneficial. This implies that learning goals need to specifically encompass epistemic development, at the classroom level but also in curriculum development and in teacher education. Focusing on cognitive heuristics (e.g. close reading of accounts, sourcing) alone does not appear to be enough. Without addressing epistemic beliefs, they can become merely rigid skills that do little to foster the epistemic belief developments that free cognitive impasses and enable deeper historical understanding.

## NOTES

1 Here, Megill appears to be talking not about the objectivity of events per se, but rather how historians deal epistemically with constructing their own understandings of the past.

2 Megill does not clearly indicate that any one of these four senses of objectivity is necessarily superior to the others. Instead, he appears to be making a case that these four senses reflect how different historians have tended to position themselves over time with respect to the relations between objectivity and subjectivity. One might then think of them as different epistemic cognitive strategies.

3 We use the term accounts here very broadly to include firsthand testimonies, photographs, paintings, pottery shards, arrowheads, and motion pictures. In one form or another they can be thought of as representing "witness to the past."

4 For example, how children in grade school are taught to interpret their textbook histories could differ perhaps even dramatically from the regulative approaches found in the community of practicing historians.

5 These criterialist beliefs suggest considerable similarity to Megill's (2007) characterization of the disciplinary objectivist.

6 The researchers noted that, putting it conversely, disagreement with all objectivist and subjectivist statements coupled with agreement on all criterialist statements would yield a 100 percent consistency score.

7 The researchers indicated that they set the bar high because of a tendency toward social desirability selection effects associated with criterialist items on the BHQ.

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# 10

## MATHEMATICAL EPISTEMOLOGICAL BELIEFS

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### INTRODUCTION

Epistemological beliefs are defined as beliefs about the nature and acquisition of knowledge. It is typically assumed that epistemological beliefs have an influence on how people think and reason, as well as on their motivational processes (Hofer & Pintrich, 1997). Much of the research on people's epistemological beliefs is situated within specific subject-matter domains, including mathematics. For that domain, there are two distinct views on the nature and the acquisition of knowledge, namely an absolutist (Platonist) and a fallibilist perspective (Ernest, 2014). Adherents of the absolutist perspective assume mathematical knowledge to be absolutely secure, fixed, and objective. They believe that mathematical objects are real and exist outside the human mind. To acquire mathematics knowledge, mathematical truths have to be discovered rather than invented. By contrast, adherents of the fallibilist perspective view mathematics as the outcome of social processes. Mathematical knowledge is seen as fallible and open to revision. Rather than emphasizing the acquisition of a fixed set of mathematical concepts and procedures, fallibilists focus on doing mathematics—within the social conventions in a particular context—and its human side. Going beyond the dichotomy of naïve and sophisticated epistemological beliefs, Ernest (2014) argues that neither the absolutist nor the fallibilist perspective is right or wrong, but that both perspectives have their own legitimacy. Most theoretical frameworks on teachers' and students' mathematics-related epistemological beliefs somehow relate to Ernest's (2014) basic distinction between the absolutist and fallibilist perspective, although there is a large diversity in the way in which differences in epistemological beliefs are expressed in the mathematics educational literature. For instance, the labels "static" (Felbrich, Kaiser, & Schmotz, 2012) and "realist" (Bolden & Newton, 2008) are also used in the literature to label epistemological beliefs similar to Ernest's absolutist perspective, whereas labels such as "dynamic" (Felbrich et al., 2012) and "relativist" (Bolden & Newton, 2008) reflect a more fallibilist perspective. Besides this difference in terminology to describe mathematics epistemological beliefs, there are still three other issues on which the available frameworks take different perspectives.

First, similar to the general literature on people's personal epistemologies, in the mathematics-related research literature distinct terms are used to label personal epistemology, such as epistemic cognition and epistemological beliefs. The first term stresses more the cognitive nature of epistemology (e.g. Garofalo & Lester, 1985; King & Kitchener, 2002), whereas the latter one emphasizes more its affective character (e.g. McLeod, 1992; Op 't Eynde, De Corte, & Verschaffel, 2006). For instance, King and Kitchener (2002) consider epistemic cognition (i.e. monitoring the epistemic nature of problems) to be a part of a cognitive processing model, besides cognition (i.e. engaging in cognitive processes such as computing, memorizing, etc.) and metacognition (i.e. monitoring one's progress). Epistemic cognition then refers to the epistemological assumptions that underlie one's reasoning (Hofer & Pintrich, 1997). By contrast, other scholars stress that epistemological beliefs are part of one's affect. More particularly, they are considered to belong to one of the three subcategories of one's affect, i.e. "beliefs," but as being more stable and having a stronger cognitive component than the other two subcategories of the affective domain, i.e. "emotions" and "attitudes." For instance, Op 't Eynde et al. (2006) distinguish between three categories of mathematics-related beliefs, each of them being composed of distinct subcategories: (1) beliefs about mathematics education, (2) beliefs about the self as a mathematician, and (3) beliefs about the mathematics class context. They frame epistemological beliefs (i.e. beliefs about mathematics as a discipline) as a subcategory of the first category, besides two other subcategories (i.e. beliefs about mathematics learning and beliefs about mathematics teaching). In this contribution we use the notion of epistemological beliefs defined as the implicitly or explicitly subjective conceptions teachers and students hold to be true about the nature and the acquisition of mathematical knowledge.

A second issue concerns the domain specificity of epistemological beliefs. Whereas formerly it was mainly assumed that epistemology was domain general, nowadays most researchers agree that there are differences in one's epistemological belief system across disciplines (e.g. Muis, 2004). Op 't Eynde et al. (2006) argued that this dissension among scholars is partly a consequence of the different instruments that are used to measure epistemological beliefs. The use of slightly modified general epistemological belief scales to measure domain-related beliefs typically supports similarities between epistemological beliefs across disciplines. But scales constructed from a domain-specific approach typically result in evidence supporting their domain-specific nature. Following Buehl et al. (2002), we hold a moderately domain-specific perspective on epistemology implying that teachers and students possess certain domain-specific beliefs about the nature and acquisition of mathematical knowledge, which are partly influenced by general domain-transcending epistemological beliefs.

Third, although scholars agree that epistemological beliefs essentially deal with the nature and acquisition of knowledge, scales measuring epistemological beliefs sometimes also comprise items regarding other mathematics-related beliefs, such as beliefs about oneself as a mathematics learner and beliefs about the mathematics class context (e.g. Mason & Scrivani, 2004, see also the review of Muis, 2004). In this chapter we apply the narrow definition of epistemological beliefs dealing only with the nature and acquisition of mathematical knowledge, although we acknowledge the close connection between these beliefs and other categories of students' mathematics-related belief system (Op 't Eynde et al., 2006).

Against this theoretical background this chapter aims at synthesizing the available empirical evidence regarding epistemological beliefs in mathematics education research. Thereby we will build on Muis' (2004) excellent review. As Muis only addressed students' epistemological beliefs in mathematics, we start with research on teachers' mathematics-related epistemological beliefs. With regard to students' beliefs, we will review and discuss the empirical research that has been published since Muis' review.

So, the next two sections address respectively teachers' and students' epistemological beliefs in mathematics. In both sections, the following issues are discussed: the nature of epistemological beliefs, individual differences in epistemological beliefs, the relationship with other beliefs, the relationship with teaching or learning behavior, and changing epistemological beliefs. The chapter ends with some challenges and future perspectives for epistemological beliefs research in mathematics education.

## TEACHERS' EPISTEMOLOGICAL BELIEFS ABOUT MATHEMATICS

It is generally acknowledged that epistemological beliefs are part of teachers' professional competence (e.g. Blömeke, Felbrich, Müller, Kaiser, & Lehmann, 2008; Kunter et al., 2013). Teachers' epistemological beliefs impact their selection of learning tasks as well as their instructional activities in the classroom. Mediated by students' epistemological beliefs, these classroom activities are interpreted by students, and form the basis for the further development and refinement of these beliefs (Feucht & Bendixen, 2010).

### *The Nature of Teachers' Epistemological Beliefs*

Different categorization schemes for teachers' epistemological beliefs have been developed within the domain of mathematics. A first categorization by Ernest (1989) distinguishes three views of teachers on the nature of mathematics: an instrumentalist, a Platonist, and a problem-solving view. Teachers with an instrumentalist view conceive mathematics as an accumulation of unrelated facts, skills, and rules. Teachers adhering to a Platonist view see mathematics as a static body of highly structured and interrelated knowledge that should be discovered. Finally, teachers with a problem-solving view on mathematics stress the process-nature (rather than product-nature) of mathematics and regard it as a dynamic and relative human invention. Whereas the first two views correspond to an absolutist perspective on mathematics, the last one takes a fallibilist perspective on mathematics.

Another categorization by Blömeke et al. (2008) describes teachers' epistemological beliefs about the nature of mathematics in terms of four categories: (1) a scheme-related perspective in which mathematics is conceived as a collection of rules and formulae (this view parallels Ernest's instrumentalist perspective); (2) a formalist perspective on mathematics which stresses the exact, formal, and logical nature of mathematics, corresponding to Ernest's Platonist perspective; (3) a process-related perspective in which mathematics is conceived as a science characterized by problem solving (this perspective resembles Ernest's problem-solving view); and (4) an application perspective on mathematics, in which mathematics is primarily perceived as relevant for society and life. Whereas the first two categories adhere to an absolutist perspective, the last two categories conceive mathematics as a fallibilist process.

A third categorization, used by Felbrich et al. (2012), builds on the work of Blömeke et al. (2008), but combines the first two and last two categories in two overarching categories, i.e. mathematics as a static science—which corresponds to Ernest's (2014) absolutist perspective—and mathematics as a dynamic process—an equivalent of Ernest's fallibilist perspective. Using this dual categorization system, Felbrich and colleagues (2012) analyzed pre-service primary teachers' epistemological beliefs in mathematics in 15 different countries, and looked at whether differences in these beliefs can be explained in terms of cultural differences between countries. At least 400 pre-service teachers of each country participated in the study. Participants were asked to rate on a Likert-scale items belonging to a dynamic and a static view of mathematics. Cultural differences between countries were measured through aggregated scores of pre-service teachers' ratings of their country on an individualistic orientation scale. Countries were described as either individualistic or collectivistic. In individualistic countries (e.g. United States, Germany, Switzerland) learners were generally conceived as autonomous subjects acquiring knowledge mainly independently on their own. By contrast, in collectivistic countries (e.g. Russia, Thailand) the role of social relationships and social pressure is more prominent: learners engage in learning to please their teachers, parents, or other societal entities. A comparison of pre-service teachers' epistemological beliefs across the different countries revealed that a great proportion of variance could be explained in terms of an individualistic or collectivistic orientation of the country. Countries in which pre-service teachers agree more with a fallibilist perspective are, in general, individualistically oriented, whereas countries in which pre-service teachers have a more absolutist view on mathematics have generally a collectivistic orientation. The study also investigated the relationship between epistemological beliefs and mathematical content knowledge. The data showed that pre-service teachers with high mathematical content knowledge conceived mathematics as more fallibilist compared to their peers with lower mathematical content knowledge.

Research has revealed that it is not easy to describe one's epistemological beliefs as either static or as dynamic. For instance, Roesken and Törner (2010) investigated mathematicians, and concluded that university mathematics teachers can hold simultaneously static and dynamic epistemological beliefs. Moreover, Beswick (2012) observed that teachers' epistemological beliefs differ depending upon the kind of mathematics that is considered. She found differences in teachers' epistemological beliefs between mathematics as a discipline and mathematics as a school subject. Relying on Ernest's (1989) tripartite distinction between an instrumentalist, Platonist, and problem-solving view on mathematics, Beswick conducted a case study of two secondary mathematics teachers, one experienced and one novice teacher. She observed that both teachers seemed to hold Platonist beliefs about the nature of the discipline of mathematics. However, the experienced teacher, and to a smaller extent also the novice teacher, conceived the nature of school mathematics from a problem-solving perspective: the focus of school mathematics is to motivate students to better understand a hierarchical and interconnected set of mathematical knowledge. As an explanation of these disparities in teachers' epistemological beliefs, Beswick suggests that experiences in the domain of mathematics education (e.g. the experienced teacher had spent some years at the Section Curriculum Office) can result in a reconsideration of the epistemological beliefs regarding school mathematics, but not in a modification of the epistemological beliefs of mathematics as a discipline.

Overall, the previous results indicate that teachers differ regarding their epistemological beliefs. Different categorization schemes have been used in the mathematics educational literature to grasp these differences in teachers' epistemological beliefs. Moreover, the distinct categorizations (e.g. absolutist and fallibilist perspective) are not mutually exclusive in the sense that teachers have either absolutist or fallibilist beliefs. Rather, teachers seem to hold simultaneously different—sometimes contradictory—epistemological beliefs, for instance dependent on whether the object is mathematics as a discipline or mathematics as a school subject.

### *The Relationship between Teachers' Epistemological Beliefs and Other Beliefs*

Based on a dataset of 98 in-service primary Thai teachers, Trakulphadetkrai (2012) investigated the relationship between teachers' epistemological beliefs about the source and stability of mathematical knowledge on the one hand and their beliefs about classroom authority on the other hand. Trakulphadetkrai developed a beliefs questionnaire (TTMEB, Thai Teachers' Mathematics-Education related Beliefs) combining existing beliefs items (e.g. Nisbet & Warren, 2000; Raymond, 1997) with newly constructed items based on qualitative interviews with Thai teachers. Exploratory factor analysis supported the existence of source of mathematical knowledge, stability of mathematical knowledge, and beliefs about classroom authority as three different factors. The results indicated that an absolutist view on mathematical knowledge as a stable and fixed form of knowledge existing outside the human mind was associated with a strong belief in teacher authority, and hence a strong belief that students should be obedient to their teachers. Chrysotomou and Philippou (2010) examined the relationship between epistemological beliefs and teaching efficacy beliefs in a sample of 37 Cypriot pre-service and 147 in-service primary school teachers. Teachers' epistemological beliefs were measured through a domain-specific adaptation of Schommer's (1990) epistemological beliefs questionnaire. Exploratory factor analyses on the teachers' questionnaires data yielded five dimensions that are similar to Schommer's (1990) conceptualization. In general, it was observed that Cypriot teachers hold rather sophisticated epistemological beliefs regarding mathematics, and that the beliefs of pre-service teachers were more availing (i.e. associated with better learning outcomes) than those of their in-service counterparts. Chrysostomou and Philippou related teachers' epistemological beliefs to confidence in their capacities to organize and coordinate effective learning environments. They observed a significant positive correlation between teachers' epistemological beliefs and their efficacy beliefs: teachers with more availing epistemological beliefs also reported higher teaching efficacy beliefs. Using linear regression analyses, they found epistemological beliefs to be a significant predictor of teaching efficacy beliefs and vice versa. However, in both cases the predictor explained only a small proportion of the variance (7 percent) in the independent variable.

In conclusion, based on the limited available research there is some empirical evidence that teachers' epistemological beliefs are related to other beliefs, such as teacher authority, and their self-efficacy beliefs. Adhering to a more dynamic, fallibilist perspective seems to be associated with other more availing beliefs, such as higher self-efficacy beliefs.

### *The Relationship between Teachers' Epistemological Beliefs and Their Classroom Practice*

In an overview of the way in which mathematics is conceived and taught, Burton (1994) described distinct, clashing epistemologies in mathematics education, namely an absolutist (i.e. conceiving mathematics as a fixed body of knowledge and skills) and a relativist perspective (i.e. considering mathematics as a cultural artifact, a means to engage and influence the world, in other words corresponding to a fallibilist perspective). At every level of education—from elementary to university education—there seems to be disagreement between what mathematics is and how it should be taught and learned. Instructional practices stemming from an absolutist or a relativist perspective typically differ with respect to the focus of teaching (transmission teaching versus inquiry-based learning), the role of the learners (dependent versus autonomous learners), classroom organization forms (competitive and individualized versus collaborative or group-based), and assessment (unseen written tests versus self, peer, and co-assessment).

Bolden and Newton (2008) gave an overview of three broad epistemological worldviews that are often theoretically distinguished in educational research, i.e. a realist, a contextualist, and a relativist worldview. Each view consists of a wider set of epistemological beliefs that serve as a lens to see the world. The realist worldview is associated with an absolutist perspective on mathematics, whereas the contextualist and relativist worldview are fallibilist in nature. The relativist worldview has a quite similar conception of mathematics knowledge as the contextualist worldview: whereas contextualists view mathematics knowledge as an agreement within communities, relativists stress that the learner constructs a unique representation of mathematical knowledge. These distinct worldviews are typically associated with distinct approaches to teaching mathematics. The realist worldview is usually connected with a behaviorist model in which isolated facts and procedures are transmitted from the expert teacher to the passive learner. The contextualist worldview is typically linked to a socio-constructivist perspective on learning and teaching mathematics that aims at facilitating students' conceptual understanding. The relativist worldview is usually associated with a radical constructivist model of learning and teaching assuming that each learner constructs his/her unique mental representation of knowledge. Since it is uncertain which different implications the relativist and contextualist worldviews have for teachers' instructional approaches, they are often not distinguished from each other in empirical research; this is also the case in Bolden and Newton's study. Although it is often assumed that teachers adhere to only one epistemological worldview and that this view is consistent across time and situation, Bolden and Newton observed that teachers hold hybrid epistemological worldviews. Based on interviews and observations with three elementary school in-service teachers they concluded each teacher expressed beliefs that represent opposing (i.e. realist and relativist) epistemological worldviews. In addition, their espoused beliefs did not always correspond to the observed instructional behavior. Explanatory factors for these differences are, among others, time pressure and coverage of content suppressing teaching for "understanding." Alternative explanations might be that teachers actually hold opposing beliefs or that the instruments used to assess beliefs impose such a categorization without reflecting what people actually believe. Using three in-depth case studies of elementary school teachers, Thompson (1984) was able to explain differences between those teachers' instructional practices in terms of differences in their epistemological beliefs. For instance, a teacher who conceived of mathematics as a coherent set of related concepts focused mainly on conceptual understanding and the relationship between mathematics concepts. Yet, Thompson also concluded that the relationship between epistemological beliefs and instructional behavior is complex. Teachers' instructional practice is not only influenced by their epistemological beliefs, but also by characteristics of the context in which teaching takes place, such as the mathematics curricula, the time available for teaching these curricula, and other beliefs regarding learning and instruction.

Based on this research evidence, one can conclude that distinct epistemological beliefs on mathematics are often—conceptually—associated with distinct instructional practices, although strong empirical evidence regarding teachers' epistemological beliefs and their observed instructional approaches remains scarce. Besides, the relationship between teachers' epistemological beliefs and their instructional behavior seems neither simple nor straightforward for at least two reasons. First, research evidence has—again—shown that teachers hold beliefs that stem from distinct epistemological (i.e. absolutist or fallibilist) perspectives. Second, particular working conditions (e.g. pressure to realize the curriculum, teachers' accountability) might impact teachers' decisions for particular instructional strategies that are not in line with their epistemological beliefs.

### *Changing Teachers' Epistemological Beliefs in Mathematics*

Many scholars have criticized the way in which mathematics is traditionally taught in schools, with a strong emphasis on the transmission of a fixed body of knowledge from the teacher to passive learners. For a number of years mathematics educators have argued for another way to conceive mathematics lessons that is more authentic to the discipline (Lampert, 1990). Within the discipline, mathematical knowledge develops gradually over time through a process of "zig-zag" from making assumptions and testing these assumptions, resulting in their acceptance or rejection. Stated differently, the focus should be on making a deliberate conjecture and examining that conjecture (e.g. by means of counterexamples) rather than on following the rules prescribed by the teacher. Yet, teachers' mathematics-related epistemological beliefs often contribute to the difficulties in changing these teaching practices in the suggested direction (Schoenfeld, 1992). Equally difficult as changing teachers' practices is changing their beliefs; they seldom change substantially without significant intervention (Cooney, Barry, & Bridget, 1998). Gill et al. (2004) aimed at changing pre-service elementary school teachers' epistemological beliefs in mathematics. One hundred sixty-one teachers were randomly assigned to an experimental and a control condition. The experimental condition was based on principles of conceptual change theory, i.e. it was assumed that epistemological beliefs could be changed if the offered alternative conceptualizations were intelligible, plausible, and fruitful. Change was promoted through refutational text containing information that may conflict with one's epistemological beliefs. This text was accompanied with the technique of augmented activation in which the focus was on salient information in the instructional text that conflicted with existing epistemological beliefs: first, readers are alerted that the information they are about to read may contain information that conflicts with their own beliefs, then they are directed to pay attention to these ideas that differ from their own (Gill, Ashton, & Algina, 2004, p. 168). The results indicated that the experimental condition promoted a greater change in pre-service teachers' epistemological beliefs than the control condition in which pre-service teachers were exposed to a traditional text, although the effect sizes were only modest.

In a longitudinal study, Charalambous et al. (2009) examined the impact on pre-service teachers' epistemological beliefs of a mathematics preparatory program based on the history of mathematics. Over a time span of two years, 94 pre-service elementary school teachers completed a questionnaire four times, including items belonging to an instrumentalist (e.g. mathematics is mainly a set of rules and theorems), Platonic (e.g. mathematics is a system representing concepts of the physical world), and problem-solving view (e.g. mathematics is an evolving body of knowledge necessary for daily activities; Ernest, 1989). Six participants completed a follow-up semi-structured interview to collect more information regarding changes in epistemological beliefs. The data indicated that pre-service teachers entered teacher training with rather strong Platonic beliefs about the nature of mathematics, conceiving mathematics as a fixed body of truths. Being exposed to the history of mathematics only partly induced the expected changes in pre-service teachers' epistemological beliefs. After two years of teacher training pre-service teachers held weaker Platonic epistemological beliefs, although the problem-solving beliefs—to which the training program hoped to contribute—also declined. The researchers explained these unexpected results, among others, in terms of pre-service teachers' difficulties with the learning content and their own past negative experiences with mathematics.

To conclude, it seems that teachers' epistemological beliefs are difficult to change. However, the available evidence suggests that well-designed interventions that counter teachers' current beliefs and that reveal the plausibility and fruitfulness of alternative beliefs might induce a change.

## STUDENTS' EPISTEMOLOGICAL BELIEFS ABOUT MATHEMATICS

### *The Nature of Students' Epistemological Beliefs about Mathematics*

Muis' (2004) review of studies that have examined students' beliefs about mathematics revealed, above all, that students at all levels of education predominantly hold non-availing beliefs (i.e. negatively influencing learning outcomes). Another important finding was that the majority of the studies supported the hypothesis that student beliefs are domain specific rather than general. Moreover, in general, students' beliefs about mathematics were found to be less availing than their beliefs about other fields of study. However, according to Muis, the available research was burdened with a number of theoretical problems (e.g. the multiple views on the dimensional structure of these beliefs) as well as methodological issues (e.g. how to obtain adequate insight into students' beliefs).

Since Muis' (2004) review, research has yielded further evidence for her conclusions about the non-availing and specific nature of students' mathematics-related epistemological beliefs (e.g. Buehl, Alexander, & Murphy, 2002). In addition the following trends have emerged: (a) increasing interest in the beliefs of young children, accompanied by the methodological question of how their beliefs can be adequately investigated; and (b) broadening the epistemological beliefs domain by investigating also what students believe mathematics is all about and where it occurs.

Starting from the lack of research on young children's beliefs and the methodological problems using questionnaires in research on young children's beliefs, McDonough and Sullivan (2014) highlighted the need to go beyond traditional methodology that focuses on quantitative data and statistical analysis, and made a plea for trying new qualitative methods. In their approach to the use of such qualitative methods, the interviewer may pose an initial preplanned prompt that is visual, verbal, and/or text-based and that asks the child to give, in turn, a visual, verbal, and/or textual response. In an exploratory study, a number of such prompts were used to investigate eight children's (age 8–9) beliefs about mathematics and its learning and teaching, such as thinking of and drawing a situation wherein mathematics learning takes place or verbally reacting to a picture of another child in a situation wherein mathematics learning was involved. On the basis of their observations, the authors concluded that "the responses of the children indicate that these 8 to 9 year olds had developed beliefs about mathematics, could articulate these in response to the varied procedures, and, being interviewed on multiple occasions over a period of time, appeared not to be reflecting a desire to please the interviewer but instead each portrayed beliefs that were idiosyncratic and complex" (McDonough & Sullivan, 2014, pp. 292–293).

The second interesting development is the exploration of an epistemological aspect not mentioned in Muis' (2004) review, namely whether and where students perceive mathematics in their environment. Martin and Gourley-Delaney (2014) asked 35 sixth-grade students to judge the mathematical nature of various activities, and asked them to explain how they make these judgments. Students completed a photo sorting activity; they took, viewed, and captioned their own photos of mathematics; viewed and commented on classmates' photos; and participated in a small group discussion. Findings showed that students attended to two major features of photos and activities when making judgments: surface cues present in the photos (e.g. numbers and money), and the possibility or necessity for mathematical action (e.g. doing a calculation, a measurement). Students also gave higher ratings in terms of mathematics nature of activities to those activities relating to their personal experience. In contrast to this latter observation, Abreu and Cline (2003) reported that children were more likely to classify high status activities (e.g. managing an office) as involving mathematics than low status activities (e.g. driving a taxi). They also found that children whose families were engaged in low status work tended to give less credit to the mathematics in their work. In the authors' interpretation, when children are unlikely to see their families as doers of mathematics, they may be less likely to see themselves as competent mathematical agents.

The above studies show children's conceptions of what counts as mathematics are not only affected by their mathematical experiences at school but also by their personal out-of-school experiences. Moreover, the contrasting results of the above studies indicate that children's ratings of how "mathematical" an activity is does not merely reflect beliefs about what mathematics is about, but is also affected by the intensity and nature of their personal experiences with that activity, and more specifically by their knowledge of what exactly is involved in that activity (e.g. what the child knows from experience about that activity and the kinds of mathematics it may require), as well as by their experientially based affects towards that activity (e.g. whether the child has learned to consider an activity as socially valuable or not).

Relying on Picker and Berry's (2000) pioneering study about the stereotyped image of mathematicians as being male, extremely intelligent, obsessed with mathematics, and socially inept, unanimously held by lower secondary pupils from various countries, Sánchez Aguilar et al. (2014) set up a study to describe the images that a group of 63 high-achieving Mexican students hold of mathematicians, using a "mathematical" version of the Draw-A-Scientist Test (Chambers, 1983). A detailed analysis of students' pictorial and written descriptions of mathematicians confirmed students' above-mentioned stereotyped image.

To conclude, recent research assessing students' epistemological beliefs has explored alternative ways to capture (young) children's epistemological beliefs, for instance through making drawings and reacting to pictures. These alternative forms of assessment have shown students often hold non-availing beliefs about the nature of mathematics and their epistemological beliefs are not only influenced by in-school but also by out-of-school experiences. However, one could also question whether young students' epistemological beliefs could be appropriately inferred from alternative assessment techniques such as judgments on the mathematical nature of particular jobs represented in photographs. More particularly, there might be a distinction between students' ability to judge the extent to which mathematics is required in out-of-school job situations and whether or not their epistemological beliefs are availing.

### *The Relationship between Students' Epistemological Beliefs and Other Beliefs*

Most studies of the last decade on students' mathematics-related epistemological beliefs analyze these beliefs in relation to other beliefs. Thereby researchers make use of a wide diversity of methodological approaches: from traditional questionnaire-based quantitative methods to highly qualitative approaches. Below we describe examples of these trends.

Illustrative of the traditional quantitative approach is a study by Roesken et al. (2011) aiming to capture the structural properties of mathematics-related affect using a questionnaire consisting of 57 statements about students' view of mathematics, its teaching, their experiences as a mathematics learner, and their mathematics self-concept. Participants were 1,436 randomly chosen Grade 11 students from all over Finland. Through exploratory factor analysis, the authors determined seven useful and statistically robust dimensions of students' mathematics-related beliefs, which encompass cognitive (e.g. math ability), emotional (e.g. enjoyment of math), and partly motivational aspects (intertwining the cognitive aspects, e.g. in effort: "it is important for me to get good grades in math" and "I'm hard-working by nature"). Interestingly, the manifest correlations showed that almost all factors correlated significantly with each other, although varying in strength (from a negligible, weak, moderate, to a strong relationship). Furthermore, the correlation matrix indicated students' epistemological beliefs about the difficulty of mathematics, together with the ability and success factors, had the strongest correlations, suggesting these factors formed the core of students' views of themselves as learners of mathematics.

Di Martino and Zan (2011) set up a qualitative study in view of clarifying the constructs of students' beliefs (including epistemological beliefs), attitudes, and emotions, and the relationships among them. Based on their analysis of elementary and secondary school students' autobiographical essays, interviews, etc., they proposed a multidimensional model consisting of three dimensions that deeply interact: emotional disposition toward mathematics (liking or not liking mathematics), epistemic perspective on mathematics (instrumental or relational), and perceived competence in mathematics. According to Di Martino and Zan, teachers should take into account these deeply interwoven relations. For instance, a student with a negative disposition towards mathematics, because he/she associates it with lots of rules and formulas to be remembered, should be treated differently than a student who thinks and feels negatively about mathematics because he/she only likes "automatic" subjects (i.e. subjects that do not require a lot of deep-level thinking) and math is not one of these. In the first case, contrary to the second one, the negative disposition is fed from a non-availing epistemological belief, most probably influenced by earlier experiences in mathematics classrooms. As such, it might make sense to attempt to change this non-availing belief through instruction.

The previous studies have contributed to our understanding of students' mathematics-related *epistemological* beliefs as a central part of their belief system related to mathematics. These epistemological beliefs seem to be significantly related to other mathematics-related beliefs (such as math self-competence), as well as to students' emotional disposition towards mathematics.

### *Relationship between Students' Epistemological Beliefs and Their Mathematical Behavior and Performance*

In her review, Muis (2004) describes how, by the early 1980s and into the 1990s, research began to focus on how students' beliefs mediate cognitive and motivational factors that underlie their mathematics learning and performance. She divided the research in this area into two approaches: more qualitatively oriented studies investigating how beliefs shape students' behavior as they engage in learning, and more quantitatively oriented studies focusing on how beliefs relate to other cognitive and motivational factors and how this constellation relates to achievement. Both approaches provided convincing evidence of the relationship of beliefs with students' learning strategies, with their motivation, and, ultimately, with their achievement. Neither approach, however, could provide strong evidence of a cause-and-effect relationship. Therefore, Muis made a strong plea for studies wherein the two approaches are integrated.

During the last decade, researchers have continued to investigate the relationship between students' epistemological beliefs and their mathematical behavior and performance. A first common feature of these studies is that this relationship is rarely studied for epistemological beliefs in isolation. With a view to assess the unique contribution of epistemological beliefs and/or to unravel the chain of relations linking beliefs and other variables to mathematical performance, epistemological beliefs are studied in combination with other beliefs and other variables, especially motivation. Second, while the literature displays a wide variation in research methods, the quantitative approach, in which large groups of students are subjected to batteries of questionnaires that are analyzed using sophisticated data-analytic methods, seems to continue to dominate. In some cases, the quantitative approach is complemented with or replaced by a qualitative approach. Third, the studies frequently involve a comparative element, either by contrasting two groups of students (different age or gender), or by contrasting mathematics with another content domain, or different subdomains within mathematics.

Buehl and Alexander (2005) used cluster analysis and analysis of variance procedures to identify students' domain-specific epistemological belief profiles, and to examine differences in students' beliefs, motivation, and task performance. Four hundred eighty-two undergraduates completed measures regarding their beliefs about knowledge, competency beliefs, and achievement values relative to history and mathematics, and participated in domain learning tasks. Cluster analysis was used to identify epistemological belief profiles within the domains of history and mathematics.

The findings supported earlier research linking sophistication of beliefs to academic outcomes: students who believed less in the isolation and certainty of knowledge, as well as in authority as the primary source of knowledge, were found to have higher levels of motivation and better performance on the learning tasks. Although the configuration of profiles differed between both domains, further analyses suggested a tendency for students to be relatively consistent in the sophistication of their beliefs across domains. According to the authors, their findings provide evidence for the dual nature of epistemological beliefs, namely, domain specific as well as general (i.e. what we labeled as a moderately domain-specific perspective on epistemological beliefs in the introduction).

Relating the epistemological beliefs of 24 undergraduate students to their self-regulation while solving problems, Muis (2008) observed that students profiled as predominantly empirical—i.e. students who judge mathematical truth on what looks right or wrong—perform worse than students profiled as predominantly deductivist (rational)—i.e. who judge mathematical truth through logic. However, her data also revealed that students who held a combination of empiricist and deductivist views did not perform worse than those with a predominant deductivist view. Consequently, these latter results show, first, that students might have epistemological beliefs that stem from two distinct epistemologies, namely the deductivist and empiricist perspective. Or, alternatively, students might not have fully formed epistemologies, but rather some ideas that can be labeled as deductivist and other ideas that can be labeled as empiricist. Second, these results question the claim that students with more sophisticated epistemological beliefs (i.e. deductivist views) always perform better than students with less sophisticated epistemological beliefs (i.e. a combination of deductivist and empiricist views).

Nasser and Birenbaum (2005) examined a structural model of mathematics achievement of 195 Jewish and 283 Arab eighth graders in view of explaining the math achievement of both groups. The model involved five learner variables: gender, epistemological beliefs, self-efficacy, attitudes, and mathematics anxiety. Multigroup structural modeling analysis indicated that in both samples epistemological beliefs had an indirect effect on mathematics achievement, attitudes, and mathematics anxiety, whereas epistemological beliefs had a direct effect on self-efficacy beliefs. Consequently, their findings suggest the effect of epistemological beliefs on students' mathematics learning outcomes is mediated by motivational factors, such as self-efficacy beliefs.

Starting from a qualitative approach, Liu (2010) investigated whether four Taiwanese college students with different math-related epistemological beliefs performed differently within three distinct performance contexts: standardized calculus problems, semi-open problems that were intimately related to the calculus course, and mathematical pattern-findings tasks that were not connected to the calculus curriculum. Results indicated that the two students with a dynamic view of mathematics (i.e. conceiving mathematics as a process involving personal creativity) performed better on the standardized calculus problems compared to the two students with a static, instrumentalist view on mathematics as a set of rules to be followed. These associations were less pronounced, however, in the other two nonstandardized kinds of mathematical tasks.

To sum up, the available research shows that epistemological beliefs are generally related to students' learning outcomes: more dynamic, fallibilist beliefs are typically associated with better learning outcomes. However, this association is not equally strong for all types of mathematical tasks. Moreover, a student's hybrid set of epistemological beliefs containing both static and dynamic views is not necessarily worse in terms of the student's problem-solving behavior than a consistent set of sophisticated beliefs. Furthermore, the effect of epistemological beliefs on students' mathematics achievement seems to be mediated by other factors, such as their self-efficacy beliefs.

### *Changing Students' Epistemological Beliefs about Mathematics*

Much of the research literature on changing students' math-related epistemological beliefs reviewed by Muis (2004) took a social-constructivist approach, and, more specifically, relied on Yackel and Cobb's (1996) theory wherein the development of these beliefs is understood in terms of sociomathematical norms and practices. Yackel and Cobb argue that if the classroom norms and practices are a major determinant of the development of beliefs, significantly altering those environments will enhance positive mathematics-related beliefs. While most of the studies reviewed by Muis involved quantitative assessment of changes in students' beliefs based on a typical pretest–posttest design, a few studies provided qualitative analyses of changes in beliefs. Most of both kinds of studies have found that implementing constructivist-oriented approaches to teaching mathematics resulted in more availing epistemological beliefs (e.g. mathematics is a way of thinking about things rather than facts and procedures to be memorized). According to Muis (2004), the quasi-experimental or descriptive nature of their designs makes it again impossible to make strong cause-and-effect claims.

During the past decade, the number of studies focused on exploring and testing new instructional approaches for changing students' mathematics-related epistemological beliefs remained rather small. A rare example is a study by Mason and Scrivani (2004) aimed at ascertaining students' beliefs about mathematics and mathematical learning, as well as changing those beliefs and related variables by modifying the classroom learning environment. Eighty-six fifth graders were divided in two groups: one in the innovative and the other in the traditional learning environment. To assess the development in students' beliefs, the authors used a self-report questionnaire referring to two of the three main categories of students' convictions in mathematics that were identified by De Corte et al. (2002): (1) beliefs about mathematics, mathematical learning, and problem-solving, and (2) beliefs about the self in relation to mathematics. Students also completed a word problem-solving test, and a self-evaluation of their own effort and understanding vis-à-vis the problems in the test. The findings showed that the innovative educational intervention contributed towards helping students construct more availing beliefs about mathematics (a strong effect, $\eta^2 = 0.59$) as well as improving their performance in solving traditional as well as unusual word problems (only a weak effect, resp. $\eta^2 = 0.07$ and $0.08$). Moreover, the innovative learning environment also positively affected students' perceptions of their own effort and understanding in mathematics, with a modest effect ($\eta^2 = 0.12$).

Another intervention study started from the frequently heard argument that integrating history into the mathematics curriculum could be an efficient vehicle to demonstrate the dynamic, potentially fallible, and sociocultural nature of mathematics (Charalambous, Panoura, & Philippou, 2009). Doing so might contribute to changing students' epistemological beliefs about the domain. Using such a historical approach, Liu (2009) investigated, in a small-scale exploratory study, how these beliefs evolved in

Taiwanese college students during an experimental year-long calculus course. Making use of an open-ended questionnaire, mathematics biographies, in-class reports, and follow-up semi-structured interviews, the author was able to change students' mathematics-related epistemological beliefs as compared to control students who followed a regular calculus course. However, because of the very small scale of the study and the high within-group variation, we treat these results with caution.

While these few studies provide indications in favor of the possibility of changing beliefs through instruction, they remain remarkably rare and do not provide deep or detailed insight into concrete mechanisms of change. Interestingly, Bendixen and Rule (2004) proposed an integrated model of personal epistemology involving three interrelated components of the mechanism of change: (a) epistemic doubt (being aware of a cognitive disequilibrium in one's epistemological beliefs), (b) epistemic volition (focusing attention and concentrating on solving the disequilibrium), and (c) resolution strategies for solving the disequilibrium (e.g. reflection and social interaction). The model has not yet been empirically evaluated in detail, and has not been developed in the specific domain of mathematics education. Nevertheless, it may be a good starting point for further research on the changeability of math-related epistemological beliefs through instruction. The success of interventions based on refutation (e.g. Gill et al., 2004; Kienhues, Bromme, & Stahl, 2008) may indicate the value of creating epistemic doubt with appropriate resolution strategies.

## CHALLENGES AND FUTURE PERSPECTIVES

This chapter provides a synthetic review of the empirical research regarding teachers' and students' epistemological beliefs in mathematics, *strictu sensu*, i.e. their beliefs about the nature and acquisition of knowledge. The major results can be summarized as follows. First, concerning both teachers' and students' epistemological beliefs a distinction is typically made between an absolutist perspective on mathematics as a fixed body of certain and objective knowledge and a fallibilist perspective on mathematics as knowledge that is constructed through cultural and social conventions and, hence, open to revision. Second, we observed teachers' and students' epistemological beliefs are closely related to other beliefs about learning and teaching mathematics, such as self-efficacy beliefs, authority beliefs, beliefs about themselves as math learners, and motivational beliefs. Notions such as "belief system" (Op 't Eynde et al., 2006) and "worldview" (Bolden & Newton, 2008) stress this integration of epistemological beliefs with other (mathematics-related) beliefs, although research has also revealed that teachers and students often hold hybrid sets of epistemological beliefs (e.g. Bolden & Newton, 2008). Third, studies have shown that epistemological beliefs are associated with particular instructional approaches and with students' learning behavior. Still, claims regarding the association between epistemological beliefs and instructional approaches are mainly theoretical, rather than based on extensive empirical evidence. Moreover, methodological problems impede ascriptions of causality to epistemological beliefs in relation to teachers' and students' behavior. Finally, the scarce research on changing teachers' and students' epistemological beliefs shows nevertheless that through instructional intervention epistemological beliefs can be changed. The technique of refutational instruction seems especially promising to induce changes in one's epistemological beliefs (Gill et al., 2004; Kienhues et al., 2008). This synthesis provides not only a framework of the current state of the art in research on mathematics epistemological beliefs, but it also points to some theoretical and methodological challenges for future epistemic cognition research in mathematics.

First, it is obvious there is a strong need for a clear and well-elaborated conceptualization of mathematics epistemological beliefs. For instance, beliefs about the nature and acquisition of mathematical knowledge are often investigated (as part of a more encompassing belief system, or not) without explicitly referring to them as epistemological beliefs. Moreover, the various categorization systems to describe epistemological beliefs further illustrate the conceptual ambiguity in this research domain.

Second, epistemological beliefs are considered to represent a continuum from naïve to sophisticated. It is generally argued that sophisticated beliefs are more availing in terms of student learning outcomes (Muis, 2004). Yet, an analysis of the evidence on which mathematicians rely shows a more nuanced, and less dichotomous picture of the suitability of epistemological beliefs. An epistemological belief that seems naïve in one context is not necessarily naïve in another context (Weber, Inglis, & Mejia-Ramos, 2014). Similarly, Ernest (2014) suggested that neither the absolutist nor the fallibilist perspective is right or wrong, but that both have their own legitimacy. This more nuanced perspective on the appropriateness of epistemological beliefs was also confirmed by empirical evidence from Muis' (2008) study that students with a hybrid of empiricist (less availing) and deductivist (availing) views did not perform worse on mathematics than those with more predominant deductivist views. We agree with Weber et al. (2014) that a more nuanced model of personal epistemology might be more fruitful for understanding the appropriateness of students' epistemological beliefs. For instance, the acceptance that something is true because the mathematics teacher or textbook states it is considered to be a naïve, non-availing epistemological belief. Yet, it is impossible for practical life that students could never believe something from an authoritative source without checking its truth through their own deductive reasoning. Similar arguments have been made in science education for valuing testimony as a key source of knowledge from others (Chinn, Buckland, & Samarapungavan, 2011).

A third challenge concerns the need to further develop and improve the methodological aspects of research on epistemological beliefs. Muis (2004) criticized the fact that reliability measures of instruments are only rarely mentioned. In more recent empirical research on epistemological beliefs, reliability measures are still rarely reported, nor are instruments subjected to serious validation. An additional difficulty in measuring epistemological beliefs is that researchers are dependent on self-report. The data obtained by self-report measures might be blurred by one's difficulties to report on these epistemological beliefs (especially with young children) or by one's difficulties to remember particular beliefs. The development of experimental instruments that spontaneously evoke epistemological beliefs, as advocated by McDonough and Sullivan (2014), is in this regard promising. Also, triangulation of data through the combination of different data collection techniques might be a fruitful approach in the examination of epistemological beliefs. More specifically, it might be promising to combine large-scale quantitative studies with more in-depth qualitative investigations (e.g. Charalambous et al., 2009), and self-report measures can be validated by observations (e.g. Bolden & Newton 2012).

A fourth challenge lies in the accurate interpretation of possible discrepancies between data gathered of the same person from two different sources, for instance self-report measures (e.g. interviews, questionnaires) and observations of actual teaching or learning behavior. These discrepancies can be due to at least two different causes. First, as illustrated in some of the studies described in this review (e.g. Bolden & Newton, 2008; Thompson, 1992), teachers' instructional behavior is not only influenced by their epistemological beliefs, but also by particular constraints of the context of teaching that are sometimes contradictory to their epistemological beliefs. Second, from a positivist approach a one-to-one correspondence is assumed between what students or teachers state, and what scholars think those statements mean (Leatham, 2006). Yet, both in the case of self-reports and of observations, beliefs are not directly observed but inferred from what teachers and students say and do (Speer, 2005). These inferences presuppose a shared understanding between the researcher and the participant. In this regard, future research might benefit from a member check in which participants are able to view and confirm the data and inferences made by researchers (Beswick, 2012). It is surprising such member checks are almost entirely missing in the current literature on epistemological beliefs.

A final challenge has to do with the design of intervention studies attempting to change teachers' or students' epistemological beliefs in mathematics. Most of the scarce intervention studies are small-scale quasi-experimental studies that have the advantage of ecological validity, but the limitation that other variables may impact the results. Also a retention test or other kind of follow-up is often lacking. One might indeed wonder to what extent a change in teachers' or students' epistemological beliefs remains after the intervention, when teachers or students are again immersed in the regular classroom context. Incorporating retention tests in the design of studies and conducting more longitudinal research might be promising for disentangling the development of epistemological beliefs.

Attempting to meet these challenges in empirical research of personal epistemology in mathematics will not be easy. However, this empirical evidence base is necessary to provide a better understanding of teachers' and students' mathematics-related epistemological beliefs.

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# 11

# EPISTEMIC COGNITION IN LITERARY REASONING

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Epistemic cognition in literary reasoning refers to how people and communities of readers go about understanding literary texts. It encompasses the nature of knowledge conveyed in and knowable from literature and the processes of ascertaining knowledge conveyed in literature, i.e. the reasoning processes, beliefs, and values that enter into interpretation of the knowledge conveyed in and knowable from any specific literary work. There are several challenges associated with explicating epistemic cognition in literary reasoning, not the least of which is defining what constitutes literature. A second challenge is that diverse disciplines contribute theoretically and empirically to the nature of epistemic cognition in literary reasoning. In this chapter we first take up the issue of what defines a literary work and the nature of the knowledge conveyed or knowable from it. We then discuss the applicability to literary reasoning of a framework on epistemic cognition articulated by Chinn et al. (2011). We use the dimensions of epistemic cognition in that framework to organize our discussion of epistemic cognition in literary reasoning as informed by theoretical and empirical traditions in literary theory and criticism, language processing, reading comprehension, and psychological research on narrative and social cognition.

## WHAT IS A LITERARY WORK?

Defining what constitutes literature is no simple task. Some researchers characterize literary works as having both literal and parallel, deeper meanings or subtexts (Schraw, 1997), but this is arguably true of other forms of discourse as well (Claassen, 2012; R. A. Zwaan, 1994). Literary works encompass a variety of genres—most traditionally, fiction, poetry, and plays—that invite the reader into an imaginary world through written text that activates an emotional response. They invite the reader into the text through literary artifices, by which we mean the intentional manipulation of language and structure to induce a reader into entering a fictional subjunctive world as though it objectively existed. Examples of literary artifices are rhetorical tools and patterns in ways of using language (e.g. metaphor, symbolism, irony, satire) or in plot structures (e.g. shifts in point of view, inverted chronologies), and archetypal character tropes

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(e.g. tragic hero, the mythic hero). These artifices appear pervasively in literary texts across historical time. They constitute a systemic interpretive "space," or set of normative conventions, that literary communities of readers and writers share.

There are certainly other genres frequently included in standard literature anthologies (e.g. essays, letters, biography, and political speeches). Typically these nonfiction works contribute to our understanding of literary movements, help us contextualize fictional works, and provide data that are often drawn upon to warrant claims about literary texts. We intentionally focus in this chapter on printed, fictional prose and poetry because literary artifices are most concentrated in such works.

## THE NATURE OF EPISTEMIC COGNITION IN LITERARY REASONING

Literary reasoning entails ill-structured problem solving (Simon, 1977); that is, literary works, especially in their greatest complexity, pose problems for which there are not simple, straightforward pathways for solution. Nor is there agreement that there are single solutions with regard to meanings. This problem-solving process is guided by readers' epistemic cognition in literary reasoning. As noted earlier, epistemic cognition in literary reasoning encompasses the nature of knowledge conveyed in literature (or knowable from literature) along with the processes, beliefs, and values brought to bear in interpreting what any specific literary work conveys. The focus on the nature of knowledge and processes of coming to know derives from the Hofer and Pintrich (1997) and Hofer (2000) formulations of personal epistemologies that could differ by domain. We argue that the nature of knowledge in literary reasoning is not singular in its scope but concerns both aesthetics (e.g. how we define that which is deemed beautiful and its impact on us) as well as the nature of the human condition (e.g. values, beliefs, or expectations regarding morality, ethics, and motivated action). To understand what is being conveyed about the nature of the human condition, readers need to pay attention to the aesthetics of how authors have crafted language and structure. The emphasis on the *how* as well as the *what* differentiates knowledge in literary reasoning from empirical knowledge that is the object, for example, of epistemic cognition in science. Differences between reasoning aimed at arguing for aesthetic or ethical knowledge claims and claims of empirical knowledge rest on the nature of what constitutes evidence and what constitutes reliable and accepted warrants to justify claims. We have found that the Chinn et al. (2011) formulation of epistemic cognition as a multidimensional construct with five components provides explanatory pathways for understanding the complexities of epistemic cognition entailed in literary reasoning.

Chinn et al. (2011) offer five components of epistemic cognition: (1) epistemic aims and values (e.g. the goals people pursue in inquiry and the worth they place on achieving these goals); (2) structure of knowledge (e.g. the structure of knowledge and the dimensions of knowledge that are valued); (3) sources and justifications of knowledge (e.g. sources people draw from to justify knowledge claims and what kinds of evidence count); (4) epistemic virtues and vices (e.g. dispositions that help or hinder accomplishing one's epistemic aims); (5) reliable and unreliable processes for achieving epistemic aims (e.g. cognitive and social processes as well as methods used to achieve epistemic aims).

In Table 11.1, we map how each of the five components of their multidimensional model can look in literary reasoning. In the sections that follow, we explore each component as they relate to literary reasoning. We draw on four major bodies of work that inform their instantiation in literary reasoning: theoretical and empirical traditions in literary theory and criticism, language processing, reading comprehension, and psychological research on narrative, social cognition, and metaphoric reasoning.

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**Table 11.1.** Epistemic cognition in literary reasoning

| Components of Epistemic Cognition | Instantiations in Literary Reasoning |
|---|---|
| Epistemic aims and epistemic values | - Interrogate conundrums of the human experience<br>- Examine relationships between content and form<br>- Examine relations across texts |
| Structure of knowledge | - Literary theorizing rarely assumes simplicity<br>• Multidimensional<br>• Contextual<br>• Probabilistic |
| Sources and justifications of knowledge | - Personal knowledge and beliefs<br>- Literary conventions<br>- Language conventions<br>- Literary traditions<br>- Other texts—literary and nonliterary<br>- Knowledge of authors<br>- Philosophical, religious, political systems of thought |
| Epistemic virtues and vices | - Appreciation of literary texts as open to multiple interpretations<br>- Dispositions to attend to nuances of language choice, language play, and text structure<br>- Disposition to deal with uncertainty and ambiguity<br>- Ideas about epistemic vices are not central to the field and where exist are rooted in debates over the nature of interpretation |
| Reliable and unreliable processes for achieving epistemic aims | Reliable processes include:<br>- Close reading<br>- Argumentation<br>- Consideration of multiple interpretations<br>- Looking for patterns |

## DIMENSIONS OF EPISTEMIC COGNITION IN LITERARY REASONING INFORMED BY LITERARY THEORY AND CRITICISM

Epistemic cognition in literary reasoning has to embody a range of approaches to literary analyses and this range makes disputes over these approaches inevitable (Tompkins, 1980). Indeed, contestation is an epistemic virtue in literary reasoning, in part because written language is the medium being examined by readers (Fish, 1980). Language is the means by which readers are invited into imaginary worlds and it is open to multiple interpretations. Openness of possible meanings creates multiple pathways by which readers can enter literary texts. The most persistent debates in the field of literary theory and criticism involve weighing the affordances and constraints of different pathways for making meaning that individuals and communities of readers construe, within particular cultural contexts and across time (Jacquenod, 1987). Thus, literary criticism places high value on contesting what language means, what it signifies. This implies that to interrogate dilemmas of the human experience readers need to appreciate the relationship between language content and form, that texts are open to multiple interpretations, and that it is important to pay attention to nuances of language choice, language play, and text structure.

With respect to the structure of knowledge, the history of literary criticism and theorizing reflects the full range from certainty and simplicity to complexity and ambiguity. Where on this continuum a particular critical method or theory lies can be contextualized by the historical time periods in which such methods and theories emerged. For example, critical methods and theory that privilege a systematic,

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almost scientific approach to the internal structure of texts (e.g. New Criticism and Structuralism) come alongside paradigm shifts in the history of science in the early twentieth century (Culler, 1975; Ransom, 1941; Thompson, 1971). Critical methods and theory that privilege the idea that literary structures are inherently unstable (e.g. Post-Structuralism, Deconstructionism) emerge alongside paradigm shifts in the history of science toward dynamic systems (Bloom et al., 1987). Critical methods and theory that privilege how issues of power are grappled with and that privilege the reader as a critical interrogator (e.g. Post Colonial theory, Black Aesthetic, Marxist, Feminist theories of criticism) emerge alongside historical power struggles over colonialism, anti-racism, and gender and sexual identities (Donovan, 1975; Hughes, 1926).

Regardless of the school of literary thought, none view interpretation as involving simplistic knowledge. Paradigms privileging meaning as internal to the text are more likely to favor the idea of unity within the text that is knowable through close internal textual examination, warranting claims by appeals to an established body of literary conventions that are employed within the text itself (Richards, 2003). Paradigms privileging meaning as emerging dynamically among the reader, the author, and the historical context of the plot or the production of the text, including the sociocultural and political aspects of the historical contexts, are more likely to favor the following ideas: meanings are not fixed and are therefore uncertain; the sources of justification for claims cannot be limited to the text; and literary conventions themselves are contestable (Eagleton, 1996; Peer, 1991). These debates make articulating a coherent epistemology of literary reasoning complicated.

Epistemic virtues (and vices) are for Chinn et al. (2011) “stable dispositions” that contribute to or impede achieving epistemic aims. Our concern is in understanding the range of knowledge and dispositions that novices need to learn in order to enter into literary debates: interpretive capacities to go beyond literal recall, the ability to wrestle with complexities that characterize the conundrums of the human condition. From an educational perspective, epistemic cognition in literary reasoning must be able to encompass knowledge and dispositions that allow the reader to take on any of the approaches to literary texts that are out there in the world, and even to develop new approaches and conventions (e.g. interpreting texts through the lens of hip hop in the current generation) (Lee, 2011). Indeed, it is this disposition to interrogate literary texts through critical lenses that the reader and communities of readers bring that has made possible Toni Morrison’s (1992) interpretation in *Playing in the Dark* of Melville’s *Moby Dick* arguing that under the political constraints of his time Melville allegorized the construct of white supremacy in the figure of the white whale, as terrorizing and elusive.

Different schools of literary theory and criticism privilege different sources and justifications of knowledge. Sources of knowledge according to Chinn et al. (2011) include “where knowledge originates” (p. 142) and “justification refers to people’s reasons for their beliefs” (p. 142). New critics beginning in the mid-twentieth century saw interpretation as requiring empirical methods and not subjective responses (Ransom, 1941). The language and structure of the text are viewed as the justifiable sources of data from which to construct claims rather than what the reader knows about the author or the historical context. Texts are presumed to reflect an internal unity (or not) based on the relationships among their parts. Structuralism offers a related focus of attention, using terminology like the “grammar” of narrative (Todorov, 1977) and “the grammar of poetry,” as noted by Jakobson (1968). Structuralism evolved beyond the intra-textual focus of New Criticism to include structural relationships among texts, the range of potential social meanings entailed in language, and the functions of cultural meanings beyond the text to inform the possibilities that configurations of structures within the text may represent (Barthes, 1988; Culler, 1975).

Reflecting ongoing debates in the field, others expanded the sources of knowledge on which the reader should draw. Northrop Frye (1957) asked, "What if criticism is a science as well as an art?" (p. 7). Frye argued that literary texts invite what he called a "centripetal" focus (e.g. on the way in which the texts works aesthetically) as well as a "centrifugal" focus (e.g. on how literature functions in the social and cultural world).

At the other end of the spectrum are theories and critical methods that privilege the reader, that empower the reader to use lenses of personal experience and political and ideological beliefs to interrogate the choices that authors make (Said, 1983, 1993). These include Post-Structuralism, Post-Colonialism, Deconstructionism, Marxist, Black Aesthetic, and Feminist approaches, among others, and the broad category of Reader Response Theory (see Eagleton, 1996, for a review).

Thus, over the history of the field are differing articulations of *epistemic aims* (e.g. understanding authorial intent versus reader response), the *structure of knowledge* (structures internal to the text versus inter-textual structures), *sources and justifications of knowledge* (the text as the source versus the reader and ideological/philosophical community norms and resources), *epistemic virtues* (valuing the internal presumed logic of the text versus pursuing instabilities and contradictions within and across texts), and commitments with regard to *reliable processes* for achieving interpretations (e.g. examining language and structure for internal unity versus examining language and structure within a text and their relations to reader's individual worldviews or broader cultural, moral, and political ecologies). These shifts do not represent revolutions in the sense that Kuhn (1970) talks about scientific revolutions where one paradigm takes precedence over the other. Rather, just as Newtonian physics remains useful for building bridges, but not exploring the inner workings of the micro-leveled world, so the evolution of literary paradigms each offer different explanatory power and enable communities of readers to tackle different questions (Stokes, 1997).

## SOURCES OF JUSTIFICATION: CONTRIBUTIONS FROM STUDIES OF LANGUAGE PROCESSING

Linguistics ranges from a focus on internal structures of language (e.g. phonology, morphology, syntax, and semantics) to fields that focus on relations between internal linguistic structures and the cultural, social, and historical contexts of how language is used and understood (e.g. pragmatics, stylistics, semiotics; the broad field of sociolinguistics and discourse analyses) (Fasold & Connor-Linton, 2006; Gumperz & Hymes, 1972; D. Lee, 2001).

Attention to internal structure and form in linguistics has influenced schools of literary criticism that privilege internal structure and form in literary texts: Russian and French formalism, Structuralism, and New Criticism. On the other hand, attention to processes of social interaction in meaning making through language has contributed to schools of literary criticism that privilege interactions between the reader and the text: Reader Response Theory, Post-Structuralism, and Critical Literacies. (See Fabb, 1997, and Schogt, 1988, for overviews.)

For example, speech act theory (Austin, 1975; Searle, 1969; Searle, Kiefer, & Bierwisch, 1980) has been used to examine relationships between reader and text, taking up the problem of how humans can understand that which is implied. For example, the sentence "How are you?" can be interpreted literally as a speaker's request about the health of the listener—a direct speech act. That same sentence, however, could in a different context be understood as a cursory greeting or as an attempt to establish a positive relationship. This attention to indirection and the possibilities of multiple meanings of utterances (e.g. polysemy) invites a theoretical framework for interrogating the social, cultural, and political spaces that influence how utterances are produced and taken up, both in oral discourse as well as literary texts. A broad family of linguistic traditions examine implicature both in everyday language and in highly stylized ways in literary texts, including Bakhtin's (1981, 1986) focus on dialogicality (e.g. the idea that novels are in dialogue with one another and therefore meanings are inherently intertextual, albeit indirectly so), Altieri's (1981) focus on the stylistic choices of authors to present through indirection their own points of view, and Judith Butler's (2011) attention to how gender or Henry Louis Gates' (1984) attention to how race may be implicated in literary works through language choices. These traditions constitute exemplary contributions in the sociolinguistic tradition to literary criticism and theorizing (Pratt, 1977).

These extrapolations from sociolinguistics influence each of the components of epistemic cognition outlined by Chinn and colleagues (2011), but in particular the sources of knowledge are now rooted in multidimensional approaches to understanding how language meanings are co-constructed among interlocutors within particular local and broader cultural contexts.

## RELIABLE AND UNRELIABLE PROCESSES FOR ACHIEVING EPISTEMIC AIMS: CONTRIBUTIONS FROM RESEARCH ON COMPREHENSION

Reading comprehension research on print-based and nonprint narratives (e.g. film, music lyrics, visual narratives, oral texts) helps us understand some dimensions of epistemic cognition relevant to literary reasoning. While our focus here is on print narratives, some of the rhetorical and structural choices made by authors of fictional works in print can also be seen in non-text based narratives.

Reading comprehension entails top-down and bottom-up processes (McNamara & Magliano, 2009; Rapp & Taylor, 2004; Spiro, 1980): readers draw on knowledge already stored in long-term memory (e.g. top down) and from attempts to examine specific details in the material being read (e.g. bottom up). Readers draw on multiple kinds of prior knowledge, including linguistic knowledge (e.g. word and sentence structures), semantic and propositional knowledge (e.g. the possible range of meaning of words and phrases), text knowledge (e.g. structure and functions of different ways of organizing information), and schema (e.g. content and affective knowledge, schemata for events, goal-plan structures) as well as knowledge of strategies for using this range of prior knowledge (Goldman, 1997; Kintsch, 1994; RAND Reading Study Group, 2002). These processes are interactive and dynamic, depending on the demands of the text, the nature of the task as the reader perceives it, and the resources the reader (individually or in interaction with others) brings to the act of making sense of the text (Goldman & Lee, 2014). The levels and specificity of these kinds of knowledge on which readers draw can explain differences between surface level interpretations of plot and interpretations of theme and structure in literature. For example, one can be competent in comprehending the plot of a story with simple language (e.g. Alice Walker's *The Flowers*), but not able or disposed to interrogate broader themes or the author's uses of language and structure to convey meaning in this same seemingly simple story (C. D. Lee, 2006). Overall, the research on reading comprehension suggests that literary comprehension demands a disposition to make meaning, to connect the reader's knowledge with the text, and to be open rather than fixed in one's orientation to making meaning. What ends such openness should be directed toward are informed by the broad communities of literary theorizing and criticism addressed in this chapter.

In addition to the kinds of knowledge investigated by researchers of basic reading comprehension processes, there are additional foundational knowledge resources for engaging in complex literary epistemological orientations and dispositions including figurative language, themes, rhetorical strategies, literary text structures, character types, and what Rabinowitz (1987) calls Rules of Notice (knowledge of a range of literary moves authors often make to guide the reader's attention) and Rules of Signification (e.g. knowledge on which readers often draw to impose significance or meaning to what they have deemed salient).

## RELIABLE AND UNRELIABLE PROCESSING: CONTRIBUTIONS FROM PSYCHOLOGICAL RESEARCH

Relevant research in psychology has addressed narrative as a sense-making process, social cognition (e.g. processes entailed in reading the internal states of others), studies of metaphor and visualization in cognitive processing, and the role of cultural schemata.

A foundational warrant addresses the role of narrative in how humans make sense of experience in the world. Bruner (1990), Pinker (1994), Sugiyama (2001), and others have analyzed how human beings in attributing significance to their experiences in the social world represent those salient experiences in narrative structures in long-term memory (J. Mandler, 1978; J. M. Mandler & Johnson, 1977; Schank & Abelson, 1977). For example, seeing a picture of a pleasurable object in a household room from your childhood can lead you to remember the people who were there, what happened, why it happened, and how you felt. Story grammar research shows that without explicit instruction, children focus on characters; their goals and motivations; events, their sequence, and logical relations; and on what is called the coda, or "So what?" (Goldman, Reyes, & Varnhagen, 1984; Johnson & Goldman, 1987; Stein & Glenn, 1979; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985). These are the building blocks of everyday and literary narratives, and thus one foundational disposition in literary reasoning is to seek to understand these elements. What we learn from literary theory and criticism is how these elements can be complexified in literature. These complexities distinguish novice from expert in terms of what knowledge, strategies, and dispositions are required to interrogate the most complex representations of character, plot, and theme. Characters can be psychologically simple or complex, stable or changing; they can range from more human-like to more god-like, from having tragic flaws to extraordinary powers. Plots can be linear or inverted, and can be single or multiple within the same text; the same event can be represented through

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multiple points of view; narrators can be trustworthy or unreliable; and narrators can be single or multiple within the same text. Story themes can reflect a well-accepted maxim or interrogate a conundrum of the human experience for which there is no single, straightforward resolution; these are often captured in archetypal themes that cross historical time frames and may be interrogated in very different ways in different cultural and historical communities.

Another warrant in the psychological realm comes from the field of social cognition (Flavell & Miller, 1998; Kunda, 1999; Meltzoff & Decety, 2003) and the emerging field of social neuroscience (J.T. Cacioppo, 2002; J.T. Cacioppo, Visser, & Pickett, 2005). Social neuroscience examines the neural substrates of social cognition, that is, the disposition of human beings from birth across the life span to learn to read and construct inferences about the internal states of other human beings. In terms of a comprehensive conception of epistemological dispositions in literary reasoning, certainly the disposition to try to figure out what makes characters tick is central, and the drive to construct such understandings of the internal states of fictional characters is greatly impacted by the reader's emotional response to the people and what they do. From the perspective of literary theory and criticism, literary knowledge (of rhetoric, plot structures, figuration, themes, character types, etc.) serves as one foundation on which readers draw in order to carry out this basic, even everyday goal of needing to understand what makes characters tick. In this case, characters can operate in worlds that, at least on the surface, appear quite different or unusual from the everyday world of the reader. The potential distance of the fictive world from the reader's experience of the "real" world can make the task of inferring the internal states and motivations of literary characters more complex.

Additionally, dual processing perspectives of information processing (Louwerse, 2008; Louwerse & Zwaan, 2009; Paivio, 1971, 1986; Sadoski & Paivio, 2000) and research on the role of cultural schemata in the processing metaphor are relevant. Dual processing perspectives claim two sets of knowledge systems support meaning making: one operates on linguistic symbols and another operates on grounded symbols (i.e. perceptual-motor representations). Linguistic symbols are implicated in processing the language used in a work of literature, whereas grounded systems can support meaning making via a process of simulation that reflects how events unfold in a fictive world (Louwerse, 2008; Louwerse & Zwaan, 2009; Zwaan, 2014). Consider the following sentence from Gary Soto's short story, *The Jacket* (Soto, 2000):

> The next day when I got home from school, I discovered draped on my bedpost a jacket the color of day-old guacamole.

Linguistic knowledge systems support lexical access to word meaning, syntactic parsing, and the propositional representation that reflects the gist of the sentence content. Grounded systems give rise to a simulation that uses a subset of the same perceptual systems involved in actually seeing similarly arranged objects (Barsalou, 1999; Stanfield & Zwaan, 2001), and *could* be experienced as mental imagery of the described scene. This simulation could also reflect the color of the jacket, which is not deemed desirable by the protagonist. Perhaps the ability to create such a simulation allows the reader to appreciate the character's sense of disgust at the jacket's color.

There are interesting theoretical connections between dual processing perspectives focusing on relationships between the visual and the linguistic in how we make sense of phenomenon and Lakoff and Johnson's (1980) discussion of what they call

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conceptual metaphors. Lakoff and Johnson claim that in everyday life, across cultures, humans operate with conceptual metaphors that embody foundational propositions (e.g. the metaphor of ideas as plants, as in "His ideas have finally come to fruition," or "That's a budding theory" [p. 126]). They argue these everyday conceptual metaphors are typically rooted in visualizations and evolve from the primacy of physical navigation in the material world (e.g. early physical movements of up as not merely learning to stand up, but psychologically to move up, to grow up, to get better). These conceptual links between metaphor and the visual are commonplace in rhetorical choices literary authors make to guide the reader's attention and invite abstract associations that we may construe as helping us understand themes. Lakoff and Turner (2009) illustrate such conceptual metaphors in poetry. These dispositions in literary reasoning to attend to plot, figurative language, characters and their internal states, and ways that authors work to help readers visualize settings, are essential to understanding epistemic cognition in literary reasoning. That there may be an evolutionary, biological substrate to such dispositions (e.g. metaphorical reasoning, visualization) may warrant their importance and the ubiquitous nature of these dispositions across works of literature (Hogan, 1997).

These and other examples from the study of metaphor (Ortony, 1979; Ricoeur, 1978; Sweetser, 1995), visualization, narrative sense-making, social cognition, and social neuroscience lead us to hypothesize that reasoning about literature involves sense-making that is central to what it means to be human, with antecedents in the evolution of our species. It is perhaps one reason why literature—in all its variations across time and space—can be found in all cultures, and serves a hermeneutic function (e.g. examining deeper meanings) in all cultures in terms of how human beings understand themselves and their environments. Indeed there is an emerging trend in cognitively oriented literary studies to consider how human evolution and the dynamic relations among mind, body, and the environment offer explanatory paths for understanding poetics, our interpretations of the figurative, of archetypal themes as these are represented in literature (Hart, 2001; Miall & Kuiken, 2002). The underlying idea is that literary production and interpretation fulfill foundational needs of human functioning. One example is represented in the prevalence of universal archetypal themes (e.g. mating, sustaining social relationships, understanding the life cycle of birth and death, motivations for and consequence of violence) that human beings wrestle with by virtue of their basic needs for survival (Hart, 2001).

While these dispositions are central to human sense-making activity, their specificity differs substantively across cultural communities. Anderson and colleagues have documented the influence of cultural schemata (Bartlett, 1932) in how readers make sense of texts (Anderson, 2004; Reynolds, Taylor, Steffensen, Shirey, & Anderson, 1982; Steffensen, Joag-Dev, & Anderson, 1979). Schemata are scripts (Rumelhart, 1980; Schank & Abelson, 1977) we internalize from experience in the world about the central and minimal essential features that help us recognize particular constructs (e.g. a horse as a four-legged animal taxonomically related to other four-legged creatures) and events (e.g. a script for eating out at a restaurant). We use and update schemata to organize information in long-term memory and to make and test predictions about what we understand about new experiences in the world. For example, Steffensen et al. (1979) found that when reading stories with minimal descriptions of an event like a wedding, readers from different cultural backgrounds made inferential elaborations based on their cultural schemata for what was entailed in a wedding. In literary texts, sometimes authors will draw on specific cultural knowledge and traditions that may also be specific to particular historical periods in the construction of plot, character, and potential warrantable themes. For example, the cultural schemata entailed in understanding why religious leaders and ordinary people in Salem would crucify Hester Prynne in Nathaniel Hawthorne's *A Scarlet Letter* would be quite different for those reading at the time the book was published compared to contemporary readers in the Western world or to readers in conservative Hassidic, Christian, or Muslim communities today.

## FROM THEORY TO REAL READERS: CONNECTIONS TO NOVICE/ EXPERT EMPIRICAL STUDIES

We have thus far illustrated theoretical foundations informing epistemic cognition in literary reasoning. We now offer examples from empirical studies of differences in how novices and experts solve problems. In these studies, experts are typically teachers or professors formally trained in the study of literature. Novices are typically high school students or undergraduates who do not have much formal training in the field. The unifying idea here has to do with the level of training in the field and the degree to which reading literature is commonplace. The parallels in what we find in the theoretical literature and in the empirical studies of novice and expert practices offer a strong warrant for the conceptualization of literary epistemic cognition we put forth.

Empirical studies of literary understanding of both prose and poetry suggest that experts have a general epistemological orientation to literature as an art form that expresses ideas about human nature (Dorfman, 1996; Galda & Liang, 2003; Peskin, 2007), and assume a purposeful author who crafts literary language to create particular effects (Graves & Frederiksen, 1991). In contrast, in a study of 150 novice literary readers by Vipond and Hunt (1984), only about 5 percent were aware "that it might be possible to impute motives to an intentional author" (p. 26).

Studies of concurrent and retrospective responses to literary texts suggest that experienced readers construct thematic interpretations and organize a text figuratively as well as literally (Graves & Frederiksen, 1996; Peskin, 1998; Zeitz, 1994). They are also more likely to believe that complicated or postmodern stories have no "points" (Dorfman, 1996) and to revise interpretations as they reread and reexamine the text. Expert readers are more likely to attend to literary devices and thematic tensions (Peskin, 1998) and to violations in convention in terms of plot or language (Peer, Hakemulder, & Zyngier, 2007).

Experienced readers' skills and practices can affect how literature influences their beliefs beyond the world of the text. In one study, experts and novices read two versions of a literary passage about struggles of immigrant life—the first in its original state and the second stripped of its literary language. When queried about difficulties of immigrant life, experienced readers of the literary version had more sympathetic responses, whereas inexperienced readers did not (Hakemulder, 2004). In this case, experts and novices had vastly different experiences in reading literature.

Research suggests that most readers, regardless of experience, are aware of and find literary language and other rules of notice—e.g. metaphors, rich imagery, juxtapositions, unusual language—to be especially salient to their reading of both poetry and literary prose. For example, Miall and Kuiken (1994a, 1994b, 1995, 1998, 2002) assert that awareness of and attention to such literary language is "psychobiological" in nature, and specifically affect-related. For example, in one study, undergraduate inexperienced literary readers found some noun phrases to elicit more affective responses when read

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as part of a poem than not, and passages rich in literary devices elicited more affective responses than other passages (Miall & Kuiken, 1994a, 1998). Similarly, other studies show that inexperienced readers find literary language to be especially "striking" (Peer et al., 2007) and that figurative language is highly correlated with readers' general emotional responses (Goetz et al., 1992). Other evidence shows that authors may use more literary devices, such as rich imagery, to communicate feelings within texts; specifically characters' emotional states are often depicted through image-rich descriptions of physical appearance (Dijkstra, Zwaan, Graesser, & Magliano, 1995).

Overall these studies demonstrate that in comparison to novices, experts attend to relationships of structure and meaning and to how these relations inform themes about the human condition.

## IMPLICATIONS FOR CONCEPTUALIZING EPISTEMIC COGNITION IN LITERARY REASONING

Chinn et al. (2011) call for expanding the domains from which research on epistemic cognition draws to include not only psychology but also philosophy. We argue in this chapter that literary reasoning as a domain is essentially interdisciplinary in nature, informed by literary theory and criticism, language processing, reading comprehension, as well as basic psychological sense-making processes. As such, it may conceptually sit at the other end of the spectrum from epistemological research on science, with research on processes of inquiry in history and the social sciences in between them. Epistemic aims in science—at least in terms of the community of scientists—are about maximizing the probability of the truth value of claims based on how well the theoretical model that the claims aim to support is justified by the data and the conditions under which the data were collected and analyzed (National Research Council, 2012). Epistemic aims in history are about probability based on how well the data fit with the accepted historical record, and how well the model or explanation takes into account the contexts under which the data were generated and possible biases entailed in the production of the data or documents from which the data are generated (Wineburg, 1991). In history as well as science, there are domain-specific explanatory models within the disciplines (e.g. interactions, energy, and dynamics in ecosystems in science; models of economic systems and political systems in history) that provide the foundations on which investigations draw. In literature, the terrain is essentially contested territory as we have attempted to illustrate in our discussion of the influences of theories of language processing and theoretical traditions of literary criticism. And even though there are, for example, contested theories of political systems (e.g. pathways for wrestling with relations between the rights of individuals and the powers of the levels of government in a democratic federal system) used to explain the motivations and actions of nation states, there is a sense of a truth value that debates over such theories must address, that is, how these systems operate in the real world. Because the meaning making of readers of literature is largely personal, social, and cultural, much of the claims in the psychological research about epistemic cognition connect to literary reasoning in very different ways than in other disciplines. If we use literary reasoning as an example, the hybridity of the enterprise itself, the fact that so many domains are invoked in its problem solving (language processing, cultural construals of people's internal states, features of texts, schemata for everyday and unusual human events, etc.) suggests that further examination of literary epistemic cognition requires digging deep into all the relevant domains that contribute to knowledge in this discipline.

Literary reasoning—as we are addressing it in this chapter—is text based and consistent with expanded attention to epistemic cognition as situated in social contexts and not just conceived as traits or kinds of knowledge and dispositions of individuals (Muis & Duffy, 2013). Attention to emerging conceptions of text comprehension that address dynamic relationships between the demands of the text, the nature of the task, what the reader brings, and the contexts under which such problem solving occurs is useful.

## INSTRUCTIONAL IMPLICATIONS: TEXT, TASK, READER, AND CONTEXT

Chinn et al. (2011) argued for an expanded definition of epistemic cognition that includes epistemic aims and value; the structure of knowledge; sources and justification of knowledge, including epistemic stances; what they call epistemic virtues and vices (e.g. intellectual courage and open-mindedness that can contribute to achieving particular goals); and reliable and unreliable processes for achieving epistemic aims (p. 142). The complexity of literary reasoning—using the range of expert communities of practice within this field—is that every component that Chinn and colleagues identify is contested territory. This contestation is what we have attempted to illustrate in the discussion of the broad array of work in literary theory and criticism. Thus, one could argue, that rather than thinking of epistemic cognition in literary reasoning as a coherent whole, it may be more useful to think about what epistemic cognition must embody. Rather than preparing novices to take on one perspective or orientation to literature, we argue that it would be more fruitful to expose them to the range of epistemic stances with regard to literature.

Discussions about the social dimensions of epistemic cognition invite not only investigations about how social contexts of problem solving are organized, but particularly with respect to literary reasoning, invoke a multitude of cultural dimensions. Specifically, we discussed how foundational research in sociolinguistics and cognitive linguistics have influenced critical traditions in literary response. This means, for example, that readers who speak nonstandard dialects of English or multiple languages may bring unique linguistic resources for interrogating metaphorical language in literary texts. Lee's (1995, 2007) research in Cultural Modeling, for example, demonstrates that everyday tacit knowledge and dispositions—specifically, speakers of African American English valuing figuration in everyday talk—can be scaffolded to become explicit and transferable to literary analyses. Gee (1989) and Champion et al. (1995) have documented connections between structures of literary narratives and narrative structures employed in African American English speech communities. Research on cultural displays in instructional discourse can expand opportunities for participation in literature classrooms as well as in other disciplines (Gutierrez, Baquedana-Lopez, & Alvarez, 1999; C. D. Lee, 2005; Orellana, 2009). Muis and Duffy (2013) discuss what they call epistemic climate. Such climates aim to expand epistemic changes in beliefs about problem solving. Facilitating such changes likely requires more than a generic focus on constructivist principles of instruction. Such changes require specialized foci on the nature of the cultural resources that learners bring to epistemic tasks and how these cultural resources are connected to the nature of the disciplines in which these tasks reside (C. D. Lee, 2010).

To the extent that instructional climate can provide a medium to support epistemic changes among novice learners, how we understand the ways that epistemic cognition can be influenced by the nature of the social context also invites attention to broader

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ecological contexts that can influence the perceptions that learners bring to the tasks at hand. Chinn et al. (2011) discuss this as the social aspects of epistemic cognition. These ecological contexts can include learners' histories of participation in related practices, such as entering high school where literature classrooms have focused primarily on literal understandings of plot and character with assumptions about a "right" interpretation that is offered and/or validated by the teacher; macro-level institutional practices and belief systems that position the learner as deficit based on race, ethnicity, language practices, and class; or long-term placement in schools where resources in terms of teacher quality, range of texts available, etc., constrain what learners think is possible (C.D. Lee, 2009). While these broader ecological processes apply regardless of the domain or discipline, they play unique roles with regard to literary reasoning, precisely because literature is rooted in wrestling with conundrums of the human experience. The fact that such conundrums are never fully resolvable invites interrogating issues connected to identity and resilience. For example, literary texts can invite novice readers to wrestle with such dilemmas as how public standards of beauty position them, and with what is entailed in wrestling with evil and tragedy in one's life, life challenges that can be inherently destabilizing and personally challenging (Spencer, Dupree, & Hartmann, 1997).

Current research on text-talk-reader-context relationships poses a fundamental challenge of school-based disciplinary learning. Conceptions of epistemic cognition are essential to understanding these relationships in learning to read in the disciplines, especially for middle and high school (Goldman & Lee, 2014; Valencia, Wixson, & Pearson, 2014). In literature, we have described dimensions of epistemic cognition that inform how we understand sources of complexity in literary texts, the attributes of tasks that are valued in the discipline, the kinds of knowledge and dispositions that such reasoning requires, and illustrations of how historical contexts and peoples' participation in everyday practices shape the epistemic work. We argue that understanding these epistemic dimensions of knowledge in literature is the foundation for examining text–task–reader–context relationships in reading. We will focus here on its challenges for reading and interpreting literature.

In the discussion of literary theory and criticism as a source of knowledge in literary reasoning, we identified the contested ways in which the structure of texts (e.g. uses of language, genres or structures of texts, deployment of rhetorical strategies) and the role of authorial intent play out. However, despite the historical and contemporary debates, it is clear that attention to structure and rhetoric are important problem-solving resources, even if the reader is disposed to reject or assume lack of a unified structure in literary texts. As a consequence, text and task demands in literary reasoning require developing both the disposition and a range of skill sets to interrogate structure and rhetoric. Common Core State Standards (National Governors Association, 2010) at this writing are the most recent articulation of standards for reading comprehension in the disciplines, but little in these standards articulates the nature of these structural and rhetorical knowledge demands, let alone how to design learning environments for novices that would support such knowledge and dispositions (C. D. Lee & Spratley, 2009).

In middle and high schools, particularly those in low-income communities, we do not sufficiently examine the complexities of literary texts, and we do not utilize the processes entailed in interrogating such texts in ways that provide novices with multiple pathways for interpretation. We do not typically structure tasks or contexts through which novices learn and show competence that reflect the epistemic aims of literary analysis, again especially for students in low-income schools. And we do not sufficiently design instruction in ways that take into account and build on the repertoires of practice (Gutierrez & Rogoff, 2003) that students from diverse backgrounds bring to the enterprise.

We describe two pedagogical designs for the teaching of literary reasoning that explicitly address the development of the knowledge and dispositions we have attributed to epistemic cognition in literary reasoning. First, Hillocks (Hillocks & Ludlow, 1984) has empirically validated a hierarchy of text comprehension questions or tasks for literature. The two most rigorous interpretive tasks are what he calls author generalizations (AG), or what is typically referred to as theme, and structural generalizations (SG). SG tasks require the reader to examine the structural and rhetorical choices made by authors and how these choices operate to convey meaning. This task does not assume a singular meaning, nor does it constrain the sources of knowledge on which the reader can draw to warrant the textual evidence linked to claims. Using a Toulmin model (Toulmin, Rieke, & Janik, 1984), the validity of such arguments depends in part on the audience to whom the argument is addressed. In Hillocks research, AG tasks around theme and character invite the articulation of criteria for making judgments (e.g. on what criteria does the reader evaluate actions as courageous or a character as tragic, or a narrator as unreliable). In line with constructivist principles of learning, Hillocks calls for the design of *gateway activities* (e.g. scenarios, surveys, opinionaires that invite contrastive cases) that students examine in order to generate, through social interaction, criteria they can use in making such arguments of judgment (Smagorinsky, McCann, & Kern, 1987).

Lee's (1995, 2007) Cultural Modeling Framework (1995, 2007) calls for the use of *cultural data sets*. Cultural data sets are narrative "texts" broadly speaking (examples of everyday talk such as signifying dialogues, song lyrics, film clips) that require the ability to detect and examine an interpretive problem (e.g. problems such as symbolism, satire, irony, and unreliable narration that influence both the structure and rhetorical choices of authors) employing Rabinowitz's (1987) Rules of Notice and Rules of Signification. Cultural data sets must embody the same structural and rhetorical problems as the canonical texts that students are being prepared to tackle *and* students must be able to tackle the complexity of these everyday narrative texts with minimal assistance from teachers. Through scaffolded discussion, students themselves articulate strategies they use to detect and impute meaning to these classic interpretive problems. With both the use of gateway activities and cultural data sets, the aim is to socialize knowledge, dispositions, and goals that are central to problems of literary reasoning (in other words, to socialize epistemic cognition in literary reasoning). They are sufficiently open that teachers and curriculum designers can draw on the range of cultural resources that students from across diverse backgrounds can bring to the table and thereby open opportunities for students to explore different approaches to literary text analyses (e.g. a feminist reading, a structural reading, a Black Aesthetic reading).

Among the challenges of designing instructional climates to influence students' epistemic cognition is understanding what beliefs they already hold with regard to the epistemic demands of the discipline. While scales for measuring such knowledge have been developed in history and science, work is just beginning with regard to literary epistemic knowledge and beliefs. Yukhymenko-Lescroart et al. (in preparation) developed an instrument for measuring adolescents' epistemological beliefs about literary reasoning around three factors: value placed on multiple readings, the idea that

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literary texts can have multiple meanings, and beliefs with regard to how and whether literature can support social functioning. Early results show that students who like reading and read frequently outside of class tend to believe that literature is more open to interpretation, multiple readings enhanced the experience of literature, and there is a social value in reading literature rather than that the meaning of literature is fixed, only a single reading of a literary work is necessary, and that literature tells us little about the everyday world.

## CONCLUSION

In arguing that epistemic cognition is inherently multidimensional, Chinn et al. (2011) call for additional research that examines with fine-grained analyses the specifics and contextual nature of such cognition, including discipline and contextual differences. The epistemic demands of literary reasoning invoke knowledge and dispositions from across multiple disciplines and can be complicated by the fact that many of the substrates of such reasoning are ontologically connected to our meaning-making processes as human beings. Yet, such processes become complicated in technical and cultural ways in the praxis of literary authors. Still, the value of unpacking such cognition with literary texts is extraordinarily important because of the ways that literature opens up new possibilities for wrestling with what it means to be human.

## ACKNOWLEDGMENTS

The research reported here was supported, in part, by the Institute of Education Sciences, U.S. Department of Education, through Grant R305F100007 to the University of Illinois at Chicago. We acknowledge the other members of the Project READI Literature Team who contributed to the thinking reflected in this chapter, Stephen Briner and Mariya Yukhymenko. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

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# 12

# DISCIPLINARY INSIGHTS INTO THE STUDY OF EPISTEMIC COGNITION

*William A. Sandoval*

Knowledge in the disciplines takes many forms, as do the processes by which these forms are created and legitimized. This is one of the basic insights to take away from the set of chapters in this section. This insight has a number of implications for the conceptualization and study of epistemic cognition. One is that forms of knowledge within and across disciplines are quite varied, and this variation extends well beyond the dimensions of simple/complex and certain/tentative that have typically been used to characterize the nature of knowledge in research on epistemic cognition (Hofer & Pintrich, 1997). Understanding in the disciplines entails coming to understand the forms of knowledge produced in that discipline and the kinds of warrants used to legitimize them. Consequently, to study epistemic cognition within the disciplines requires attending to how people come to understand disciplinary knowledge forms and their construction, i.e. the epistemic forms and games (Collins & Ferguson, 1993) of a discipline.

A second implication from the disciplinary perspectives on epistemic cognition reflected in these chapters on science, math, history, and literature is that there may be considerable opportunities for productive scholarship looking across disciplines, and beyond them, to explore the ways disciplinary learning bridges to everyday settings of reasoning. In science education, for example, there is growing attention to the historical failure of, and current need for, school science learning to be more useful outside of school (Bromme & Goldman, 2014). With respect to the study of epistemic cognition, work specifically aimed at contrasting epistemic cognition across the disciplines or across settings where disciplinary knowledge or thinking might come into play could highlight important non-epistemic factors that might influence epistemic cognition. These factors are very likely to be tied to the goals people pursue in various settings, both epistemic aims (Chinn, Buckland, & Samarapungavan, 2011) and non-epistemic ones.

A final implication from the disciplinary perspectives on epistemic cognition in this volume is that the study of learning in the disciplines is a crucial site for studying how people come to understand knowledge and knowing more generally. Learning in the disciplines involves learning the epistemic practices of a discipline to create and



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evaluate disciplinary forms of knowledge. Such contexts, as the chapters in this section show in detail, provide rich settings in which to study how learners come to make sense of the epistemology of particular disciplines. Developmental and educational psychologists have under utilized disciplinary learning as a site for testing general models of epistemic cognition and its development (see Hofer & Bendixen, 2012).

## DISCIPLINARY PERSPECTIVES ON KNOWLEDGE AND KNOWING

Each of the chapters on epistemic cognition in science (Elby, Macrander, & Hammer, 2016/this volume), mathematics (Depaepe, De Corte, & Verschaffel, 2016/this volume), history (VanSledright & Maggioni, 2016/this volume), and literary reasoning (Lee, Goldman, Levine, & Magliano, 2016/this volume) provides a frame for interpreting the epistemology of their discipline. These frames are quite useful because they provide a guide for thinking about epistemic expertise in discipline-specific ways. The details of these epistemological frames vary from discipline to discipline, of course. This variability is itself extremely helpful for making clear some important points about knowledge and knowing within disciplines. Here I highlight two that I consider especially important for broader scholarship on epistemic cognition. One is that each of these chapters makes clear that within and between disciplines there is a great deal of variability in disciplinary stances on objectivity, variability that highlights the possibility that "the structure of an individual's knowledge does not have straightforward implications for his or her view of the structure of the world" (Chinn et al., 2011, p. 150). They also reflect what Chinn and colleagues point out as the multidimensional structure of knowledge, including not just complexity, but universality, and the stochastic nature of many claims about the world (see Chinn et al., 2011).

A second point is that the variability in the kinds of knowledge disciplines strive to build gives rise to an equal variety of epistemic practices developed in the disciplines to build and evaluate knowledge. It is especially notable that these processes are also quite specific, even within disciplines, reflecting the historical ways in which disciplines, and particular fields within them, develop epistemic cultures (Knorr-Cetina, 1999) to solve their particular epistemic problems. Each of these chapters points to the need for epistemic cognition research to attend not just to the general structure of knowledge, but to disciplinary forms of knowledge and the epistemic practices surrounding their development.

### *Disciplinary Perspectives on Objectivity*

Each of the chapters in this section includes an effort to describe the epistemology of its discipline. Elby, Macrander, and Hammer locate this discussion in their review of research on beliefs about the nature of science (NOS). That work has historically been closely tied to interpretations of the philosophy of science as guides to articulate the facets of epistemology that ought to be included in any deep understanding of science. Thus, within science education NOS research has always been focused on an epistemology of science, rather than a general "personal epistemology." Similarly, VanSledright and Maggioni summarize trends in the epistemology of history, as Depaepe and colleagues do for mathematics. Both chapters explicitly address the dilemma of distinguishing the epistemic, the structure of knowledge, from the ontic, the structure of reality (Chinn et al., 2011). Put simply, this dilemma is whether or not there is some objective reality independent of knowers, and thus whether subjectivity comes from

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limits to human capacities to perceive such objective truths or whether all "truth" is subjective. VanSledright and Maggioni provide a cogent discussion of the dilemma of objectivity in history, tracing it back to some of our earliest historical accounts from Ancient Greece. This dilemma has its counterpart in science, dating back at least to Bacon's effort to impose objectivity as an ideal feature of science (Leatherdale, 1974). Depaepe and colleagues trace a similar dilemma in mathematicians' thinking about their discipline, contrasting an "absolutist" position that sees mathematical truths as independently objective from knowers, to a "fallibilist" position that sees mathematics as a social outcome.

Lee et al. introduce literary interpretation as a new discipline for study of epistemic cognition. Related to arguments by Chinn and his colleagues (Chinn et al., 2011; Chinn & Rinehart, 2016/this volume), Lee and colleagues show how literary interpretation works toward ends like "understanding" and "meaning" rather than "knowledge" in the strict sense of justified true belief. Thus, literary interpretation seems to always work at two levels: interpreting an author's intended meaning in a text, and interpreting the relations between such meaning and what it has to say about "conundrums of human experience" (Lee et al., 2016/this volume, p. 177). From Lee and colleagues' analysis, objectivity seems possible only, if at all, at this first level of an author's intended meaning.

These chapters make it clear that within the disciplines there is epistemological variability; there is disagreement about the degree of objectivity of the world and the possibility that objective truth, if it is real, can be comprehended with certainty. If this is the case within disciplines, some of which are quite old, then one can wonder what value there is in postulating psychological models that simplify or ignore that variability. If professional mathematicians, for example, can argue for an epistemological absolutism to mathematical truth, or scientists or historians can debate the ultimate objectivity of accounts of the world, then psychological theories of epistemic cognition make a very basic error in asserting that "absolutism" is inherently less epistemologically sophisticated than "evaluativism" (to borrow labels from Kuhn, Cheney, & Weinstock, 2000). This error has been identified before as the error of confusing the epistemic, what we can know about the world, with the ontic, how the world really is (Chinn et al., 2011; Greene, Azevedo, & Torney-Purta, 2008). Many of the chapters in this handbook suggest this error is becoming less common. The four chapters in this section provide glimpses into how the disciplines have tended to approach such vexing questions.

This seemingly inextricable conflation of the epistemic and ontic within disciplines further suggests that characterizing the nature of knowledge along continua from simple to complex, or tentative to certain (Hofer & Pintrich, 1997), is itself not epistemologically nuanced (a useful term introduced by Depaepe et al.). Rather, such designations can be made about particular claims but not knowledge, per se. To be sure, NOS researchers have tended to claim scientific knowledge is more appropriately seen as tentative rather than certain, but some push back against such a dichotomy by insisting that some knowledge claims can be taken as certain; however, such judgments are made about particular claims, not an omnibus science knowledge (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003).

The chapters in this section align with Chinn and colleagues' (2011) argument that the structure of knowledge within the disciplines is multidimensional, and that questions of the certainty or simplicity of knowledge claims are answerable only via a discipline's own processes for knowledge production, and are tied to perspectives on the possible objectivity of knowledge. These perspectives on objectivity cannot easily be labeled as more or less sophisticated.

### *Plurality and Specificity of Reliable Processes for Knowing*

These chapters on epistemic cognition in the disciplines can be read as a call to focus research more clearly on reliable processes for knowing. One of the refreshing, perhaps not too surprising, insights from these chapters is that there are a great many, rather specific, processes used to try to know. Each chapter makes clear that processes for knowing in the disciplines are themselves tied to conceptualizations of forms of knowledge. VanSledright and Maggioni frame historical interpretive procedures in relation to a knower's perception of the nature of historical objects (e.g. documents, pictures, paintings) and whether such objects carry their own meaning or have meaning imposed upon them. To the extent meaning is imposed, then historians have to come to some agreements about the legitimate procedures by which such impositions are allowed. In science, while not discussed at length by Elby et al., there has been a great deal of philosophical and educational work focused on practices of experimentation, modeling, argumentation, and so forth (National Research Council, 2007). Sociological studies of science show conclusively that the forms of such practices are specific to science fields (e.g. Knorr-Cetina, 1999) rather than science writ large. Lee et al. detail a great deal of variety in the ways both the aims and processes of literary interpretation have been pursued historically, and how such differences are reflected in contemporary practice. As they discuss, what is considered to count as "the text" varies among schools of literary theory, as do associated objects, to borrow from VanSledright and Maggioni, that might be brought to bear to interpret texts.

The chapters in this section show forms of knowledge vary considerably across the disciplines, and reliable processes of knowledge production are closely tied to these forms. Scientists construct theories and models. Mathematicians trade in axioms, theorems, and proofs. Historians use historical objects to develop accounts, while literary theorists produce interpretations from texts. These are very different kinds of epistemic artifacts produced with different sorts of methods and practices, and evaluated with very different criteria. These differences arise from the ways in which disciplines wrestle with very different features of the material world to generate meaning, including the disciplines discussed in this section or others such as archaeology or law (Goodwin, 1994), and these differences manifest in genres of disciplinary writing (Bazerman, 1988). VanSledright and Maggioni and Lee and colleagues address this issue of intradisciplinary variability most directly, but these chapters collectively call attention to the need for research on epistemic cognition to attend not only to epistemic aims (Chinn et al., 2011), but also to disciplinary epistemic forms and the epistemic practices developed around them.

## DISCIPLINARY LEARNING AS A SITE FOR EPISTEMIC COGNITION RESEARCH

The chapters in this section make abundantly clear that learning within the disciplines is a fruitful site for research on epistemic cognition. I see this work as having unfolded quite differently from more general work on epistemic cognition. By more general, I mean models of epistemic cognition from developmental and educational psychology that have historically treated knowledge as a monolithic, unitary (Hammer & Elby, 2002) construct, rather than the variable, multidimensional collection of forms discussed above and elsewhere (Chinn et al., 2011). Monolithic views are much less common today, but have much more room to take the specific substance of disciplines

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into account. I see two opportunities for epistemic cognition research derived from disciplinary specificity. One is the value of comparing the disciplines to their schooled versions, and the other is looking across disciplines.

### *Modeling and Observing Knowledge about Disciplines*

As suggested above, one of the great advantages of studying epistemic cognition within contexts of disciplinary learning is that the disciplines provide models of expertise that can guide examinations of learning and development. Such models function in at least two ways. One is as a means to understand individual learning and development in relation to the development of disciplinary expertise, including epistemic sophistication or nuance, as Depaepe et al. put it. A second way is that perspectives on how disciplines work provide a contrast between the discipline and its school version.

As school subjects, for instance, history and science are often criticized for focusing too much on facts and not enough on the processes by which each discipline builds its facts. Elby et al. and VanSledright and Maggioni both describe how reforms of each school subject aim to create closer approximations to professional practice. This turn toward practice thus provides a setting to explore approximations between novice and expert epistemic cognition: learning to think like a historian, or scientist, or mathematician. This is a crucial contribution of research on epistemic cognition in the disciplines: rather than comparing epistemic beliefs to school-oriented outcomes such as achievement, such work focuses on the development of disciplinary expertise, defined in terms of the discipline itself.

The conceptual, procedural, and epistemic expertise of the disciplines is bound up in specific disciplinary practices (cf. Duschl, 2008). For epistemic cognition researchers, efforts to learn disciplinary practices thus shed light on the tacit epistemic commitments (aims, virtues, reliable processes) (Chinn et al., 2011) learners may hold, at least with respect to some particular practice and the kind of knowledge such a practice is intended to produce. The claim here is that studying people's efforts to make particular kinds of knowledge claims (e.g. scientific models, historical accounts, mathematical proofs, literary interpretations) provides a window into their ideas about what such knowledge is and how it can be gotten.

It will always be the case, however, that learning disciplines in school means learning some approximation of that discipline. Consequently, studying disciplinary practices within school settings necessarily entails understanding the degree to which learners pursue disciplinary practice in some authentic relation to disciplinary goals or instead to satisfy school goals. The explicit study of epistemic goals appears to be somewhat rare within the disciplines, in the sense of understanding how learners engage disciplinary practice in relation to what those learners perceive they are trying to accomplish. The empirical finding that engaging in authentically scientific practice in school does not tend to lead to changes in ideas about NOS (Sandoval, 2005) is, at least partially, a reflection of differences in epistemic aims: students are not doing science in school, they are doing school science. For example, students do not seem to draw on their own experience to consider relations between scientific theories and experiments (Sandoval & Morrison, 2003). The authors in this section review abundant examples of how conceptions of knowledge and knowing influence school learning in science, mathematics, and history. A good deal of this work compares surveys of epistemic beliefs to school achievement measures. An important avenue for epistemic cognition

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research within the disciplines is to look more carefully at how students' engagement in disciplinary practices affects how they come to understand the nature of particular disciplines. For example, Ryu and Sandoval (2012) showed young children's ideas about scientific arguments can change through sustained instruction, but did not link such changes to children's ideas about what scientists do or how science works.

### *Epistemic Cognition across the Disciplines*

Looking across the four chapters in this section, there are clear similarities in the epistemic dilemmas at issue, such as how people coordinate claims with evidence, or map correspondences between claims to knowledge and the world those claims are made about. Yet, it is also clear that few researchers are looking across disciplines in a substantive way. As issues of domain specificity have arisen within personal epistemology research, some have sought to compare how students might think about mathematics specifically (e.g. Muis, 2004) or psychology compared to science (Hofer, 2000). Historically, this work has simply taken general surveys and inserted "science" or "mathematics" as appropriate, leaving it up to respondents to interpret what those labels might mean.

Much more research is needed that compares how students pursue disciplinary practices. A recent example is Herrenkohl and Cornelius' (2013) comparison of elementary students' arguments in science and history. They found that within each disciplinary context, students' arguments took quite different forms, reflecting students' perceptions of differences within those disciplines. Students' historical arguments included more analogies than their scientific ones, whereas children's scientific arguments were more theory driven. These and other differences show these children perceived the work of history and science to be held to different criteria. Herrenkohl and Cornelius documented these differences through analysis of students' actual work, both artifacts they produced and classroom talk around them, although the study did not expressly ask children how they thought such work related to what historians or scientists do themselves. More of this sort of work looking across disciplines is needed, and it could usefully compare students' participation in epistemic practices with their reflections on the aims of such practices and the criteria by which those aims are judged as met (Sandoval, 2012).

## EXTENDING DISCIPLINARY EPISTEMIC COGNITION RESEARCH

Judging from the chapters in this section, most of the work within disciplines on epistemic cognition is aimed toward helping people learn those disciplines more fully. This is an important goal, of course, but an equally important question is this: how does learning a discipline in school allow people to use that discipline outside of school? How does learning science, history, mathematics, or literary reasoning help people who are not scientists, historians, mathematicians, or literary scholars (e.g. as authors, critics, or academics)? The general answer to this has to do with the broad values of an education, of having multiple ways of understanding the world and one's place in it. Here, I am interested in more specific answers. How do people make use of disciplinary ways of knowing in their own lives? Are there better and worse ways to do so? If so, how can school help people learn better ways of using disciplinary knowledge and ways of thinking in their everyday lives? Educational research is generally focused on school-oriented outcomes and tends not to look past school. Epistemic cognition research suffers from this same myopia, with notable exceptions being work on text comprehension (Strømsø & Kammerer, 2016/this volume) and Bromme and colleagues' work on public understanding of science (e.g. Bromme, Kienhues, & Porsch, 2010; Scharrer, Bromme, Britt, & Stadtler, 2012). Yet, these chapters on epistemic cognition within disciplines provide ways of approaching the bridge from school to everyday life.

### *Everyday Versus Disciplinary Thinking*

Children learn a great deal about science, mathematics, literary reasoning, and history before they begin formal schooling. The family and community contexts in which such learning happens, moreover, continue to operate once formal schooling has begun, such that school learning is not entirely isolated from home and community activity. Thus, formal schooling begets a complex, ongoing interaction between school and community, especially home, that creates a range of so far mostly unexplored territory for research on epistemic cognition (cf. Bricker & Bell, 2016/this volume). To what everyday use do people put their understanding of history, math, science, or literature? Thinking in terms of development, it is important to consider how it is, for example, that young children develop ideas about hypotheses and hypothesis testing by kindergarten (Moshman & Tarricone, 2016/this volume). What are the sources of such ideas? How do they then influence how people approach, epistemically, science learning, or any learning?

Taking Chinn et al. (2011) as a starting point, models of epistemic cognition and its development would be well served by research that examines variations among epistemic aims and the processes, reliable and unreliable, that people use to pursue them. One context where such links have been pursued is in the science education research on so-called socioscientific reasoning, i.e. reasoning about social issues that have some scientific component. A finding from that work is that students typically subordinate science to their own ends (Kolstø et al., 2006; Nielsen, 2012), although work in this area tends not to examine the goals students pursue in such contexts, and these studies typically occur within school settings, which potentially invoke school aims unrelated to everyday concerns. When adults encounter science they are typically trying to understand it in order to solve some other problem, such as treating their autistic child (Feinstein, 2014). Feinstein notably avoids evaluating such encounters from a normative perspective of what people should do, instead seeking to document how they frame science knowledge in relation to personal aims, both epistemic (e.g. understanding causes of autism) and non-epistemic (e.g. feeling good about their child's treatment).

There is a longer history of work establishing how the mathematics people do outside of school looks very different from school mathematics (Lave, 1988). As Lave (1997) memorably put it, "*how* math is learned depends on its being *math* that is learned, and how math is learned in school depends on its being learned *there*" (p. 19, italics in original). As suggested above, it is centrally important to look in a fine-grained way at the everyday contexts in which people have reason to employ disciplinary knowledge and ways of knowing in their lives. In my view, this includes looking at how people accomplish their own aims, and the epistemic practices they pursue (Chinn et al., 2011; Kelly, 2016/this volume). It also should include, however, efforts to understand how people conceive those aims, in context, and how they view the relations between their own epistemic and non-epistemic aims, and their own epistemic practices (Sandoval, 2012, 2014).

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### *Generalizing Disciplinary Epistemic Cognition*

The chapters in this section suggest multiple ways that research on epistemic cognition in the disciplines can further the agenda of modeling epistemic cognition more broadly. In science, history, mathematics, and literary reasoning, there are numerous examples of research related to learners' interpretations of reliable processes for making knowledge in those disciplines. For example, VanSledright and Maggioni summarize research in history, showing how novices approach historical reasoning practices such as contextualization. Elby et al. review research in science on how students engage in scientific experimentation or argumentation. Lee et al. review a wide variety of work from various perspectives on how people engage in aspects of literary interpretation. While Depaepe and colleagues focus more on what could be considered traditional notions of epistemic belief, they also refer to studies of particular forms of mathematical problem solving. How, then, do people generalize their conceptions of knowledge and knowing beyond the disciplines they learn?

Depaepe and colleagues introduce the idea of epistemological nuance as an alternative to more traditional perspectives on sophistication versus naïveté. They argue that the suitability of a particular epistemic belief is contextual, a point argued as well by Elby and colleagues in their chapter and elsewhere (Elby & Hammer, 2001). These arguments align with the trend against omnibus attributions of sophistication (Chinn & Rinehart, 2016/this volume) emerging from various strands of epistemic cognition research (e.g. Bråten, Strømsø, & Samuelstuen, 2008; Hofer & Bendixen, 2012). One conclusion readers can draw from this set of chapters is that the phenomenon of such contextualization can be studied directly within the disciplines, because the disciplines provide normative guidance on questions of suitability. That is, researchers can inquire into the application of particular epistemic beliefs, or resources, using Hammer and Elby's term, in relation to disciplinary epistemic practices and aims. This proposal is derived in part, for me at least, from Chinn and colleagues (2011) suggestions about relations between epistemic aims, epistemic virtues and vices, and reliable processes of knowing. My view is that such relations can be studied within contexts of disciplinary learning because of the extent to which the disciplines make epistemic commitments (i.e. aims, virtues, evaluative criteria) and processes explicit.

The chapters in this section are generally silent on how work in their disciplines might generalize, reflecting what appear to be two distinct trends. One is a trend of independence: scholars of education within the disciplines naturally focus on that discipline, and as each of these chapters shows, this entails defining an epistemology of that discipline that might serve as an educational target. An unfortunate consequence of this quite natural narrow focus is that researchers rarely look beyond their disciplines to see what scholars in other disciplines are learning, what approaches they are using, and how such comparisons might contribute to general theorizing about epistemic cognition and its development.

The other trend visible in these chapters, more so in some (Depaepe et al., 2016/this volume; Elby et al., 2016/this volume) than others (Lee et al., 2016/this volume), is a trend of importation: when researchers have sought to connect work within a discipline to broader work on epistemic cognition they have tended to import constructs and measurement strategies from what until recently was called personal epistemology research. My reading of the chapters in this section is that such importation is not especially helpful, especially if it is not accompanied by the export of findings and methods developed within disciplinary research.

The major objection to importation is probably clear from the discussion to this point: general models of epistemic cognition (as reviewed in Hofer & Bendixen, 2012) have not taken the substance of the disciplines seriously. Even while scholars of personal epistemology have increasingly examined issues of domain specificity over the last two decades, such work has often tended to ignore the actual forms of knowledge and processes of knowing particular to specific domains. Elby et al., for example, summarize how NOS research in science education has articulated epistemological dimensions specifically related to science (e.g. the nature of theories, inference versus observation) that go well beyond the polar dimensions common to epistemic cognition studies. Further, it is well established in science education that students typically sound quite epistemologically naïve when discussing science in general compared to when they are discussing specific topics or contexts (Sandoval, 2005), and this also seems to be the case for professional scientists (Samarapungavan, Westby, & Bodner, 2006; Wong & Hodson, 2009). The apparent "wobble" described by VanSledright and Maggioni appears to be a similar phenomenon in history. Such findings may well characterize both students' and professionals' reasoning within the disciplines.

The implication from both the specificity and contextualization of epistemic cognition within the disciplines is that general models of epistemic cognition and its development must account for them. While this basic point seems increasingly accepted, the further implication is that epistemic cognition research within the disciplines can be much better leveraged in developing and testing general models. Bendixen (2016/this volume) provides an example of this kind of effort, synthesizing research from a range of disciplines as taught in elementary school to evaluate claims from her integrative model of epistemic cognition. To my mind, it is an open question whether that or any other available model has been articulated clearly enough to produce testable explanations and predictions of epistemic cognition in particular contexts. It is definitely the case, however, that such efforts at synthesis are very much needed, especially as they may relate to particular aspects of epistemic cognition, like what people think counts as evidence, or what aspects of information sources are scrutinized, for certain kinds of claims or with respect to certain epistemic aims (e.g. Bråten et al., 2008).

Scholars of epistemic cognition research within the disciplines can themselves do more to relate their work to more general efforts to model epistemic cognition. Recent situated cognition perspectives on epistemic cognition (Chinn et al., 2011; Hammer & Elby, 2002) emerged from science education in response to the accumulation of evidence in that work (Sandoval, 2014). Obviously, this Handbook is an effort to put these communities into closer dialogue. The extent to which such dialogue is taken up is likely to have a strong effect on both efforts to develop coherent theories of epistemic cognition and its development, and instructional approaches to develop disciplinary understanding usable in everyday life.

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# Section III

## Epistemic Cognition Within and Beyond the Classroom

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# 13

# EXPLORING IMAGES OF EPISTEMIC COGNITION ACROSS CONTEXTS AND OVER TIME

*Leah A. Bricker and Philip Bell*

## INTRODUCTION

As Moshman (2015) noted, "Epistemic cognition is a topic in cognitive psychology that concerns people's knowledge about matters of epistemology, a topic in philosophy" (p. 1). We identify as scholars in the fields of science education and the learning sciences, and we have studied youths' science-related learning across settings and over time (e.g. Bell, Bricker, Reeve, Zimmerman, & Tzou, 2012a). As readers who are familiar with learning-across-settings literature from our two fields will know, many scholars who explore learning in this way do not theorize about epistemology or epistemic cognition specifically.[1] We wish to use this chapter to argue for focused attention on people's epistemic cognition across settings and over time, and we draw in large part on Chinn et al. (2011) to support our claims.

In order to make our case about why we think that explorations of epistemic cognition across settings and over time would enrich literatures related to learning and related to epistemic cognition itself, we begin with a transcript excerpt from our research to illustrate and then define how we use the term "epistemic cognition." Because ideas about context and time are critical to our argument, we also discuss how we think about the word "context" and its relationship to time, and then relate that discussion to ideas about epistemic cognition. Next, we showcase three examples of epistemic cognition and epistemology-related research that exemplify studies of these constructs across contexts. After that, we summarize a study that we conducted with our colleagues that we think highlights another example of epistemic cognition across contexts and time, as well as highlights methods-related issues. We end the chapter with concluding remarks and a discussion about future research directions.

To begin the conversation, we invite readers to consider the following transcript excerpt from our study of science and technology learning across settings and timescales (see Bell et al., 2012a). This transcript excerpt documents a conversation in a science center between a mother (Stella) and her daughter (Brenda).[2,3] They were visiting a dinosaur exhibit, and standing in front of a dinosaur fossil.

1. *Stella:* So this is a real fossil.
2. *Brenda:* It is?
3. *Stella:* Yeah.
4. *Brenda:* It is?
5. *Stella:* Yeah.
6. *Brenda:* I don't think so.
7. *Stella:* Yes. Read this. [Stella pointed to museum signage.]
8. *Brenda:* I think it's a cast.
9. *Stella:* Mm-mm [Stella shook her head "no."]
10. *Brenda:* Well, I know but mommy, they, like, re-did it. Mommy because why, why would there be a slit like right here? [Brenda pointed to a part of the fossil.]
11. *Stella:* Well because they cannot pick it up in just one piece…
12. *Brenda:* //I know but…
13. *Stella:* //and move it.
14. *Brenda:* Are you sure it's not like…a cast?
15. *Stella:* //I think it has to be uh, uh picked up in sections of a…
16. *Brenda:* //Are you sure it's not a cast over it?
17. *Stella:* I'm pretty sure that it isn't sweetie.
18. *Brenda:* It would say original fossil right there! [Brenda pointed to the exhibit signage.]
19. *Stella:* It doesn't have to say original fossil.
20. *Brenda:* YES IT…DOES!
21. *Stella:* //If you read what it says…
22. *Brenda:* //Mommy! I read it. Yes it does.

As readers will note, Stella and Brenda were debating about whether the fossil in front of them was an original or whether it was a cast. Stella used text from an exhibit sign as evidence for her claim that the fossil was real, and Brenda used the same exhibit sign (and the lack of explicit notification on the sign that the fossil was "real") as evidence for her claim that the fossil was a cast. In addition, Stella and Brenda used other types of evidence to warrant their claims, although they did not make the sources of that evidence explicit in their talk. For example, in turn of talk 10, Brenda referenced some previous knowledge related to "slits" she saw in the fossil (the fossil was mounted on a wall and noticeably segmented into sections). In turn of talk 11, Stella countered with her thinking about how museums transport and assemble large fossils like the one in question. Brenda did not accept Stella's thinking as a reason for why this particular fossil was an original, and continued to assert that the fossil in question was a cast. In turn of talk 18, Brenda referenced previous knowledge related to museum signage, and the practice of identifying important aspects of exhibits (e.g. explicitly noting on signs whether fossils are original or casts). In turn of talk 19, Stella disagreed, but Brenda insisted. For readers' information, after this discussion Stella and Brenda left this dinosaur fossil and promptly saw a sign that noted that all fossils in this particular section of the exhibit were casts. This sign alerted visitors that throughout the exhibit, they would be told which fossils were original and which were casts so that visitors would have a sense of when they were viewing an artifact that was millions of years old.

In addition to the specific content of Stella and Brenda's utterances, we have written elsewhere about their interaction patterns (Bricker, 2008; Bricker & Bell, 2014).

The discursive patterns that readers note in the transcript (e.g. argumentative discourse, relatively equal turn taking, utilization of verbal and nonverbal evidence for claims being made) were typical of Stella and Brenda's interactions at the time of their enrollment in our research. Yet, Brenda interacted very differently in her school science classroom during this same time period, often only speaking when called on by her teachers, and then speaking very quietly and not elaborating beyond the response that Brenda thought was called for given teachers' questions. We return to the potential significance of this later in the chapter.

We submit that this transcript excerpt serves as an example of epistemic cognition, based on Moshman's (2015) definition of epistemic cognition as "…the aspect of metacognition that is concerned with truth and justification and that serves as the basis for reasoning" (p. 31). Moshman related thinking and reasoning in the following way:

> Thinking is the deliberate application and coordination of one's inferences to serve one's purposes….Examples of thinking that have received substantial study in cognitive psychology are problem solving, decision making, judgment, and planning…. Reasoning is thinking aimed at reaching true or justifiable conclusions….Examples of reasoning are logical reasoning, scientific reasoning, moral reasoning, and argumentation….Reasoning is the epistemic aspect of thinking, the aspect that aims at justification and, to the extent possible, truth. (pp. 22–23)

Stella and Brenda were both thinking about whether the fossil in front of them was an original fossil or a cast, and they were each providing reasons for their thinking in order to try and justify their thinking, and ultimately arrive at the "true" answer. As we note above, some of their reasons stemmed from evidence they found in the space (e.g. a museum sign). They did not state explicitly the sources for other reasons they offered, but their discourse made it clear that they had sources in mind (e.g. Brenda's use of the word "cast," a technical term that she learned somewhere and then utilized in the context of this discussion).

Additionally, we argue that Brenda and Stella's aforementioned interaction patterns enabled their thinking and reasoning to be visible to us as researchers and thus allowed us the opportunity to analyze the components of their thinking and reasoning. It is important for us to note that this exemplar showcases an instance of epistemic cognition in the wild (cf. Hutchins, 1995), as opposed to examples of epistemic cognition elicited through laboratory studies (cf. Hofer & Pintrich, 2002). Later in the chapter, we will discuss the potential significance of this related to another aspect of our learning across settings research.

## CONCEPTIONS OF CONTEXT AND TIME AND RELATIONSHIPS TO EPISTEMIC COGNITION

Beliefs about knowledge (e.g. how it is obtained and best interpreted, what knowledge is true and why, who decides what knowledge is true and why) serve to influence how one thinks and reasons in any given context (cf. Hofer, 2008). In our example of Brenda and Stella's debate, both of their arguments seemed to be influenced, in part, by beliefs related to how museums represent information about exhibits on signage. Tabak and Weinstock (2008) asserted with respect to epistemic beliefs that, "What is most needed at this point is a better understanding of how epistemological beliefs are shaped and constructed through day-to-day interactions" (p. 192). We assert that the same holds true for epistemic cognition in that we need a better understanding of epistemic cognition as it occurs as part of interactions with others, across a variety of contexts, and over time.

What do we mean by "context"? The word context is typically used to denote different physical settings. Stevens (2000) noted that often in ethnographic and other qualitative studies of learning, "…context has been a key term that is usually assigned to *different settings* which, in turn, are argued to organize different social and epistemological outcomes" (p. 133, emphasis in original). Stevens proposed a finer grained interpretation of context, stemming in part from sociolinguistics (e.g. Duranti & Goodwin, 1992). This expanded definition of context allows for different problems or practices, for example, within the same setting to constitute different contexts (e.g. problem-based mathematics instruction and more traditional mathematics instruction in the same classroom constituting two different contexts). This is a notion of context as physical space, but, additionally, as material, social, and cultural space.

Livingstone (2003) also wrote about context as being more than simply a physical setting, and said, "…we refer in spatial ways to the intellectual, social, and cultural arenas through which we move. People close together physically may be 'miles apart' in terms of social distance or cultural space, living…in totally different worlds" (p. 6). Lemke (2000) contended that a spatial view is incomplete and reminded his readers that context includes not just settings but also time. He stated that, "Every human action, all human activity takes place on one or more characteristic timescales" (p. 273). He asked how seemingly isolated events could end up constituting a lifetime, and how those events come to have meaning for those experiencing them. He urged researchers to try and take into account the multiple timescales involved in phenomena of interest to them.

Chinn et al. (2011) argued for expanded images of what counts as epistemic cognition, and they argued for the possibility that the same person's epistemic cognition could vary by context. The authors returned to philosophical scholarship to warrant their argument that conceptions of epistemic cognition should be broadened in order to increase the utility of epistemic cognition literatures with respect to better understanding human learning. The authors proposed a framework of epistemic cognition that included the following five components: (a) epistemic aims and epistemic value, (b) structure of knowledge and other epistemic achievements, (c) sources and justification of knowledge and other epistemic achievements, together with related epistemic stances, (d) epistemic virtues and vices, and (e) reliable and unreliable processes for achieving epistemic aims (see p. 142).

They noted the following about why they thought this expanded framework is needed with respect to better understanding epistemic cognition, as well as better understanding learning processes:

> First, our proposed framework expands the range of topics investigated, and some of these new topics may be important in predicting and explaining learning and reasoning processes. Second, our framework indicates that EC [epistemic cognition] is often highly specific and often varies from situation to situation. To predict and explain learning in a given situation, one needs to know the specific epistemic cognitions that are operative in that situation. Our proposed framework helps identify these specific cognitions to afford more fine-grained, situational explanations of learning processes. (p. 146)

We take this to mean that context matters when investigating epistemic cognition (as does the development of that cognition over time).

Chinn et al. (2011) sounded a cautionary note to researchers investigating epistemic cognition using this expanded framework when they noted that, "Cognitions are epistemic only if they are directed at epistemic aims or accomplishments" (p. 158). Not every thinking and reasoning process is related to epistemology. Returning to our example of Brenda and Stella's debate in the science center, we argue that the epistemic aim present in this debate was to decide whose belief was true about whether the fossil on display was an original or a cast, and about whether, and if so how, a science center as a particular type of context (in this case, physical space) represented that knowledge to visitors. As we previously noted, this type of argumentative discourse was typical of Brenda and Stella's interactions, but this discourse was not linked to epistemic aims in all contexts that Brenda navigated. For example, Brenda once stated to us, "I like to argue…," and "I just argue for fun with my friends." Arguing for fun with one's friends, while perhaps being a good way to practice one's argumentation skills, does not necessarily have an epistemic purpose.

We are not arguing that epistemic cognition is (or should be) a more privileged type of learning process. Rather, we are attempting to make a methods-related point. For example, what if we would have attempted to draw inferences about Brenda's epistemic cognition using only her "argue for fun" statement (perhaps recorded as a response on a survey instrument)? We contend that if researchers attempted to assess Brenda's epistemic cognition with one instrument and in one context only, they might have drawn overly simplified, and in some cases erroneous, conclusions about Brenda's epistemic cognition with possible implications for her learning. We return to this point later in the chapter. Now, we would like to turn to three examples from others' research that highlight expanded images of epistemic cognition in accordance with Chinn et al. (2011), and that highlight why explorations of epistemic cognition across contexts and timescales could be fruitful.

## RELATIONSHIPS AMONG EPISTEMIC COGNITION AND SCIENTIFIC AND HISTORICAL ARGUMENTATION

Leslie Rupert Herrenkohl and Lindsay Cornelius (2013) used Chinn et al.'s (2011) expanded framework of epistemic cognition to analyze the same fifth and sixth grade students' argumentation as part of their science and history curricula. In partnership with teachers, they designed curricular units (which they referred to collectively as the Promoting Argumentation project) to scaffold students' argumentation in both school subjects, and then studied students' argumentative practices in detail. They based this work in part on the argument made by Stevens et al. (2005) that the field needs a better understanding of how the same youths navigate across different school subjects (e.g. science, history, and mathematics) and make sense of those subjects in their own right and in relation to each other.

Herrenkohl and Cornelius described key features of two of the curricular units used in their analysis (a sinking and floating unit in science classrooms, and a Rosa Parks unit in history classrooms), and described Chinn et al.'s (2011) expanded epistemic cognition framework. They then described the data they collected (discourse of whole group and small group discussions, and then written student work), and their analytic processes (extensive coding of discourse). Herrenkohl and Cornelius reported their

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findings in two parts. First, they reported summary findings (reported as code clusters and their frequencies) across the various classrooms that used the two curricular units. For example, they found during the science unit that over half of all the discourse in the four classrooms focused on "formulating arguments" (i.e. how one builds an argument in the sciences) and "defining arguments" (i.e. meta-commentary about arguments and theories in the sciences and how they are related). Herrenkohl and Cornelius also found that "formulating arguments" made up the largest percentage of the kind of talk during the history unit in all four classrooms, but unlike the science unit, "imaginative and analogous thinking" (e.g. reconstructing historical contexts) was the second most prevalent code to describe argument-related discourse during the history unit (see Figures 4 and 5 and pp. 431–433 for a fuller discussion of these findings). Herrenkohl and Cornelius reported that there was a great deal of similarity between students' argumentative practices in their school science and history classrooms. They noted that perhaps this was to be expected because the curricula for each school subject was constructed using the same types of structures, such as "…shared scaffolds to support thinking like scientists and historians, and a shared…structure for reporting about arguments" (p. 432).

For the second analysis presented in the paper, Herrenkohl and Cornelius developed a case study in which they analyzed the discourse in one classroom across the two curricular units using the five components of Chinn et al.'s epistemic cognition framework. In other words, this second analysis reported on the same students constructing disciplinary arguments across contexts (i.e. science and history units) within the same classroom. They chose this particular classroom because the teacher's practices ensured that students had multiple opportunities for extended discussion with each other (as opposed to usual discourse patterns in many classrooms where teachers' talk accounts for the majority of talk) (see Cazden, 1988).

In summarizing their findings for this second analysis, Herrenkohl and Cornelius reported that they were able to find evidence of all five components of epistemic cognition in classroom talk, and they took this as evidence that "…the fifth- and sixth-grade students participating in Promoting Argumentation were taking up critical epistemic issues that confront historians and scientists and were initiating discussion to address these epistemic concerns…" (p. 456). For example, and in relationship to epistemic aims (the first component of Chinn et al.'s framework), classroom discourse provided evidence that the operating epistemic aim in the classroom during the sinking and floating science unit was that of scientific inquiry as a knowledge building activity. This activity involved formulating hypotheses in relation to an investigative question, testing hypotheses empirically and in comparison to existing theoretical frameworks, and then using that work as evidence for an explanatory claim related to the operating investigative question.

During the Rosa Parks history unit in the same classroom, historical inquiry was also highlighted as an epistemic aim of knowledge building in history, but the activity was framed differently given disciplinary differences. For example, students examined various primary and secondary sources related to the events that took place on a Montgomery, Alabama, city bus in 1955, and this led to discussions about perspective taking and "true" accounts. Classroom "…discussions about diaries led students to consider the idea that an event could give rise to multiple, differing interpretations that were all in a sense true" (p. 455). Herrenkohl and Cornelius noted in a footnote that these types of findings exposed "…key differences between history and science with

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regards to epistemic aims and the structure of knowledge in each discipline (Chinn et al., 2011)" (p. 450).

Herrenkohl and Cornelius noted in their concluding remarks that because they were using classroom and small group-level discourse, they were not able to make claims about individual students' epistemic cognition across these two contexts (science and history units), which they also contended would be important research to conduct. Regardless, Chinn et al. (2011) called for more research that examines epistemic cognition of groups, and we contend that Herrenkohl and Cornelius' analyses is an example of research that begins to explore this terrain (their group being a group of students) across contexts (the two units in a single classrooms), and over time (students' argument construction over the course of the units).

## LEARNING TO NAVIGATE MULTIPLE EPISTEMOLOGIES

Researchers have also started to explore the role of cultural practices and context in epistemic cognition (cf. Gottlieb and Wineburg, 2012). In this next example, we profile a small subset of Megan Bang and Douglas Medin's scholarship that explores an example of this terrain in detail (e.g. Bang & Medin, 2010; Medin & Bang, 2014). Although epistemic cognition specifically was not a focus of this research, their work has implications for our argument that it is instructive to examine epistemic cognition across contexts and over time. Bang and Medin theorize about the cultural bases of epistemologies, and have conducted their research with the help of Native American communities in urban and rural settings. Bang and Medin have long argued that matters of epistemology are not the same across contexts. For example, they have claimed that schools often serve to negate Native American youths' epistemologies stemming from family and community cultural practices, whether this is done purposefully or inadvertently.

For example, Bang and Medin (2010) argued that:

> In education, most epistemology research makes the assumption that the epistemologies that students come to classrooms with are inferior, or less productive, compared with the one(s) that researchers and educators (for our purposes, science education) are trying to assist students in learning. Some researchers have claimed that successful science education will require students to learn or replace the personal epistemologies they bring with them with an epistemology that is aligned with a Western scientific epistemology (King & Kitchener, 1995; Strike & Posner, 1985). (pp. 1015–1016)

Bang and Medin leveraged the work of Hammer and Elby (2003)[4] with respect to epistemological resources that students develop as part of their lived histories, and that are cued in various contexts given the situation at hand. Examples of epistemological resources related to physics learning (which is often the subject of Hammer and Elby's scholarship) are "knowledge as propagated stuff" and "knowledge as fabricated stuff" (see Hammer & Elby, 2003, p. 56). Bang and Medin questioned whether these resources vary according to cultural practices, and culturally framed epistemologies.

For example, Bang and Medin (2010) examined various practices (e.g. fishing), in which different groups of people (urban and rural Native Americans, rural European Americans) participate, in order to explore epistemologies. They reported that

European American youths and adults' descriptions of "nature" included framing nature as a setting where practices like fishing take place (i.e. nature is the backdrop for these practices). In contrast, Native American youths and adults' descriptions of nature "…focus more on relations and include relevant context.…Native parents said that they want their children to realize that they are a part of nature" (p. 1017). European American parents described nature as something to take care of, but as something external to humans (i.e. a setting for their activities, for example). In other studies where Bang and Medin made use of a sorting task to investigate understandings about how youths understood the concept of "alive" (Bang & Medin, 2010), they found that Native youths "…answered differently for each context, saying, for example, that an elder but not a science teacher would say that rocks and water are alive" (p. 1017).

Bang and Medin argued that these findings showcased starkly different epistemologies (relational in Native American communities versus categorical and hierarchical in European American communities). They argued that our schools, curricula, assessment, and the like in the United States are designed using European American epistemologies. Medin and Bang (2014) stated about science education specifically:

> Given that science instruction is seldom recognized as a set of cultural practices, many Native students may perceive a sharp divide between everyday practices and what takes place in school. The lack of recognition of science and science education as being a set of cultural practices may implicitly or explicitly teach Native students that their own orientations and practices are not recognized or appreciated in school contexts or relevant to professional science. Consequently, it may be hard for Native students (as well as others) to resist the view that science is indeed a practice peculiar to white males and that science learning consists of "received wisdom" of the dominant culture. That's not a prescription for engagement with science. (p. 183)

Bang and Medin (2010) argued that instead of framing school (usually implicitly) as a game of eradicating students' epistemologies that they bring with them to classrooms and replacing them with the sanctioned epistemologies (the epistemologies related to Western science, for example), educators should think about "…supporting students' navigation of multiple epistemologies" (p. 1009).

In Bang and Medin's research, context can be thought of as physical space (in- and out-of-school), but their research is also helpful in thinking about contexts in the elaborated sense that Stevens (2000) and Livingstone (2003) discussed. In other words, different cultural practices (as undergirded by different epistemologies) can constitute different contexts. Bang and Medin argued that different epistemologies stem from these different cultural practices, and can lead to people being physically co-located (in a classroom, for example), but nonetheless using very different lenses at times to make sense of the world. This can be quite problematic when these youths are together in a school science classroom, for example, where only one set of cultural practices and one undergirding epistemology are sanctioned as "correct" (and these practices and epistemology are tied to Middle and Upper Middle Class White epistemic values, sources and justification of knowledge, epistemic virtues and vices, and the like in Chinn et al.'s terminology).

We contend that an exploration of epistemic cognition across settings and over time could help surface more of these types of nuanced perspectives so that our various communities (e.g. researchers, teachers, curriculum developers) might have more

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informed conversations about how to best support all youths' learning. Some of this might involve helping youths learn to "code switch" (cf. Gumperz and Hymes, 1986) between various epistemologies and epistemic practices (e.g. what criteria are used for judgment in what contexts and why; in any given context, what are the epistemic virtues and vices at play). We now turn to one image of this "code switching" that Gottlieb and Wineburg (2012) call "epistemic switching."

## EPISTEMIC SWITCHING

Eli Gottlieb and Sam Wineburg (2012) studied 16 experts (historians, scientists, engineers, and clergy and religious teachers) as they engaged with primary and secondary sources with respect to two different events: (a) the American Thanksgiving and (b) the Biblical Exodus. Some of the historians self-identified as religiously committed (either Jew or Christian). The clergy and religious teachers (Jews and Christians) were not trained historians. None of the scientists and engineers identified as religiously committed and none were trained historians. In this study, these events (Thanksgiving, Biblical Exodus) constituted the contexts that participants moved across using various textual sources. Temporal aspects of these two contexts played prominently in the textual sources and in participants' interpretations of them, and in that sense, participants moved across time as well. Gottlieb and Wineburg used a think-aloud task where they asked participants to read each piece of text aloud and then verbally recount what they were thinking as they were reading.

Gottlieb and Wineburg found that participants used one of four "strategies of coordination" for interpreting these texts in these two different contexts (Thanksgiving and Biblical Exodus). For example, some participants used a "serial-parallel" strategy where they engaged each context's texts sequentially, but did not privilege one membership over the other (e.g. historian and religious believer). In contrast, some participants used a "simultaneous-hierarchical" coordination strategy where they used memberships simultaneously when engaging texts from each context, and did privilege one membership over the other when interpreting various texts. Gottlieb and Wineburg presented mini case studies of various participants who illustrated each category (see pp. 99–109).

Gottlieb and Wineburg argued that participants' memberships (e.g. as an historian, as a member of the clergy, as a Jew or a Christian, as a scientist) directly impacted how participants engaged with these texts. Gottlieb and Wineburg noted the following about epistemic switching:

> We use the term *epistemic switching* to describe how participants dealt with the multiple memberships evoked by these texts. This term denotes a participant's use of multiple frameworks of epistemological assumptions (e.g., historical, theological, scientific) for interpreting documentary evidence.…When such switches occurred…they generally signaled a shift from one set of assumptions about the nature of knowledge to another. (p. 98)

They claimed that the importance of their work was in documenting the ease in which the experts participating in their study switched between epistemologies when interpreting texts from different contexts. They used their findings to push against stage-related theories of epistemological development (citing Hofer & Pintrich, 1997 and Greene, Torney-Purta, & Azevedo, 2010, for example), as well as to question what counts as sophisticated reasoning (i.e. an adherence to a single epistemology through possible integration of multiple epistemologies, or switching among multiple epistemologies given context).

Gottlieb and Wineburg pondered the role of context in epistemic cognition (p. 117), and tied their discussions to potential linkages between epistemic cognition and identities:

> Rather than treating context as something that can be defined in terms of *either* content *or* setting *or* professional community *or* religious affiliation, and so on, researchers should endeavor to design studies that take more seriously the notion…that context is all of these – and more – at one and the same time (cf. A.B. Cohen, 2009). (p. 117, emphasis in original)

This argument has large implications for research design. Chinn et al. (2011) also discussed the need for studies of epistemic cognition that involve the use of a variety of methods (e.g. interviews, observations), in addition to the questionnaires that have been the hallmark of epistemic cognition research (see Chinn et al., 2011, p. 163). Chinn et al. argued "…that many existing EC measures measure cognitions at too course a grain size to explain the variance in performance on learning tasks" (p. 163). We turn next to a summary of one of our own research studies that explores these methods-related issues directly.

## DISCUSSIONS OF METHODS FOR INVESTIGATING EPISTEMIC COGNITION ACROSS CONTEXTS

In this section, we report on some of our own research where we deliberately put data from youth responses to lab-based epistemic scenarios (see Amsterlaw, 2006) in conversation with data from a team ethnography of youth science and technology learning across settings and timescales (see Bell et al., 2012a). This work was part of the National Science Foundation–funded LIFE (Learning in Informal and Formal Environments) Center (http://life-slc.org/). We sought to work across disciplinary and methodological boundaries to explore learning from various vantage points. In the process, we became quite interested in the sources people cite as evidence during reasoning processes. For example, readers will remember that Brenda and Stella both cited the same museum sign (and unstated ideas about the information on museum signs) as evidence for the claims they made during their debate about a particular dinosaur fossil. How is that kind of evidentiary sourcing accomplished in moments of everyday reasoning and as researchers, what types of methods might we use to investigate this?

The study profiled here built from Amsterlaw's research (2006) in which she investigated the reasoning of first, third, and fifth graders, as well as the reasoning of adults. Specifically, she was interested in how her research participants distinguished what she termed "actual" reasoning from nonreasoning activities (e.g. flipping a coin), and how participants thought about "good" versus "bad" thinking and reasoning in the context of decision making. Readers will remember that Moshman (2015) identified decision-making as one category of thinking, with associated logical or thoughtful reasoning. He also defined epistemic cognition as "…the aspect of metacognition that is concerned with truth and justification and that serves as the basis for reasoning" (p. 31). Amsterlaw sought insight into children's development of metacognition (thinking about one's own thinking) (see Hacker, Dunlosky, & Graesser, 2009). We discuss momentarily how we sought insight into the sources participants used to justify their reasons.

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To investigate her questions, Amsterlaw used four types of reasoning scenario tasks that described decision-making in everyday situations: (a) decision-making using a thoughtful reasoning strategy (versus a random selection method like flipping a coin), (b) decision-making through consideration of alternative possibilities before making a decision (versus jumping to conclusions), (c) decision-making by gathering and weighing relevant evidence (versus using one's hunches), and (d) decision-making by considering both pros and cons (versus considering only pros). In each task scenario, a fictitious child made a decision using a "good" or "bad" version of one of the aforementioned strategies. Amsterlaw also asked participants questions about decision-making outcomes (e.g. using a "bad" process but getting a "good" outcome with respect to what the fictitious child wanted). Amsterlaw asked participants to rate the fictitious child's thinking and reasoning related to the decision he/she made on a Likert scale. Amsterlaw then asked participants to discuss why they had chosen the ratings that they did. The following is an example of one of the scenarios:

> Kate has a big lilac bush growing in her yard. One day, Kate's lilac bush looked funny. Its flowers were getting droopy. Kate knew that plants need sun, water, and good dirt to grow, but she didn't know what was wrong with her lilac bush. So she had to figure it out. This is what she did: Kate checked the plant all over for clues about what was wrong—whether it was the sun, the water, the dirt or something else. (So she didn't go with her very first thought about what it was; she checked the plant for clues about what was wrong.) That's how she decided it was probably the sun. It turned out that Kate was wrong. The plant really needed better dirt. (See Amsterlaw, 2006, p. 464, for an earlier version of this task that was modified to create this task.)

Among other findings, Amsterlaw reported developmental changes with respect to children being able to distinguish between reasoning and nonreasoning processes (with older children more able to make this distinction than younger children). In addition, Amsterlaw found developmental changes with respect to children privileging decision-making process over decision outcomes (again with older participants better able to do this), and noted that when children favored positive outcomes regardless of reasoning processes, it indicated that they were not able to distinguish between "good and bad" thinking and reasoning strategies. Amsterlaw concluded with the following statement: "A crucial next step in this research path will be to evaluate developmental relationships between children's metacognition about reasoning and their reasoning behavior in naturalistic settings" (p. 459).

In order to begin to explore the relationship between metacognition about reasoning and reasoning behavior in naturalistic settings, Lee et al. (2005) analyzed the responses that Amsterlaw's participants gave during their encounters with the scenario tasks. The researchers looked for everyday references in the responses as one way to better understand what experiences might have informed participants' categorizations of any given scenario as an example of "good" or "bad" thinking relative to a specific decision and why. They found that Amsterlaw's participants frequently made references to everyday influences on their thinking and reasoning about whether the decisions made by the children in the scenario tasks constituted "good" or "bad" thinking and reasoning. These references included mentions of family members, knowledge learned in school, and personal experiences. Everyday references occurred in 57 percent of the participants' responses. Figure 13.1 shows a breakdown of the influences participants mentioned (see Lee, Amsterlaw, Reeve, Bell, & Meltzoff, 2005 for additional details).

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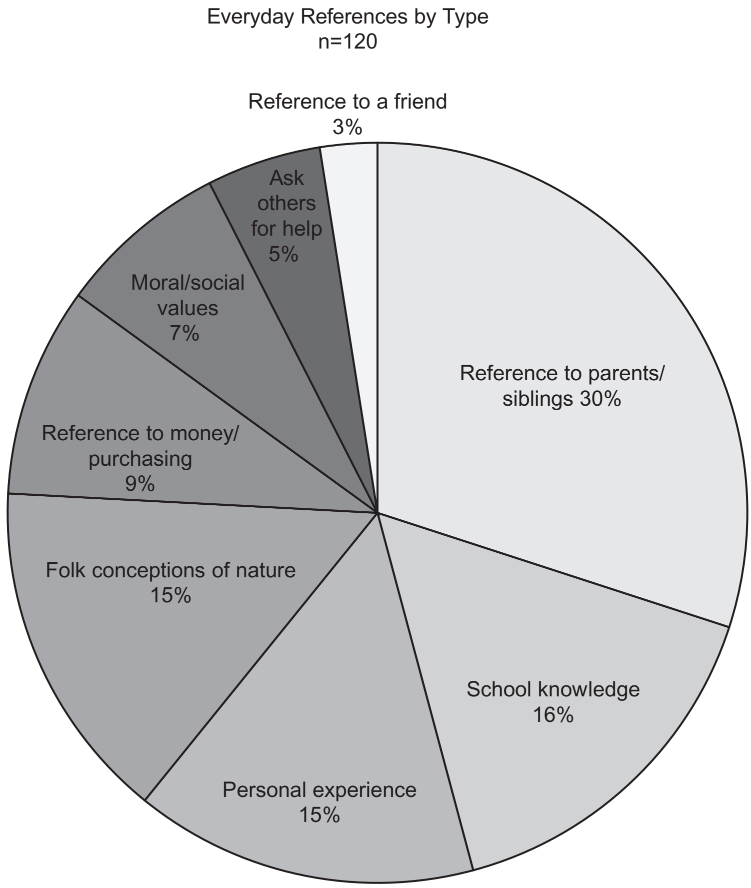


**Figure 13.1** Categories of everyday references mentioned by participants.

After conducting the analysis of Amsterlaw's data and finding everyday references, we invited Amsterlaw to administer her thinking and reasoning scenario tasks with the youth participating in our aforementioned ethnography of youth science and technology learning across settings and timescales (Bell et al., 2012a). Our hypothesis was that we would find similar results to those that Amsterlaw had reported in her 2006 article (e.g. outcome bias), and to the findings reported by Lee et al. (i.e. everyday references as part of the participants' rating explanations), but that we would better understand these everyday references and be able to think about their implications due to the fact that we had been studying these youth in the various settings that they navigated for over a year. To test this hypothesis, Amerstlaw accompanied us to participants' homes during a regularly scheduled home visit, and with participants' consent, administered the scenario task protocol. All interviews were video- and audiotaped, and the tapes were transcribed.

We did find that the ethnography participants showed some of the patterns that Amsterlaw found as reported in her initial research involving the reasoning scenarios. For example, the focal youth in the ethnography (who were in the fourth and fifth grade at the beginning of the ethnography) were better able to distinguish between "good and bad" thinking and reasoning strategies (e.g. using evidence versus using eenie, meenie, minie, moe) than their younger siblings. In addition, the focal youth were more attuned to "good" reasoning processes (even if the outcome was not desirable) than their younger siblings.

We also found, like in Lee et al.'s analysis of Amsterlaw's original sample, that ethnography participants made everyday references when explaining their ratings for each of the task scenarios. For example, with respect to the aforementioned example task scenario about Kate and the lilac bush, one of the ethnography participants objected to the image representing the task scenario. The image depicted the fictitious Kate standing next to a small, scraggly looking plant that was supposed to be a lilac bush.

The following is a transcript excerpt that showcases the conversation this participant had with Amsterlaw:

1. *Participant:* Plants don't look like that.
2. *Amsterlaw:* They don't look like that? What do you mean?
3. *Participant:* They look weird.
4. *Amsterlaw:* What's weird?
5. *Participant:* It's like they're in the desert or something.
6. *Amsterlaw:* Yeah. There, those flowers are getting droopy.
7. *Participant:* She was wrong. [Participant pointed to the middle star, an indication of okay reasoning].
8. *Amsterlaw:* So she gets the middle one?
9. *Participant:* Mm-hmm.
10. *Amsterlaw:* Ok.
11. *Participant:* She should have asked some people if they had a plant like that and if that ever went wrong.
12. *Amsterlaw:* Ok.
13. *Participant:* And she could have looked at the leaves and seen if they were turning brown or something cause if they were turning brown they would have been through fall or they wouldn't have enough sun.
14. *Amsterlaw:* Ok.
15. *Participant:* But it was the soil.
16. *Amsterlaw:* Yeah. Ok.
17. *Participant:* You should always check the soil.

In this transcript excerpt, we noticed several issues. First, the participant exhibited the outcome bias in turn of talk 7 that Amsterlaw reported on in her 2006 article. In other words, the girl in the scenario, Kate, used what was meant to be a "good" reasoning process in the scenario task description (i.e. she did not act on her hunch, but instead checked the plant for various clues as to what might be wrong with it). Yet, the participant rated Kate's thinking and reasoning as "okay" because Kate ended up with the wrong answer (i.e. thinking it was too much sun that was negatively impacting the plant instead of it being related to depleted soil).

Additionally, we noted that the participant immediately told Amsterlaw (in turns of talk 1, 3, and 5) that the lilac bush in the representation looked "weird," and that "plants don't look like that." Using the same analytic techniques for coding everyday references in Amsterlaw's original sample that Lee et al. used, we are not at all certain that we would have counted these utterances as an everyday reference. However, because we had worked with this participant for over a year at the time of this interview with Amsterlaw, we knew her comments were part of an everyday reference. This participant's house was filled with various types of plants from ornamentals, to herbs, to seedlings for various garden patches that filled the backyard of the house.

The participant's grandmother who lived with the participant and her family was a master gardener, and this participant and her siblings often helped their grandmother with both the plants in the house and with the gardens outside. Perhaps the participant was thinking about her own lived experiences working with her grandmother (an "expert other" when it came to all aspects of plants), when she commented in turn of talk 11, "She should have asked some people if they had a plant like that and if that ever went wrong."

Furthermore, we noted that the scenario task made use of the word "dirt," but the participant used the word "soil" (in turns of talk 15 and 17). Again, we are not certain we would have coded this as an everyday reference if we had not spent so much time with this youth. Besides studying the ethnography participants at home, we were also in their school science classrooms. In fifth grade, this participant had conducted a variety of science investigations as part of engaging in a unit about processes that shape the Earth's surface (e.g. erosion, weathering, deposition). Many of these investigations involved the use of soil, and the teacher always corrected the students if they used the word "dirt" instead of "soil," telling them that dirt is a lay term implying that something is not clean (e.g. dirt under one's fingernails). She said that soil is a technical term referring to part of the Earth's surface, and that students needed to use technical terminology in science class. We cannot be sure if this is the source of the participant's use of the word "soil" in this transcript excerpt. Perhaps this terminology was also part of the family's gardening and plant activity systems. Regardless, we argue that the use of this terminology, terminology that was different from the word used in the scenario task, was noteworthy and almost certainly related to this participant's activities (in school, out of school, or both). (See Bricker, Amsterlaw, Lee, Bell, & Meltzoff, 2007, for more information about this particular analysis.)

One of the findings from this study surprised us: the fact that unlike the participant in the aforementioned transcript excerpt, many of the ethnography participants offered very little by way of explanation for their ratings. They tended to offer one sentence responses, such as, "[Very good] cause she didn't pick randomly and she checked the requirements." Amsterlaw often had to ask additional follow-up questions in order to obtain more information about participants' thinking, asking for more detailed explanations, asking for clarifications, and the like. Because Amsterlaw was administering the protocol in the participants' homes, we simply assumed that they would display similar interaction patterns and discourse patterns as they did in all other home activities, including responding to our various interview questions. Yet this was not the case. Amsterlaw was interviewing these youths over a year after we had started working with them and their families. During our interviews with them at this time, we sometimes had to hold interviews over the course of several home visits because their responses to our questions were extensive (and often times included artifacts, trips to other parts of the house to show us something, etc.). Perhaps they reacted this way to Amsterlaw because they did not know her, but we also contend that many performed with respect to these scenario tasks as they did on school-based tasks in their school classrooms. In almost all cases, for example, participants offered only as much information as they felt necessary to complete the task, and then were ready to move on to the next scenario. That is, they read the interactional frame as one of quick, transactional questions and answers, and not one associated with sustained reasoning or sense-making.

We noted at the beginning of the chapter with respect to Stella and Brenda's debate in the science center that Brenda did not engage in this type of interaction (extended debate) at school during formal instruction (at the time of her participation in the ethnography).

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She was almost always silent, except when called on, and then she would respond quietly and with "short" answers. We were continuously struck by the differences in Brenda's interaction and discourse patterns in in-school versus out-of-school contexts (see Bricker & Bell, 2014 for additional details). In response to the example scenario task featuring Kate and the lilac bush, Brenda said the following very quietly, "It was bad [decision-making] because she thought it needed better, um, sun but it needed better dirt and…she…yeah." Amsterlaw then asked Brenda, "Is that it?" and Brenda said "Mm-hmm." Stella was nearby during this interview, and at four different times during the interview, Brenda attempted to bring Stella into the discussion, saying things like, "Mama, I don't know how to say it." We sensed that Brenda wanted to engage in this activity with Stella, like the two of them engaged in all other out-of-school activities that we documented. However, Stella resisted and we assumed that this was because she sensed that Amsterlaw wanted Brenda's individual responses without discussion with others.

When analyzing Brenda's responses to the various scenario tasks, one might conclude that she was a naïve thinker (e.g. at times favoring outcomes over thinking processes). However, we knew from all of the time that we had spent with her at the time of this interview that she was anything but a naïve thinker. We were not convinced that showing outcome biases was always a sign of "bad" thinking in every context and in every situation, as assumed by the logic of the clinical interview task. For example, one of the tasks referenced a decision to buy a new puppy. The fictitious child in the scenario thought only about the good aspects of getting a puppy, but did not think about aspects that might be challenging. Brenda said that this boy's thinking "…was very good because he, he decided to get a puppy and he really, really liked having his puppy." Brenda and Stella had gotten a new puppy at the beginning of their participation in the study, and had researched various aspects of dog ownership and specific dogs for months before making their decision. Perhaps she was reading some of this into the scenario task? Regardless, the scenario tasks were privileging a type of thinking that is highly valued in academic settings, but that might not always be highly valued in every other settings and for every purpose.

Deliberately architecting a study that utilized different research methods and theoretical stances enabled us to begin deep discussions in the LIFE Center about learning, epistemology, and the like. The goal was not to prove each other's camps right or wrong (a goal that none of us thought would be productive in service of better understanding the social foundations of human learning, which was the LIFE Center's mission). Rather, the goal was to explore how methodological and theoretical orientations could work together and push on each other in service of making substantive contributions to the field, and to showcase what aspects of cognition and learning were highlighted through specific orientations so as to better understand the underlying phenomena more richly. With our description of this work, we wish to showcase the power of using multiple methods, stemming from different theoretical and scholarly traditions, when studying epistemic cognition. We argue that if the field wants a robust understanding of epistemic cognition, there have to be more examples of studies that explore the same people's epistemic cognition across contexts and over time, using a variety of methods.

## EPISTEMIC COGNITION ACROSS CONTEXTS AND OVER TIME: FUTURE DIRECTIONS

We have often utilized the following quotation from Nasir et al. (2006) as a warrant for the need for more cross-setting and longitudinal science-related learning research:

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> Often, people can competently perform complex cognitive tasks outside of school, but may not display these skills on school-type tasks. This finding indicates the importance of understanding learning in out-of-school settings, and how to build on this learning to support learning in school. (p. 491)

We submit that the same type of research related to epistemic cognition would be quite useful to the field for the same reasons that Nasir et al. articulated and given its current scarcity (please see Bell et al., 2012b, for one relevant theory of learning across time and place that could be used in studies of epistemic cognition). Chinn et al. (2011) noted some interesting future directions for research in epistemic cognition that we would like to echo (in addition to research that explores more "fine-grained and situated" images of epistemic cognition [p. 163]). They too called for an increased focus on different kinds of research study designs (including interdisciplinary and we would add, transdisciplinary research) that use a collection of methods in order to more deeply explore epistemic cognition across contexts. They also called for more development of temporal images of epistemic cognition by exploring developmental trajectories related to their proposed five components of epistemic cognition. Additionally, as discussed above in relation to the three studies we profiled in this chapter, Chinn et al. called for increased attention to social aspects of epistemic cognition, including better understanding the details of group epistemic cognition (and its relationship to individuals' epistemic cognition within any given group). As Bromme (2005) noted, "…it is clear that knowledge is represented not only in individual minds, but also in books, in the Internet, and in social and technical artefacts. Accordingly, epistemology…describes processes and problems of *individual* knowledge attainment only in a limited number of cases" (p. 198, emphasis in original). At the end of her chapter titled "Personal Epistemology and Culture," Hofer (2008) posed a series of questions to the field related to epistemological research, and one of them seems particularly important to this discussion: "Are we overly focused on individual knowing and ignoring socially distributed aspects of knowledge…?" (p. 17).

Chinn et al. also argued that there is a dearth of research exploring ties among emotion, learning, reasoning, and the like (for one exception, see Lemke, 2013). They stated that "… philosophers have observed that certain emotions seem critical to knowledge production – emotions such as curiosity and a passion for finding things out (Code, 1991)" (p. 162). Gottlieb and Wineburg (2012) reported emotions present in participants' voices as they discussed their thinking related to their interpretations of the texts they engaged as part of the Thanksgiving and Biblical Exodus contexts. For example, they reported that one participant's voice conveyed "puzzlement" (p. 108) and "unbridled anger" (p. 110). What part do these emotions play (if any) in epistemic cognition? How do emotions interact with ideas about what one counts as knowledge in any given context, and how one might evaluate knowledge claims differently in different contexts? We are very interested in this line of inquiry and plan to explore it in the future.

## ACKNOWLEDGMENTS

Related to our own work that we discuss in this chapter, we wish to thank our colleagues Jennifer Amsterlaw and Tiffany Lee of the Learning in Informal and Formal Environments (LIFE) Science of Learning Center (http://life-slc.org/). We gratefully acknowledge their intellectual influence, as well as the intellectual influence of our other LIFE colleagues. We also wish to thank the National Science Foundation (Awards

SBE-0354453 and SBE-0835854), although our opinions and interpretations expressed in this chapter are strictly our own. We extend deep gratitude to the youths and their families who participated in the ethnographic work we discuss in this chapter. We would also like to thank the editors of this Handbook, as well as an anonymous reviewer, for the excellent feedback on earlier versions of this chapter.

## NOTES

1 We draw on Hofer and Pintrich's (1997) definition of epistemology as "…an area of philosophy concerned with the nature and justification of human knowledge" (p. 88).
2 All names of research participants are pseudonyms.
3 The following are transcript conventions used in this chapter (cf. Jordan & Henderson, 1995): brackets [] = clarifying notes; double slash // = overlapping or interrupting talk; ellipses … = a pause; all caps = emphatic speech.
4 Chinn et al. (2011) referenced Hammer and Elby's research as an example of scholarship that explores epistemic cognition across contexts and finds differences, which Chinn et al. used as evidence for the need to explore epistemic cognition using finer-grained analyses than have been used in the past.

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# 14

# EPISTEMIC COGNITION IN LEGAL REASONING

*Michael Weinstock*

The stakes in legal reasoning are quite high. People can be sent to prison, ordered to pay large settlements, or denied compensation for perceived wrongs. Moreover, the decisions need to be predominantly right and justified or people will lose faith in the legal system. Civil democratic society depends on the trustworthiness of the legal system and a sound, fair decision-making process. Because of this, and because it is the province of lawyers and philosophers, the rational and evidentiary bases for decisions are carefully delineated. However, how legal philosophers and lay reasoners construe the epistemic nature and practices of legal reasoning likely differ. Whereas the framing of legal reasoning set forth by expert philosophical epistemologists and those trained in legal thinking is important for defining the domain of legal epistemology and for setting ideal standards of legal reasoning, it is equally important to understand and differentiate expert legal epistemology from the untutored, folk epistemologies that lay legal decision-makers bring to the task (Weinstock, 2009).

The aspect of legal reasoning focused on in this chapter concerns how judges, in particular lay judges such as jurors, reach conclusions in deciding a case. This involves reasoning about and from evidence and the application of a standard of proof. An aspect of professional legal reasoning, the establishment of procedures in legal settings, is also of concern for this chapter. The decisions about what counts as evidence, how decisions should be based on evidence, standards of proof, and the deliberative task of the jury define an epistemic space. Other aspects of professional legal reasoning, such as in making laws, the creation and application of precedents, and drafting legal documents, are less relevant to everyday epistemic cognition and will not be discussed.

Although there may be an ideal, prescriptive epistemic basis for reasoning in the legal domain, the typical epistemic cognition of lay legal reasoners, such as jurors, has considerable, practical implications for the workings of legal systems that are not recognized in the legal reasoning literature. Moreover, the formal definitions of legal reasoning in judges' instructions to the jury consist of general guidelines of what may be considered as evidence and the charge to decide a case based on that evidence (e.g. U.S. Court of Appeals Sixth Circuit 2014). However, actual reasoning practices about a case are not spelled out in the formal guidelines. Juror reasoning skills, which will be referred to in the section on empirical studies on legal reasoning and epistemic cognition, include matching evidence with specific verdict criteria, explaining not only why one verdict was chosen but why other ones were not, explaining how others could justify alternative verdicts, and making counterarguments against one's own verdict. Each of these reflects the requirements of the juror to consider the evidence in relation to possible verdicts and anticipates the juror's task of considering and justifying a verdict choice in deliberating with other jurors. This chapter will highlight what is distinctive about epistemology in the legal domain in order to explore the epistemic nature of the domain and illustrate how formal and typical legal reasoning might converge and diverge.

In addition to looking at specifics of the realm of legal reasoning and legal epistemology, examination of the legal domain allows for a particular consideration of the nature of both philosophical epistemology and everyday epistemic cognition. Although germane to thinking about everyday epistemic cognition, issues regarding the socially constructed nature of knowledge domains and, with few exceptions (Chinn, Buckland, & Samarapungavan, 2011; Fitzgerald & Cunningham, 2002; Muis, Bendixen, & Haerle, 2006), philosophical epistemological discussions remain in the background in the literature. However, in the legal domain, social, philosophical, and common-sense understandings all come into play in relatively transparent ways. For instance, the definition of evidence in law is based on social goals regarding justice, philosophical considerations of the basis of knowledge, and considerations of how people who apply the law understand and use it in a common-sense way. Thus, the legal domain is somewhat uniquely positioned as a topic for exploring epistemology in that it brings to the fore the interplay between social, individual philosophical, and everyday epistemology.

This chapter will discuss the larger issues mentioned above as well as specific epistemological concerns that appear in the legal reasoning literature and have relevance to research on epistemic cognition. The chapter first focuses on theory, presenting an overview of epistemic dimensions of legal reasoning and then presenting relevant epistemological perspectives from philosophy and the field of epistemic cognition. The next section looks at aspects of legal reasoning that highlight issues of epistemic cognition referring to relevant research. These aspects include considerations of reasonable doubt and certainty, evidence, the basis for a decision, and deliberation. In the final section I will discuss implications for the study of epistemic cognition and what understanding of epistemic cognition's role in legal reasoning means for civic education and courtroom procedures, such as voir dire and jury instructions, that might guide epistemic cognition in legal decision-making.

## THEORETICAL BACKGROUND

As this chapter concerns reasoning and epistemic cognition in the legal context, it is important to make a distinction between civil-law and common-law systems. Civil law has roots in Roman law and is primarily used in continental European countries and former colonies of these countries, as well as in Russia, Japan, and China. Common law has roots in Medieval England and is practiced in the United Kingdom and former British colonies including the United States.

In civil law, the law comes solely through the legislative process with reference to legal scholarship, laws are codified, and judges have the role of gathering evidence and questioning in court (Apple & Deyling, 1995). In common law, case law developed in the courts is a significant part of the law along with legislation, legal precedence plays a larger role than codified laws and statutes, and judges play a referee role in court with lawyers responsible for presenting evidence and questioning witnesses in an adversarial system. Although both systems admit lay participation in the legal decision-making process, with lay judges and even juries in some civil-law countries, the participation of lay legal reasoners is more common in jury systems that exist in common-law countries.

Because the focus of this chapter is on everyday epistemic cognition, most examples it draws on are from the common-law system of the United States, where there is concern both within the legal community and among researchers with lay, novice reasoning given the role of juries. Moreover, because the system relies on case law precedence, debates among legal practitioners about practical, but epistemic issues provide an interesting context to consider the interaction between formal, prescribed decision-making processes and epistemic cognition. Likely when deciding cases the reasoning and epistemic cognition of professional and lay judges in civil-law countries resemble that of judges and jurors in common-law countries, although their roles diverge in certain ways. Thus, the discussion in this chapter will also apply at least to aspects of legal reasoning in the civil-law system.

## *Epistemic Features of Legal Reasoning*

Although certainly influenced by philosophical discussions of epistemology, the formal epistemic parameters of reasoning regarding legal cases are set by judicial processes. The types of issues found in the instructions that American judges give to juries, with wording fought over in and decided by courts, would be at home in an epistemology primer. The pattern criminal jury instructions issued by the U.S. Court of Appeals in the Sixth Circuit (2014, p. 4) say:

> You have two main duties as jurors. The first one is to decide what the facts are from the evidence that you saw and heard here in court.... Your second duty is to take the law that I give you, apply it to the facts, and decide if the government has proved the defendant guilty beyond a reasonable doubt.

The sections following this charge include burden of proof, reasonable doubt, evidence defined, consideration of evidence, direct and circumstantial evidence, and credibility of witnesses. Each topic includes citations of case law decided by the Sixth Circuit or the U.S. Supreme Court to justify the language used in the instructions. In these and in pattern jury instructions issued by other circuits and state courts, the commentaries are replete with discussions about notions of fallibility, proof, doubt, certainty, what counts as evidence, testimony, and other topics of concern to epistemologists. These discussions and decisions reflect the thinking of legal experts and prescribe the bases for their decisions as well as those of other professional and lay judges.

Although epistemological issues are front and center in the legal process, epistemic activity is actually strictly circumscribed. With the exception of real-world knowledge, all evidence is prepared and presented by external sources within the confines of the courtroom. All evidence is presented through testimony. Judges and jurors do not produce or construct evidence; they are triers or finders of fact. They cannot seek more evidence even if it would be helpful and clarifying to do so. Moreover, some evidence may be inadmissible and excluded from court—or, jurors are instructed to ignore it—even if in everyday reasoning contexts it would be germane to deciding what happened.

### *Philosophical Perspective on Legal Reasoning*

In the common-law system, legal practitioners are the main interpreters and creators of the principles of legal reasoning (Pardo, 2007). The leading lights in legal thinking have been lawyers and judges from the eighteenth century through the still influential American jurist John Wigmore in the early twentieth (Shapiro, 1986). At first, such jurists were interested in bringing rational enlightenment ideas to the legal system and were mostly influenced by thinkers in the empiricist tradition, in particular John Locke and, later, John Stuart Mill. Of note, James Wilson, one of America's Founding Fathers and one of the original Supreme Court justices, was more influenced by an opponent of Locke, Thomas Reid, of the Scottish School of Common Sense, who criticized the extreme skepticism of the empiricists, believing that epistemology had to be rooted in common experience. This common sense, plain understanding tenor, and the concerns of the empiricists for testimony about observable evidence underscore the thinking of Anglo-American legal epistemology. Particularly because the practitioners are often lay thinkers, it is important that definitions of evidence, proof, and standards for conviction be defined as plainly, intelligibly, and practically as possible as reflected in pattern jury instructions.

Legal epistemology has also been of interest to academic philosophers. Whereas individual epistemology is clearly relevant to legal reasoning, Goldman's (1999) general account of social epistemology and focused account on law is of particular interest. Two of three aspects of social epistemology (Goldman & Blanchard, 2015) have relevance for considering epistemic cognition and legal reasoning. The first, social evidence, includes testimony, the primary source of evidence in the courtroom, and peer disagreement, which is part of jury deliberation. The second concerns the epistemic implications of given institutional practices particularly in comparison with alternative practices. As case law precedence explicitly defines and constrains the task and procedures of judging, the courtroom context epitomizes this aspect of social epistemology. In addition, comparisons of alternative practices are reflected in the constant evolution of the language of the judge's instructions to the jury, and differences in these instructions in different jurisdictions show an active concern with the epistemic consequences of different types of institutional practices. The third aspect of social epistemology concerns the epistemic quality of groups' beliefs and knowledge. Although this has relevance to the decision of the jury as a whole, the focus of this chapter is individuals' epistemic cognition, so this aspect will not be discussed.

Goldman (1999) extrapolates from his concern with reliable processes and justified true beliefs in individual epistemology positing that these concerns are also valued in social activities. He examines institutional practices around knowledge in general, and in specialized domains such as law, and evaluates how they are guided by "veritistic" (truth-seeking) values. Recognizing that the common-law practices are also based on extraveritistic values—e.g. fairness, social acceptability, substantive and procedural justice, timely decisions, individual rights—he evaluates legal practices for their adherence to veritistic goals aimed at the acquisition of truth.

Of relevance to the topic of epistemic cognition are issues he addresses that impact in particular on lay decision-making, recognizing that laypeople are legal novices and naïve (his term, Goldman, p. 309). Regarding evidence, he questions exclusionary rules, the tight control that the court has on what gets admitted as evidence in court, as "veritistically suspect." Among his concerns about looser restrictions on the admissibility of expert testimony is that laypeople, and indeed judges, do not have sufficient knowledge to evaluate it. Moreover, as each side presents its own experts, he says that "it is easy for the confused juror to perceive the intellectual merits of the two sides as a deadlock" (p. 309). This resonates with epistemic cognition research that has long examined the issue of how people make sense of competing expert or authoritative accounts (Bråten, Britt, Strømsø, & Rouet, 2011; King & Kitchener, 1994; Kuhn & Weinstock, 2002; Perry, 1970). Goldman has particular concerns with the adversary system. While the idea behind the system is to encourage each side to produce as much evidence in its favor as possible, thus leading to maximal truth acquisition, in operation it leads to the shaping and obfuscation of evidence. Jurors hear filtered evidence and are subject more to the skills of the attorneys. Another issue concerns the two-sided nature of the adversary system, as opposed to an open search for information. As shown above regarding experts and later regarding particular everyday epistemic perspectives, this emphasis on opposing sides can be problematic for some jurors in evaluating the evidence (Weinstock & Cronin, 2003).

Given the focus on social practices and epistemology, Goldman pays surprisingly little attention to juries. He explains this is because the rationale for the juror is essentially extraveritistic (i.e. rather than simply truth-seeking, juries exist to balance the power of authorities, connect people to civic life, etc.). In examining the veritistic qualities, he appears less concerned about juries than the issues mentioned above. He notes that a well-known study on level of agreement between jurors and judges (Kalven & Zeisel, 1966), showing about 78 percent agreement, could be seen as problematic. However, he points out that these are cases that went to trial, and therefore are more difficult, and that some of the disagreement could come if the judges were in error. Although throughout his discussion, Goldman seems concerned about naïve lay legal reasoners who have insufficient knowledge, are often left in the dark, and can be manipulated, he thinks that lay judges in the civil-law system serve as an important corrective on professional judges' biases and particular class perspectives. Thus, the extraveritistic reasons for including lay legal reasoners might serve truth-seeking values as well.

### *Epistemic Cognition*

Among various approaches to epistemic cognition (see Chinn et al., 2011; Hofer & Pintrich, 1997), the focus here is on the theory developed by Kuhn and colleagues (Kuhn, 1991; Kuhn & Weinstock, 2002; Leadbeater & Kuhn, 1989). This approach pertains to epistemic cognition in the legal context as it was developed to help explain the development of argument and adult reasoning about everyday problems (Kuhn, 1991; Kuhn, Pennington, & Leadbeater, 1983). Research using this approach has used juror reasoning as an example of an everyday problem, given that it is a reasoning context that many adults in common-law countries engage in for which they receive no specific training.

Kuhn proposes that the main task in epistemic development concerns the coordination of objective and subject aspects of knowing (Kuhn, 1991, 2001; Kuhn & Weinstock, 2002). Because the lifelong developmental claims are beyond the scope of this chapter, the focus here will be on the perspective of each level. In one epistemic perspective, "absolutism," knowledge is considered to be objective and certain. If there are discrepant knowledge claims, then only one can be correct and the other must be wrong. Knowledge does not need to be justified, as all of the facts line up on the side of the correct claim and they are taken as self-evident.

In a second epistemic perspective, "multiplism," knowledge is understood to be subjective and uncertain. As the name implies, this view holds that there are multiple possible perspectives. Knowledge claims are considered to be idiosyncratic and based on biased personal opinion. Given the multiplicity of claims and personal perspectives, knowledge cannot be adjudicated and all claims are considered to be equally right (or wrong).

The third perspective, "evaluativism," represents the integration and coordination of objective and subjective aspects of knowing. In this view, knowledge is necessarily uncertain and needs to be justified as there could be alternative explanations. Evaluativists do not regard evidence as self-evidently connected to a claim; the same evidence might be used to support multiple claims, but the evidence and its relation to a claim can be evaluated to allow for one claim to be seen as better justified than another. That multiple claims could be right to a degree does not mean all claims are equal. The evaluativist perspective is considered to be the one that best supports skills of argument construction and evaluation (Kuhn & Weinstock, 2002).

According to Kuhn and Weinstock (2002), these perspectives operate as "theories-in-action" that guide knowledge construction and evaluation. The theory may not be applied with awareness or with systematic expression, but how claims are made and the form of evidence used in an argument reflects the perspective (Kuhn, 1991). Such a theory-in-action is dynamic, rather than consisting of static beliefs, and responsive to information so one might invoke different theories-in-action that guide thinking about different domains, with different expectations about epistemic concerns such as the possibility of certainty, possibility of justification, source of knowledge claims, nature of information, types of relevant support, and reasons for disagreement. However, it is assumed that, in particular when confronting new knowledge claims in a field in which one is not expert, there is basic consistency in epistemic orientation across domains (Kuhn, Cheney, & Weinstock, 2000). A juror's epistemic theory-in-action comes to the fore and guides reasoning when confronted with the task of evaluating information and claims about past events, producing a claim about what happened, and matching the evidence and claim to one of the verdict choices.

## STUDIES ON LEGAL REASONING AND EPISTEMIC COGNITION

Judges and jurors have the same guidelines for the bases in reaching decisions. For jury trials, the guidelines are often written in pattern jury instructions or manuals for judges, which are used by judges to instruct the jury in a specific case. These products of the legal institution define the epistemic parameters of the judging and are explicitly intended to have epistemic consequences insofar as they orient reasoners toward good and relevant evidence in making their decisions. However, findings from juror reasoning research indicate that the everyday epistemic cognition individuals bring to the task may converge with or diverge from the social epistemological goals. The little research that specifically investigates the relationship between epistemic cognition and legal reasoning was undertaken in a series of studies by Kuhn, Weinstock, and colleagues. The discussion below will focus mostly on their findings as well as findings by others that highlight the role of social epistemology in legal reasoning.

### *Evidence*

The first duty of jurors, according to the U.S. Sixth Circuit (2014), "is to decide what the facts are from the evidence that you saw and heard here in court" (p. 4). Given the importance of this duty, that instructions regarding reasonable doubt and deliberation emphasize that decisions must be made giving full consideration to the evidence, and the great interest in evidence in legal scholarship, the jury instructions regarding evidence are typically quite sparse. Under the heading, "Evidence Defined," (section 1.04) the Sixth Circuit instructions state (p. 16):

1. You must make your decision based only on the evidence that you saw and heard here in court. Do not let rumors, suspicions, or anything else that you may have seen or heard outside of court influence your decision in any way.
2. The evidence in this case includes only what the witnesses said while they were testifying under oath; the exhibits that I allowed into evidence; [the stipulations that the lawyers agreed to]; [and the facts that I have judicially noticed].

The next sentence reads: "Nothing else is evidence." The instructions go on to delineate other things, such as lawyers' statements, that are not testimony, and therefore not evidence, and emphasize that testimony the judge struck down is not evidence. They finish with a reminder to base decisions only on the evidence defined above.

The next section (1.05) is "Consideration of the Evidence." The entire instruction reads: "You should use your common sense in weighing the evidence. Consider it in light of your everyday experience with people and events, and give it whatever weight you believe it deserves. If your experience tells you that certain evidence reasonably leads to a conclusion, you are free to reach that conclusion" (p. 18). Section 1.06 distinguishes between direct evidence (e.g. a witness testifying to seeing rain) and circumstantial evidence (e.g. inferring it is raining when someone walks into court with a wet raincoat and umbrella), advising the juror that the law makes no distinction between the weight of these types of evidence and it is up to the juror to decide how much weight to give any evidence. Section 1.07 charges the juror to decide how credible or believable each witness is.

The nature of evidence and justification from evidence are so central to epistemology that the everyday epistemic understandings that people bring to the courtroom would clearly play a role in their decision-making. In the absence of more detailed instructions than those given above and of formal training in justification and argument, these epistemic understandings should became even more salient in the knowledge-rich, uncertainty-rich context of legal decision-making. Just the opening charge to decide what the facts are from the evidence invokes issues in epistemic cognition. In one study, the epistemic cognition of jurors (the participants were on jury duty, but not assigned to a trial) was assessed according to Kuhn's typology through an interview concerning two discrepant accounts of an historical event (Kuhn & Weinstock, 2002). The jurors differed in whether they understood historical accounts to be fact (absolutist), opinion (multiplist), or a mixture of fact and interpretation (evaluativist). Given different epistemic understandings regarding what is presented as evidence about a past, historical event, people might well have different epistemic understanding regarding the nature of evidence of past events presented at a trial, which, in turn, might influence reasoning about the evidence (see Kuhn, Weinstock, & Flaton [1994a] regarding juror reasoning as a type of historical reasoning task). When considering a criminal case, jurors who demonstrated absolutist understanding of an historian's account as pure fact were less likely to evaluate the credibility or plausibility of testimony in trials, one prescribed aspect of considering the evidence as well as something Goldman and Blanchard (2015) argue is necessary with the social evidence of testimony.

Regarding sparse instruction on consideration of evidence, epistemic perspectives come into play in how that is done. For instance, jurors assessed as absolutist were less likely than multiplists and particularly less likely than evaluativists to consider evidence in relationship to legal verdict criteria (i.e. the definition of each verdict given in the judge's instructions) or in relationship to verdict choices other than their own (Weinstock & Cronin, 2003). Mentioning the evidence in reference to verdict criteria demonstrates an epistemic understanding that to justify and create knowledge, evidence and theoretical basis must go hand-in-hand (Kuhn, Weinstock, & Flaton, 1994b). The absolutists also accounted for less of the evidence in choosing their verdicts.

Of practical importance, the amount of evidence used and juror reasoning skills were related to verdict choice. Of four possible verdicts, those less skilled tended to choose one of the verdicts overtly argued for by the prosecuting or defense attorney. They seemed to use evidence as shaped by the lawyers, and the lawyers' statements—legally excluded as evidence—in choosing verdicts and seemed less likely to give consideration to the range of possible verdicts. The ability to consider evidence, which differed by epistemic perspective, could have had an effect on the veritistic goals and the outcome of the trials used in the study.

The amount of evidence covered in making a verdict choice was also related to juror reasoning skills (Weinstock & Flaton, 2004). Those mentioning less evidence tended to be absolutely certain about their verdict choices. Those who were highly, but not absolutely certain, a characteristic of evaluativist thinking, mentioned the most evidence.

Whether people weighed direct and circumstantial evidence differently was not tested in these studies, and it would seem to be an important avenue of research. However, these studies did look at the judgment of testimony credibility. Absolutists, less than evaluativists, judged the credibility or plausibility of testimony (Weinstock, 2005; Weinstock & Cronin, 2003; Weinstock & Flaton, 2004). Moreover, those judging testimony credibility least were more likely to choose one of the verdicts argued for by the lawyers (Weinstock, 2005).

In sum, full consideration of evidence and judging the credibility and believability of testimony appeared related to people's epistemic perspectives. Performing these functions facilitated true consideration of the range of possible verdicts in contrast with those who could not perform these functions effectively. With reference to social epistemology, those who were absolutist in their epistemic cognition were less able to fulfill the veritistic intent of the juror guidelines with regard to the full and critical examination of evidence in the form of testimony.

### *Reasonable Doubt and Certainty*

The second duty of the juror (U.S. Court Sixth District 2014) is to "decide if the government has proved the defendant guilty beyond a reasonable doubt." This standard of proof has proven to be most difficult to define and understand in legal decision-making. In the

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history of the standard, the term "satisfied conscience" was first used in the 1660s, with "doubt" rarely mentioned. At the same time, evidence had the connotation of something someone believed. In the 1750s terms such as judgment and understanding replaced belief, and the phrase "beyond a reasonable doubt" began to be used and began to be linked to the idea of "moral certainty." In empiricist John Locke's formulation, moral certainty represented a degree of probability, the highest one followed by confidence, confident belief, and mere opinion. This formulation indicates that moral certainty and beyond a reasonable doubt represent high probabilities of guilt but are not meant to suggest absolute certainty. Unlike mathematical certainty, moral certainty admits fallibility (Shapiro, 1986).

Today, definitions of reasonable doubt in pattern jury instructions vary. The U.S. Fifth Circuit (2012, p. 12) says that reasonable doubt is "based upon reason and common sense after careful and impartial consideration of all the evidence…" and "…proof of such a character that you would be willing to rely and act upon it without hesitation in making the most important decisions of your own affairs." The Ninth Circuit (2010, p. 39) instructions include: "Proof beyond a reasonable doubt…leaves you firmly convinced the defendant is guilty. It is not required that the government prove guilt beyond all possible doubt. A reasonable doubt is a doubt based upon reason and common sense and is not based purely on speculation." The New York State Courts instructions (2014, p. 2) include: "The law recognizes that, in…human affairs, there are very few things… that we know with absolute certainty," "does not require…to prove…beyond all possible doubt," "not sufficient to prove that the defendant is probably guilty," and "it is an actual doubt, not an imaginary doubt…." The Illinois Court (2014) instructions do not define it, with commentary stating that the Illinois Supreme Court found it "is a term which needs no elaboration and we have so frequently discussed the futility of attempting to define it that we might expect the practice to be discontinued" (p. 52).

From an epistemic cognition perspective, reasonable doubt raises several issues, particularly given no clear definition. The instructions assume that all people will accept doubt in knowledge, readily distinguishing mathematical, absolute certainty from moral certainty. However, in a study that asked jurors to report their level of certainty about their verdict choices, absolutist thinkers tended to report either 100 percent certainty or complete uncertainty—either you know absolutely or you cannot know (Weinstock, 2009). Regarding accepting probability as a standard for knowing, absolutists tend to believe when there are two accounts—such as with the prosecution and defense—one must be objectively right and the other wrong. There is no room for probably right or for another claim to be possibly right. In contrast, evaluativists in the study claimed high but not absolute certainty about their verdict choice, often reporting something like "95 percent certain."

Whether or not people can assess their level of doubt, let alone understand what beyond a reasonable doubt would be, is also questionable. Nondeliberating mock jurors, from a civil-law country with a long history of juries, were willing to convict with a probability of guilt at 0.57, considerably below a standard of moral certainty (Magnussen, Eilertsen, Teigen, & Wessel, 2014). This, at least, indicates that people are willing to make a knowledge claim based on probabilities, while at the same time it shows that people either cannot sense their degree of doubt or do not understand the high standard of reasonable doubt. In that study, jurors who deliberated did have a higher standard of proof, being willing to convict at 0.68 probability of guilt, but still below the probability of guilt of 0.9, a figure commonly accepted as reflecting the standard of beyond a reasonable doubt (Kagehiro & Stanton, 1985).

Varying definitions of reasonable doubt in judges' instructions might bring variation to the probability of a finding of guilt (Dhami, Lundrigan, & Mueller-Johnson, 2015; Horowitz & Kirkpatrick, 1996). Horowitz and Kirkpatrick (1996) found that with a definition of "firmly convinced" the probability rating of guilt was 0.8, the closest to the accepted probability of reasonable doubt at 0.9. Juries receiving a "moral certainty" definition had the lowest standard of proof, less than 0.6, similar to juries receiving no definition. The doubt based on a reason definition was rated at under 0.7. These findings demonstrate that the legal definitions have epistemic consequences, but they do not look at differences in epistemic cognition as a possible individual difference in responsiveness to various definitions. Definitions provided in the judges' instructions might also influence legal reasoning processes. Juries receiving "firmly convinced" instructions produced verdicts that tended to correspond with the evidence, and they focused more on the evidence and less on nonprobative issues than juries given other instructions (Horowitz & Kirkpatrick, 1996).

In studies connecting epistemic cognition to reasoning, those who professed absolute certainty in their verdict choices were less skilled in justifying their verdict choices, less likely to produce counterarguments against their own verdict choices (i.e. less likely to recognize the possible fallibility of their claims), and more likely to choose verdicts argued directly for by the defense or prosecution rather than consider a wider range of possible verdict choices (Kuhn et al., 1994b; Weinstock & Cronin, 2003). Moreover, three measures of certainty—about the general possibility of being certain, the possibility of a juror being certain, and their certainty about their verdict choice—were strongly associated (Weinstock, 2009). Those who believed it possible to be 100 percent certain (assessed with the discrepant historical accounts interview) also believed a juror could be 100 percent certain and felt 100 percent sure about their verdict choices. Likewise, those expressing evaluativist levels of certainty (e.g. 95 percent), also did so across the board. Jurors' evaluations of how certain they were in the specific cases appeared to be a function of the epistemic understandings they approached the case material with. Their overall epistemic perspective and specific beliefs about the possibility of certainty predicted various skills of juror reasoning (Weinstock, 2009; Weinstock & Cronin, 2003).

In sum, a standard of beyond a reasonable doubt begs questions regarding how certain people believe they need to be to claim knowledge, such as that an accused person is guilty. From the epistemic cognition perspective, any definition that suggests that one need not know with absolute certainty provides the space for different standards depending on epistemic perspective. From a social epistemological point of view, a lack of clear definition perhaps exacerbates the epistemic consequences seen in differences in epistemic cognition. Following Goldman's principle that the epistemic consequences of a practice be compared with alternatives, perhaps differences in legal reasoning that appear related to differences in instructions might be investigated in research, both for the sake of the jury system and to better understand the relationship between social epistemology and epistemic cognition. In addition, the legal guidelines might better address different epistemic understandings of reasonable doubt.

### *Evidence as Basis for the Decision*

Early research on how weighing of evidence leads to particular verdicts and how new evidence is integrated with previously heard evidence relied on logical and algebraic inference models (see Hastie, 1993). Such mathematical approaches have clear appeal in modeling complex activity, but have been criticized for telling us little about how jurors actually think (Hastie, 1993; Pennington & Hastie, 1986). Alternatively, Pennington and Hastie (1986, 1992) posited the story model: a juror constructs a mental model of the testimony that takes the form of a story. New evidence is incorporated into the story through a weighing process where each piece of evidence would be weighed according to its role in the story (Pennington & Hastie, 1992). In the end it is the story that best incorporates the evidence that serves as the basis for a decision. The juror then compares the story to the given verdict criteria, and the best match to the story will be the verdict.

The story model, however, does not account for possible individual differences in building the story and matching it to the verdict choice. Findings cited above suggest that not everyone makes a good search of the possible verdicts and considers the body of evidence in relation to each of them. For some, the body of evidence all adds up to a single verdict choice, so the matching aspect of the story model would be weak. Moreover, although the mental model appears in the form of the story, the steps toward building the story may not be narrative-like and the justification of a verdict choice need not have a narrative structure (Pennington & Hastie, 1986). In one study looking at how people structured the evidence in their verdict justification, some cited only single pieces of evidence, some also gathered evidence into narrative structures, and others gathered diverse, nonchronologically related pieces of evidence into a relational argument (Weinstock, 2011). It was assumed that strictly narrative thinking in the service of building the story model would be limited in that the coherence of stories might make it difficult to account for unrelated or discrepant evidence and to consider how certain evidence might fit into a different story. Indeed, absolutists were found to be particularly likely to justify their verdict choices only with narratives or isolated pieces of evidence. Only one evaluativist constructed just a narrative while most made relational arguments. One explanation of this is that the way one structures evidence is dependent on argument skills, and epistemic cognition predicts such skills. Another possible explanation that might be further investigated is that people construe their task differently depending on what they view as reliable processes for achieving epistemic aims (Chinn et al., 2011). The reasons for choosing to use a narrative or relational argument might be probed. Perhaps the aim of those relating narratives is to tell their knowledge, whereas the aim of creating relational arguments from diverse pieces of testimony is to transform knowledge (Bereiter & Scardamalia, 1987; Weinstock, 2011).

### *Deliberation*

The final duty of the juror is to engage in deliberation. A question little investigated in epistemic cognition and important for considering social epistemology is how individual epistemic cognition influences knowledge-building in a social context and how people handle the task of knowledge-building when there is peer disagreement. Warren et al. (2010) paired jurors who chose different verdicts and analyzed their deliberation. A group consisting of multiplists and evaluativists spoke more than absolutists, commented more on the discussion, critiqued the assertions of the other more, and referred more to verdict criteria. Importantly, in pairs where just one person referred to verdict criteria, in over 90 percent of the cases that person persuaded his or her partner. Finally, dyads in which each partner had a different epistemic perspective had significantly fewer utterances and referred more to their own thought processes than dyads in which the partners shared epistemic perspective. Apparently, people with similar epistemic perspectives, although disagreeing about the verdict, were more comfortable engaging in dialogue. Perhaps a common understanding of the nature of evidence made it easier to talk about it and the conclusions to be drawn from it. For instance, it might have been easier for an absolutist to deliberate with another absolutist who took testimony at face value and construed the task to be to decide which account was right or wrong than to deliberate with an evaluativist considering how a piece of evidence might or might not fit each of the verdict choices.

## IMPLICATIONS FOR THEORY, RESEARCH, AND PRACTICE

Empirical research shows that there are gaps or potential gaps between the formal definitions of knowledge and means of knowing in the legal context and the way people actual reason given the epistemic perspectives they bring to the legal task. This suggests a need for greater attention to the wording and conceptualization of guidelines for legal decision-makers. Jury instructions and commentary in them indicate that the legal system treats all reasoners as the same and equally qualified. Although it is assumed that "experts" (judges) and "novices" (jurors) will and should use the same processes of knowing, in fact this is not likely the case given that among themselves jurors differ in their reasoning abilities and epistemic cognition.

The rewriting of jury instructions to take these gaps into consideration and guide for skills and epistemic cognition should be considered. Nevertheless, people will always come to the task with their particular epistemic perspectives. The rewriting of instructions, which should be done with greater attention to everyday epistemic cognition, would need to be done cautiously. Emphasizing the distinction between beyond a reasonable doubt and absolute certainty was found to lower the probability of guilt people used for conviction (Wright & Hall, 2007).

A more likely remedy would be formal training in argument and fostering evaluativist epistemic cognition, either as part of jury duty or civic education in schools. In addition, a program of epistemic sensitization (Porsch & Bromme, 2011) in the courtroom might improve reasoning and epistemic cognition. In the Porsch and Bromme study, students who received a short text highlighting uncertain knowledge about scientific issues showed more evaluative epistemic beliefs and attended more to various sources. Something similar might be done to highlight the potential uncertainty of the trial information and the likely disagreement between jurors in order to foster better consideration of more of the evidence. This could be done at the start of jury duty or built into voir dire. Researchers have found that the voir dire jury selection process can be used effectively to debias and educate jurors (Crocker & Kovera, 2010; Lieberman & Sales, 2007). Judges' questions and instructions in voir dire could orient prospective jurors toward the need to critically evaluate testimony, consider evidence within a framework of alternative explanations, and use evidence to justify their own verdict choice as well as discount the others.

A reevaluation of the direction of research on epistemic cognition over the last couple of decades suggests different issues to consider in legal epistemology. Chinn and colleagues (2011) turned to philosophical epistemology to explicate a framework for epistemic cognition that includes five components. Although Kuhn and colleagues' theory and research topics would mostly be included in two of the components, the sources and justification of knowledge and reliable and unreliable processes for achieving epistemic aims, Chinn et al. provide a more detailed framework that could productively be considered in relation to legal reasoning. For instance, whereas Kuhn and colleagues focus on knowledge as coming from external, objective sources or from subjective processes, Chinn and colleagues specify perceptual processes as a source. This would be relevant to how reasoners value eyewitness compared with other forms of testimony. Whereas Kuhn and Weinstock (2002) looked at jurors' judgment of witness credibility, they did not investigate jurors' epistemic understanding of testimony or their grounds for credibility evaluation. Chinn and colleagues argue that examining the grounds for trusting sources, including testimony, is important in their source of knowledge component. Although not in the legal context, recent work has looked at the relationship between epistemic cognition and trustworthiness evaluation (Barzilai & Zohar, 2012; Bråten et al., 2011) and children's development of evaluation of the trustworthiness of testimony (Harris, 2007). Such lines of research applied to courtroom testimony would be both theoretically and practically meaningful and would address the social epistemological concern of treating testimony as a particular type of evidence (Goldman & Blanchard, 2015).

As the legal system in common-law countries is a domain that uniquely and transparently establishes applied, social epistemological principles, epistemic cognition should be considered in interaction with social epistemology and socially prescribed definitions and procedures of knowing and epistemic aims. Certain formal social institutions, such as schools, establish and maintain epistemic standards both in explicit and implicit curricula and in the way the school is structured, adapts to new contexts and knowledge, and disseminates information, as well as in the way its staff learns and develops. But there is also epistemology in less formal, but certainly significant social institutions. Beyond a reasonable doubt, as it were, jurors' legal epistemic cognition is shaped by popular, possibly verisitic television shows such as *Law and Order* or *CSI*. In sum, greater attention should be paid not just to how people operate with epistemic cognition in the social world, but how social epistemology can shape their epistemic cognition within and across contexts.

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# 15

# EPISTEMIC COGNITION AND READING FOR UNDERSTANDING IN THE INTERNET AGE

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## INTRODUCTION

Traditionally, epistemology has been the business of philosophers, but during the last few decades people's personal epistemology has attracted increasing attention within the field of educational psychology. Research on personal epistemology concerns laypersons' cognitions related to knowledge and knowing (i.e. the epistemic) rather than trained philosophers' theories about such issues (Hofer & Bendixen, 2012). Reading could itself be considered a way of knowing (Cunningham & Fitzgerald, 1996), and texts are certainly important sources of knowledge. Readers do not always search for texts with the objective of acquiring new knowledge, for example when reading a crime novel, but texts have been central sources of knowledge in educational settings for centuries (Resnick & Resnick, 1977). In the twenty-first century the amount of information available in printed and digital media is constantly increasing. Along with this increasing quantity of information sources, the number of ways readers can access informational texts (e.g. via search engines), and the different formats in which texts are presented, such as hypermedia, Internet pages, or e-books, have increased as well (Alexander, 2012). Moreover, because anyone can publish almost any information on the Internet, information sources can vary considerably in their quality. This heterogeneity of information sources may also represent a challenge to readers, as more responsibility for evaluating those sources is transferred from publishers to readers. Hence, the role of epistemic cognition in reading may be even more evident in the digital age than when printed texts reviewed by professional gatekeepers were the primary knowledge sources (Spiro, Feltovich, & Coulson, 1996).

The purpose of this chapter is to review theory and research on the role of epistemic cognition when reading informational texts. We will report results from both studies on printed text material and studies focusing on digital texts. Following Alexander (2012), we focus on "the fundamental goal of reading as that of learning from text" (p. 263), which can also comprise the search for and selection of information, for instance, by the use of search engines. Thus, although readers' epistemic cognition could potentially also be involved in the comprehension of works of fiction, we will restrict our review to texts used in educational settings and other texts from which readers seek to gain knowledge. We will review some central studies demonstrating a relationship between epistemic cognition and readers' processing and understanding of single printed texts. However, our main goal is to show how epistemic cognition is possibly even more important when readers try to build integrated mental representations by evaluating and comprehending information that is presented in multiple documents and located in complex text environments such as the Internet.

The rest of the chapter is divided into three main sections. In the first, we will briefly outline how epistemic cognition is understood in the present chapter, and provide a brief theoretical background on central models of text comprehension. In the second, we review research on the relationship between epistemic cognition and learning from text(s). Of specific interest will be the role of epistemic cognition while readers deal with multiple printed or digital texts. Finally, in the third, we will summarize the review and discuss implications for future research and education.

## THEORETICAL BACKGROUND

### *Epistemic Cognition*

A number of different conceptualizations of personal epistemology have been proposed. Although it is not the purpose of this chapter to discuss conceptual matters regarding personal epistemology, we will briefly outline how personal epistemology is understood in the present chapter.

Beliefs about knowledge and knowing have commonly been referred to as personal epistemology or epistemological/epistemic beliefs (e.g. Hofer & Pintrich, 1997; Schommer, 1990), and are thought to affect students' learning and problem solving in multiple ways. Also, the act of evaluating claims as such could relate to epistemological questions, in the sense that we ask what it takes for a proposition to be justified (Murphy, Alexander, & Muis, 2012). Several researchers have suggested that cognitive processes aimed at defining, verifying, or justifying knowledge should be regarded as aspects of personal epistemology and that the term epistemic cognition, including both beliefs and the application and influence of those beliefs, may be a more accurate term than just epistemic beliefs (e.g. Ferguson, Bråten, & Strømsø, 2012; Greene, Azevedo, & Torney-Purta, 2008; Kitchener, 1983). Thus, we will here refer to *epistemic cognition* as cognitions related to knowledge and processes of knowing.

There is now a large and steadily growing body of literature, including several paradigmatic approaches, on questions related to epistemic cognition (e.g. King & Kitchener, 2002; Kuhn & Weinstock, 2002; Schommer, 1990). Our point of departure will, however, be the multidimensional framework of Hofer and Pintrich (1997), which describes four dimensions of beliefs about knowledge and knowing. This has probably been the most influential model during the last decade (Bråten, Britt, Strømsø, & Rouet, 2011; Chinn, Buckland, Samarapungavan, 2011). The framework describes two dimensions of epistemic beliefs concerning the nature of knowledge and two concerning the nature of knowing, with each dimension considered to reflect a continuum: (a) *certainty of knowledge*—ranging from the belief that knowledge is absolute and unchanging to the belief that knowledge is tentative and evolving; (b) *simplicity of knowledge*—ranging from the belief that knowledge consists of more or less isolated facts to the belief that knowledge consists of highly interrelated concepts; (c) *source of knowledge*—ranging from the belief that knowledge is transmitted from external authority to the belief that knowledge is actively constructed by individuals in interaction with the environment; and (d) *justification for knowing*—ranging from justification through observation, authority, or what feels right to the use of rules of inquiry and the evaluation and integration of multiple sources. Researchers applying Hofer and Pintrich's (1997) framework have not consistently been able to identify the four dimensions of epistemic beliefs, partly due to measurement issues (Buehl, 2008). However, all four dimensions were identified as important aspects of people's epistemic cognition when Bråten et al. (2011) reviewed a set of studies using different methodological approaches.

During the last few decades, it has been debated to what extent epistemic cognition is domain-general or domain-specific (Muis, Bendixen, & Haerle, 2006). A domain-general perspective implies that people hold the same belief about knowledge in all domains or disciplines, for example that knowledge is absolute and unchanging, while a domain-specific perspective entails variation across domains as to whether knowledge is unchanging. Some researchers also suggest that epistemic cognition varies according to the topic readers' attend to (Bråten et al., 2011), or the context and situation of the learning activity (Hammer & Elby, 2002). The discussion continues, but there seems to be less debate over whether epistemic cognition is *either* domain-general *or* domain-specific, although there has been increasing attention to discipline-specific and more contextually anchored epistemic cognitions in recent research (Chinn et al., 2011; Hofer & Bendixen, 2012; Muis et al., 2006). In the present chapter, we will not deal with this question during our research review, but we will return to it in the concluding discussion.

The four-dimensional framework of Hofer and Pintrich (1997) has recently been challenged on a conceptual level, partly based on ideas from philosophical epistemology. Greene et al. (2008), for example, argued that beliefs about knowledge in a strictly philosophic sense deal with questions of ontology, while justification of claims about knowledge is at the core of epistemology. According to Greene et al. (2008), a number of different kinds of justifications are referred to in philosophy. Accordingly, one could assume multiple dimensions in individuals' beliefs about justification for knowing, such as appealing to rationality, observation, experience, expertise, or coherence between new claims and established knowledge. This more fine-grained perspective on *justification for knowing* also illustrates that the continuum assumed in the Hofer and Pintrich (1997) framework may be problematic. For example, justification by authority may rule out the presumably more sophisticated approach whereby, in the Hofer and Pintrich framework, readers adhere to justification by rules of inquiry. However, it is conceivable that some readers may refer to both authority and rules of inquiry as important means of justification. Thus, *justification for knowing* is more likely multidimensional than one-dimensional. Regarding the authority dimension, one should also note that it seems reasonable that novices, who do not know the discipline, would justify a claim by referring to an expert, while that may not be the case for experts themselves (cf. Bromme, Kienhues, & Porsch, 2010). Thus, the degree of sophistication attached to the different kinds of justifications may partly depend on the reader's level of expertise.

Chinn et al. (2011), also referring to philosophical epistemology, suggested that Hofer and Pintrich's (1997) framework could be extended by including several new components, specifically epistemic aims, epistemic value, and epistemic virtues and vices. We believe the suggestions by Greene et al. (2008) and Chinn et al. (2011) are valuable contributions to a further understanding of epistemic cognition, and note that both, in various ways, also represent important aspects of the Hofer and Pintrich (1997) framework. For the purpose of the present chapter, however, we find the multidimensional framework appropriate, partly because the dimensions suggested by Hofer and Pintrich (1997) constitute a structure well suited for summing up much of the reading-related research in the field, but also because their framework represents an important point of reference for several recent theoretical developments (e.g. Bråten et al., 2011; Chinn et al., 2011; Greene et al., 2008).

### *Comprehension of Printed and Digital Texts*

Text comprehension is the processing of information to extract meaning from text and comprises a number of subprocesses, including basic lower-level processes such as orthographic processes and decoding (McNamara & Magliano, 2009). Two essential processes involved in text comprehension seem to be the construction of coherence within a text and the construction of bridges to readers' prior knowledge. The influential construction-integration (CI) model of Kintsch (1998) describes how readers construct a mental representation of a single text based on its lexical and syntactic surface and how they make inferences based on its coherently related parts. A deeper, more elaborated understanding of a text is constructed as readers make inferences integrating prior knowledge with a mental representation of the document's explicit content. Text comprehension, however, is not only a question of cognitive processes taking place whenever readers meet a text. Comprehension is also affected by readers' goals, willingness to invest effort in the comprehension process, motivation and interest in the topic, epistemic cognition, strategic skills in handling the task, and the sociocultural context of the activity (e.g. Alexander, 2012; Bråten et al., 2011; Cromley, Snyder-Hogan, & Luciw-Dubas, 2010; Taboada, Tonks, Wigfield, & Guthrie, 2009).

Whereas Kintsch's (1998) CI model explains the comprehension processes taking place when a single text is read, it does not explain how readers deal with multiple texts containing information on the same subject. Both in and outside of school, readers often face multiple texts presenting more or less congruent information on the same issue. The documents model, proposed by Perfetti et al. (1999), is an extension of the CI model in that readers' mental representations of single texts are expanded to mental representations of multiple texts. Perfetti et al. (1999) suggested that an adequate mental representation of multiple texts containing contradictory information must include an additional layer, the intertext model, containing information about the texts, for example about features such as author, publisher, date of publication, and so forth, as well as about how the different texts relate to each other. By tagging source information to important content, readers may differentiate between documents and evaluate the contribution of each document to a comprehensive understanding of the topic or situation (Rouet, 2006).

Reading multiple printed texts may be a challenging task. In order to construct a coherent representation of the texts' content, readers have to compare and integrate content across texts and also keep in mind "who says what, and why." Reading multiple digital texts located on the Internet may be an even more challenging task. Nonlinear hypertext structures, in addition to an almost unlimited amount of information, require a high degree of control from the reader (Scheiter & Gerjets, 2007). To access information on the Internet, readers continually have to decide which paths to follow, that is, which information to read in which order. This can easily lead to increased decision-making demands, information overload, and disorientation, and thus to impaired reading performance (DeStefano & LeFevre, 2007). Moreover, although a wealth of information can be accessed on the Internet, there is no guarantee as to its validity and reliability. Information providers on the Internet can vary considerably in terms of their expertise or motives, and contrary to traditional information sources, such as printed publications, documents on the Internet seldom have explicit editorial review policies or undergo quality controls. Thus, readers themselves are responsible for "gatekeeping," that is, evaluating the relevance and quality of information found online. As source information on websites is often not displayed in a salient way (Britt & Aglinskas, 2002), this can be a difficult task.

However, reading printed and digital texts are not entirely different activities. Skills and strategies required to read printed texts are also needed when reading on the Internet (Leu et al., 2015). Still, it is suggested that reading on the Internet requires reading strategies to be modified in new ways, and that some additional skills are needed (Cho, 2014; Coiro, 2011; Leu et al., 2015). For example, Leu et al. (2015) suggested that the demands of "online text comprehension" require the reader to place greater emphasis on the definition of important questions (reading goals), as well as on how to locate information, how to critically evaluate information, and how to synthesize information from different sources (see also Brand-Gruwel, Wopereis, & Walraven, 2009). All those activities may apply to the reading of printed texts as well, but the challenge is to modify those activities to a more complex context. Based on a review of research on different sorts of reading, Afflerbach and Cho (2009) concluded that a group of strategies particularly involved in digital reading could be labeled "realizing and constructing potential texts to read." In a later study, Cho (2014) identified "text location strategies" as central to how students identify and select useful texts to read. Although such strategies also could be helpful when selecting printed texts, they seem to be essential, as well as of a somewhat different nature, when reading on the Internet. For example, text location strategies in the form of flicking through pages when searching, skimming for specific information, or browsing among and choosing library books could be helpful when reading printed text. Those strategies are, however, related to a single text or a limited set of texts, whereas text location strategies in an open-ended nonlinear hypertext environment require additional skills such as generating relevant search terms, evaluating search results pages and menus, and judging the relevance of hypertext links (Cho, 2014).

### *Epistemic Cognition and Learning from Text(s)*

Given that epistemic cognition concerns readers' beliefs about what constitutes knowledge, where knowledge is located, and how it is acquired, it seems reasonable that such beliefs could affect how readers gain knowledge from texts. As outlined above, two central processes in text comprehension involve constructing a coherent text representation and linking text content to prior knowledge (Kintsch, 1998; McNamara & Magliano, 2009). Readers who, for example, tend to believe that knowledge in a particular domain consists of an unorganized set of discrete and absolute truths (Ryan, 1984) may invest little effort in constructing a coherent representation of the text and be reluctant to activate prior knowledge in doing so. Such beliefs could thus impair text comprehension when reading a single text, and maybe even more so when readers face the challenge of integrating information across multiple texts. Work by Jacobson and

Spiro (1995) and Bendixen and Hartley (2003) indicates that instructional hypertext environments that require navigation between several pages and active knowledge construction are particularly suited for learners with adaptive epistemic beliefs, whereas learners with less adaptive beliefs (e.g. that knowledge is simple and certain) seem to be better off with more structured, system-controlled learning environments or textbooks. When using the open Internet to learn about an issue, which implies even less structure than an instructional hypertext environment, this finding is likely to be even more pronounced.

Both the documents model (Perfetti, Rouet, & Britt, 1999), which describes comprehension of multiple texts, and the "online text comprehension" research (Coiro, 2011; Leu et al., 2015) emphasize that readers' attention to source information is essential for locating and identifying relevant and reliable texts for reading. Those tasks seem to be closely related to epistemic beliefs in the sense that beliefs about where knowledge resides and how knowledge is justified may affect which texts readers decide to read, that is, their "realizing and constructing potential texts to read" (Afflerbach & Cho, 2009). When readers are challenged by the complexity of multiple digital texts, adaptive epistemic beliefs may instigate judgments about the accuracy and quality of texts, whereas less adaptive beliefs may imply that readers select texts based on unsuitable criteria (e.g. "authorities must be right" or "this confirms my own experience").

## RESEARCH ON EPISTEMIC COGNITION AND LEARNING FROM TEXT(S)

In the next section we will review research on the relationship between epistemic cognition on the one hand and text comprehension and learning from text(s) on the other. Above we have argued that the reading of single printed texts does not represent a totally different activity compared to the reading of multiple digital texts, as skills involved in the former also apply to the latter. Thus, we will start with a brief review of research on single text reading, although our main focus will be on research concerning how epistemic cognition may relate to the reading of multiple texts—both printed and digital.

### *Epistemic Cognition and Single Text Comprehension*

In one early study of the relationship between personal epistemology and reading, Ryan (1984) asked how students' beliefs about knowledge were related to their criteria for understanding a textbook chapter. Students who believed that knowledge in academic settings was an unorganized set of discrete and absolute truths tended to assess their reading comprehension based on the amount of information they could recall, whereas students who conceived of knowledge as a selection of interpreted and integrated propositions were more likely to assess their reading comprehension according to the degree to which they could integrate and apply text information. The latter students also achieved the highest text comprehension scores.

A number of studies have since confirmed the results from Ryan's (1984) research, showing that readers who tend to believe that knowledge is complex and tentative demonstrate better comprehension of single informational texts than readers who believe knowledge is certain and simple (e.g. Kardash & Scholes, 1996, Qian & Alverman, 1995; Schommer, 1990; Schommer, Crouse, & Rhodes, 1992). For example, Schommer found that belief in certain and unchanging knowledge negatively predicted students' interpretation of text passages (Schommer, 1990), while Schommer et al. (1992) found that the less students believed in simple knowledge the better they performed on a comprehension test. Qian and Alverman (1995) found that students who believed in certain and simple knowledge had more problems understanding a refutational text on Newton's theory of motion than students who assumed knowledge to be complex and tentative, while Kardash and Scholes (1996) reported that students who believed in certain knowledge tended to avoid inconclusive and tentative interpretations of complex textual information. Those results were later confirmed in studies by Mason et al. (2008) and Kendeou et al. (2011), with the latter study also demonstrating that beliefs in knowledge as evolving rather than certain were also positively related to productive on-line processing of refutational text. In summary, students considering knowledge to be tentative and complex seem to be aiming at comprehension and not only memorization when reading single texts. Similarly, Richter and Schmidt (2010) found that when extrinsic motivation to learn was low, beliefs in uncertain knowledge were positively related to whether students looked for evidence supporting claims stated in texts and also to students' reported tendency to check if those claims were in alignment with their own experience. Those results align with results from text comprehension research, which emphasize the importance of integrating information units across the text and linking it to prior knowledge in order to construct a coherent mental representation (e.g. McNamara & Magliano, 2009). Beliefs in knowledge as a set of more or less isolated facts do not seem to contribute to the integration processes needed for text comprehension, however.

Although it is theoretically plausible that individuals' beliefs about knowing (i.e. source and justification dimensions) also would affect single text comprehension, this has not been demonstrated—at least not for informational texts. There are, however, studies showing that beliefs in personal construction rather than in extracting the author's intended meaning may facilitate comprehension when reading narrative texts (Schraw, 2000; Schraw & Bruning, 1996). One could speculate that beliefs in personal interpretations would play a more positive and significant role in the comprehension of narratives than when readers aim to understand the messages communicated in informational texts (Strømsø, Bråten, & Samuelstuen, 2008). The scarcity of research results on relationships between beliefs about knowing and single text comprehension could be due to the measurement problems that characterize much of the research on epistemic cognition (Buehl, 2008); alternatively, beliefs about knowing may be more closely related to comprehension of more complex text material, such as multiple printed and digital texts.

### *Epistemic Cognition and Learning from Multiple Texts*

In research on multiple text comprehension, readers are typically presented a fixed set of more or less contradictory texts on a specific topic. Those texts may be presented in a printed or a digital format. We will not distinguish between those formats in this section, as whether a fixed number of texts are read on a screen or on paper does not necessarily make a big difference in this context. The hypertextual nature of the multitude of texts on the Internet may, however, represent an even more challenging reading task, and we will attend to how epistemic cognition may relate to the reading of such texts in the next section.

In the present section our focus will be on how epistemic cognition may relate to readers' construction of a coherent mental representation of content from a fixed number of partly contradictory texts. Based on the Hofer and Pintrich (1997) framework, Bråten et al. (2011) demonstrated in a series of studies that topic-specific epistemic beliefs (about the issue of global warming) predicted students' comprehension of the texts in several ways.

Regarding certainty beliefs, readers who believed that knowledge about the global warming issue is tentative and evolving demonstrated better multiple text comprehension than those who tended to believe that this knowledge base was absolute and unchanging (Strømsø et al., 2008). Confirming this result, two later studies showed that readers aiming to construct arguments from texts seemed to profit from believing in the tentative and evolving nature of knowledge (Bråten & Strømsø, 2010a; Gil, Bråten, Vidal-Abarca, & Strømsø, 2010).

With respect to simplicity beliefs, results indicated that believing knowledge about global warming to consist of highly interrelated concepts rather than more or less isolated facts seemed to facilitate the construction of a coherent mental representation of multiple texts (Bråten & Strømsø, 2010a; Strømsø et al., 2008), and also that readers believing knowledge to consist of simple facts tended to trust questionable information from a newspaper more than readers holding the belief that knowledge concerning global warming is complex (Strømsø, Bråten, & Britt, 2011).

Regarding source beliefs, results from Bråten et al. (2008) and Strømsø et al. (2008) indicated that readers aiming to comprehend partly contradictory multiple texts on a complex issue like global warming profited from believing that such knowledge was transmitted from external authority rather than actively constructed by the reader. In contrast to results from the reading of narratives (Schraw, 2000; Schraw & Bruning, 1996), it seems that the comprehension of complex informational texts requires that readers to a lesser degree rely on subjective interpretations of the texts' content—particularly if their own knowledge of the topic is limited. Source beliefs also seem to affect readers' trust in multiple texts and their criteria for such trust, with readers believing knowledge to be transmitted by experts found to put less emphasis on personal opinion as a criterion, and to focus more on content when judging the trustworthiness of potentially reliable information sources (Strømsø et al., 2011).

Justification beliefs seem to come more into play when readers work on multiple than on single informational texts. Readers who believe that knowledge claims should be justified through reason, rules of inquiry, and the evaluation and integration of multiple sources demonstrated better multiple text comprehension than readers who tended to emphasize observation, authority, or what feels right (Bråten & Strømsø, 2010b; Strømsø & Bråten, 2009). Using a multidimensional measure of justification beliefs, Bråten and colleagues found that beliefs in personal opinion as a means of justifying knowledge claims in science were negatively related to multiple text comprehension, whereas beliefs in justification through corroboration across multiple sources were not only positively related to multiple text comprehension (Bråten, Ferguson, Strømsø, & Anmarkrud, 2013; Ferguson, 2015; Ferguson & Bråten, 2013), but also had an effect mediated by effort and deeper-level reading strategies (Bråten, Anmarkrud, Brandmo, & Strømsø, 2014). Of note is that epistemic cognition regarding justification for knowing was also identified in students' processing of multiple informational texts by the means of think-alouds (Ferguson et al., 2012) and that justification through corroboration across multiple sources positively predicted both readers' sourcing skills and argumentation in essays based on the texts (Bråten, Ferguson, Strømsø, & Anmarkrud, 2014).

### *Epistemic Cognition and Internet-Based Reading and Learning*

Results from research on the relationship between epistemic cognition and comprehension of single and multiple texts may also apply to reading on the Internet. "Online text comprehension" does, however, seem to represent a new challenge to readers, in that they, from innumerable information sources, have to locate and evaluate potential texts to read in order to construct a coherent representation of these texts (Afflerbach & Cho, 2009; Alexander, 2012; Coiro, 2011; Leu et al., 2015). This complex task may involve a more salient role for epistemic cognition among readers.

With regard to certainty and simplicity beliefs, several (concurrent or retrospective) think-aloud studies (Hofer, 2004; Mason, Boldrin, & Ariasi, 2010a; Whitmire, 2004) indicate that students who believe that knowledge is simple and unchanging engage in online reading in a brief and perfunctory way. They seem to predominantly select information sources consistent with their own views while hardly searching for additional sources, integrating information from multiple sources, or reflecting on the credibility of the sources. In contrast, students who hold the view that knowledge is complex and interconnected, as well as tentative and evolving, seem to consider conflicting information, try to justify knowledge found in web pages by comparing multiple information sources, and critically evaluate information sources on the basis of the URL of a website or information about the author and publisher and their affiliations. For example, by examining learners' navigation logs, Pieschl et al. (2008) found that the more university students believed in complex knowledge, the more web pages they accessed when navigating an instructional hypertext to learn about genetic fingerprinting. Moreover, an eye tracking study by Mason and Ariasi (2010) revealed that whereas beliefs in certain and unchanging knowledge were associated with more time spent on the most well-known information source, beliefs in tentative and evolving knowledge were associated with more concentration on controversially discussed, newer information, given that it was provided by an authoritative information source. In a similar study, Mason et al. (2014) found that university students who believed more in knowledge as complex and based on evidence spent more time fixating on graphical information provided on web pages of ambiguous reliability, indicating a more critical evaluation of the provided information.

In addition to their relationship with processing activities during Internet-based reading, beliefs in complex knowledge also seem to be positively related to Internet-based comprehension and learning. Tu et al. (2008) investigated the role of epistemic beliefs in secondary-school students who were tasked to learn about a conflicting topic by using the Internet. Results showed that students who believed that knowledge was actively constructed and derived from reason were better able to answer open-ended questions requiring deliberation and reflection than those who believed that knowledge was an accumulation of certain and unchanging isolated facts. In contrast, epistemic beliefs were not related to students' performance on questions that did not require the comparison and integration of information across multiple sources. Similar results were found by Jacobson and Spiro (1995). In summary, the above-cited studies on relationships between certainty and simplicity beliefs and Internet reading indicate that beliefs in tentative and complex knowledge are positively related to more thorough searching behavior and evaluation of information sources, increased time spent on reliable sources, and better results on open-ended tasks demanding reflection.

With regard to epistemic cognitions concerning source and justification, results from two studies by Mason and colleagues with high-school (Mason, Ariasi, & Boldrin, 2011) and university students (Mason, Boldrin, & Ariasi, 2010b) indicated that students who were epistemically active in regard to both the source of knowledge (i.e. reflecting on the credibility of sources) and the justification for knowing (i.e. reflecting on the veracity of the information on the basis of scientific evidence) showed better learning outcomes than those who were only epistemically active in regard to source of knowledge. This was demonstrated in essays reflecting evaluation and the acknowledgment of the inconclusive nature of the topic. Similarly, secondary-school students who believed that scientific knowledge was supported by evidence, and who reflected more on the scientific evidence addressed in the web pages, learned better the causes of the phenomenon under investigation (Mason et al., 2010a). Detailed analyses of think-aloud protocols by Greene et al. (2014) indicated that beliefs about knowledge as contextualized and situated, and beliefs that knowledge claims need to be justified upon their coherence with other claims, positively predicted Internet-based learning, measured as a gain in participants' conceptual understanding. Based on the developmental framework of Kuhn and Weinstock (2002), Barzilai and Zohar (2012) showed that sixth-grade students with evaluativistic epistemic beliefs outperformed students with absolutistic beliefs in critically comparing and integrating information from multiple websites. It should be noted that absolutist beliefs imply that no justifications are needed, while evaluativist beliefs involve justification by rules of inquiry and what counts as knowledge in the relevant domain.

While the students in the study by Barzilai and Zohar (2012) did not differ in their evaluation of the websites' trustworthiness, other studies with older students found relationships between epistemic cognitions (about knowing) and critical evaluations of the trustworthiness of web pages. Yang et al. (2013) found that the less university students believed that knowledge resided in external authorities (such as teachers, textbooks, or scientists), the more critical they were in evaluating how well arguments were presented in web pages, as indicated by retrospective interviews. A study by Kammerer et al. (2014) showed that when reading multiple websites about a controversial issue, beliefs that knowledge claims need to be justified through the use of multiple sources, reasoning, and prior knowledge activation were related to an increased attention to website logos. Furthermore, justification beliefs were also positively related to more source references provided in students' essays after reading. In summary, results from the studies cited above show that epistemic cognitions about source and justification of knowledge may be related to reading on the Internet in several ways, with epistemic cognitions seemingly affecting readers' attention and references to source information, evaluation of content, and comparison and integration of information across texts, as well as their resulting comprehension of the issues in question.

### *Internet-Specific Epistemic Beliefs*

Due to the specific characteristics of the Internet, such as limited editorial gatekeeping and high heterogeneity of information sources, Bråten et al. (2005) suggested focusing specifically on epistemic beliefs related to the Internet as a particular type of knowledge resource, that is, on Internet-specific epistemic beliefs. They found that university students who held the belief that the Internet is a reliable knowledge resource that contains correct and detailed information were reportedly more competent and experienced less problems when conducting web searches, evaluating information sources, and using the retrieved information in their coursework than were students who had doubts about this issue. Similar results were later found in other studies (Chiu, Liang, & Tsai, 2013; Kammerer, Amann, & Gerjets, 2015; Kammerer & Gerjets, 2012; Lee, Chiu, Liang, & Tsai, 2014; Strømsø & Bråten, 2010), also with respect to more direct measures of search and evaluation behavior. For instance, Kammerer and colleagues (Kammerer et al., 2015; Kammerer & Gerjets, 2012) found a positive relationship between beliefs that the Internet is a reliable knowledge resource and Internet users' focus on objective (i.e. scholarly, factual) websites during a web search on a medical issue. At the same time, these results indicate that readers who are more skeptical about the Internet being a useful information resource are more reluctant to involve themselves in demanding information search and evaluation tasks on the Internet. On the other hand, readers who believe that the Internet is an authoritative source of true, simple facts may not fully realize the challenge represented by the multitude of different information sources found on the Internet when the task is to identify and use reliable and relevant information sources.

Kammerer et al. (2013) and Kammerer et al. (2015) also found that university students and nonacademic adults, respectively, who believed that the Internet was a reliable knowledge resource were more certain about their post-search decisions about two conflicting therapies. The results by Kammerer et al. (2013) also indicated that students with such beliefs reflected less on the nature or credibility of different kinds of web-based information sources encountered in the search engine results page. While this finding could be an indication of a lower degree of source evaluation, another explanation might be that students mainly focused on reliable information sources while ignoring the other kinds of sources.

To conclude, until now the relationships between beliefs about the Internet as a reliable knowledge resource and critical evaluation of online information have not yet been fully researched, with the findings to date leaving substantial room for interpretation. In this context, however, it should be mentioned that the items used to measure these beliefs are also somewhat ambiguous in regard to whether they mean that (a) all or at least most knowledge on the Internet is correct, or that (b) at least instances of correct knowledge can be found on the Internet, with the latter apparently being a more appropriate belief than the former. Moreover, it should be mentioned that while some studies examined beliefs concerning Internet-based knowledge about study-related content (e.g. Chiu et al., 2013; Kammerer, Bråten, Gerjets, & Strømsø, 2013; Lee et al., 2014; Strømsø & Bråten, 2010), others examined beliefs about Internet-based knowledge in general (Kammerer et al., 2015; Kammerer & Gerjets, 2012). It seems reasonable that students who doubt that the Internet contains correct knowledge about study-related content also have a higher awareness of the challenges involved in finding high-quality study-related knowledge on the Internet. In contrast, with respect to Internet-based knowledge in general, individuals who have developed skills to find high-quality information on the Internet and to differentiate it from low-quality information might have good reason to believe that correct knowledge can be found on the Internet. Future research is needed to investigate in more detail how individuals interpret statements such as "The Internet contains accurate knowledge" in specific contexts and how such beliefs are related to their online reading and learning.

Regarding Internet-specific beliefs about justification, the findings are more conclusive. Several studies indicate a positive relationship between the belief that knowledge claims encountered on the Internet need to be checked against other information sources, reason, and prior knowledge, on the one hand, and the degree of elaborated argumentation and reported use of self-regulatory strategies during web searches, on the other (Chiu et al., 2013; Kammerer et al., 2013; Strømsø & Bråten, 2010). Moreover, Kammerer et al. (2015), who further distinguished between Internet-specific beliefs concerning justification by multiple sources and beliefs concerning personal justification (e.g. Ferguson, 2015), found that individuals who believed that Internet-based knowledge claims needed to be critically evaluated through cross-checking and corroboration across multiple websites were more focused on objective (i.e. scholarly, factual) websites during a web search on a medical issue. In contrast, beliefs concerning personal justification were positively related to the time spent on commercial websites. That is, the more the individuals, who had low prior knowledge about the medical issue, believed that knowledge claims on the Internet required justification by the use of prior knowledge and reasoning, the more time they spent on commercial web pages. Accordingly, these kinds of justification beliefs seemed to be related to a rather unfavorable navigation behavior when searching the Internet for an unfamiliar issue. To conclude, relationships between readers' Internet-specific justification beliefs and reading do not seem to stand out from the results presented in the prior section.

## SUMMARY AND DISCUSSION

Our research review clearly indicates that epistemic cognition may affect readers' processing of and learning from informational texts, whether they read single texts or multiple texts, or deal with texts located on the Internet. Research on single-text reading reports mainly on relationships between beliefs about the certainty and simplicity of knowledge, whereas research on multiple printed and digital texts seems to demonstrate that also epistemic cognition regarding how we come to know (source and justification) affects readers' processing and outcomes. Successful reading of contradictory multiple texts and Internet texts also seems to demand more from the reader in terms of adaptive epistemic cognition. That is, in order to compare and integrate across contradictory texts, readers should profit from holding beliefs about knowledge as tentative and complex, since beliefs about knowledge as certain and simple may likely restrain the reader from reading more than one text. Also, the online comprehension tasks related to searching, selecting, and evaluating multiple texts on the Internet seem to be related to both the knowledge and the knowing aspects of epistemic cognition.

Across the different studies, some beliefs may be regarded as more adaptive to reading tasks than others, with those beliefs sometimes referred to as sophisticated (e.g. Schommer, 1990). Regarding source beliefs, the belief that knowledge is transmitted from authorities has traditionally been labeled naïve. Our research review suggests, however, that trust in authorities may sometimes be the more adaptive beliefs. Results from Strømsø et al. (2008), for example, showed that reliance on authority is not necessarily naïve, and that readers low in prior knowledge actually may need to trust authorities and rely less on their own interpretation of meaning. This illustrates that more attention should be paid to the role of individual difference variables, such as prior knowledge, attitudes, or interest (cf. Bråten, Anmarkrud et al., 2014, Van Strien, Brand-Gruwel, & Boshuizen, 2014), in future research on the relationship between epistemic cognition and text comprehension. For instance, it might be the case that prior knowledge about the subject matter moderates the relationship between beliefs concerning personal justification and readers' evaluation strategies or text comprehension, with beliefs concerning personal justification being more adaptive for individuals with more prior knowledge. Furthermore, advanced epistemic beliefs (e.g. that knowledge is tentative and evolving) might counteract the formation of a biased representation of a controversial issue due to strong prior attitudes regarding the issue (cf. Van Strien et al., 2014). Another exception from the traditional labeling of some beliefs as generally more sophisticated is the finding that beliefs in the Internet as a reliable knowledge resource seem to be related to more competent web search behavior. As outlined above, future research should examine what characterizes individuals who believe the Internet is a reliable knowledge resource and what they exactly mean by it.

Results from the reviewed studies indicate that the extent to which different kinds of epistemic cognition are adaptive may vary according to the nature of the text material. Thus, justification and source beliefs seem more salient when readers deal with complex printed and digital multiple texts than when they read single texts. Also, beliefs about certainty and simplicity seem to relate to different patterns of reading behavior when students read printed texts than when they read on the Internet. These results could indicate that the roles of readers' epistemic cognitions vary with the information technology used and how texts are located and presented. In summary, the results suggest that contextual features of the reading situation probably need to be considered in research on the role of epistemic cognition in the reading of informational texts.

Regarding the discussion on the domain-general versus domain-specific nature of epistemic cognitions, we agree that this should not be an either–or discussion (Muis et al., 2006). We do, for example, agree that knowledge claims, to a varying degree, will be justified differently across academic domains (Chinn et al., 2011; Donald, 1990). Several studies indicate that the domain-specific nature of epistemic cognition increases with participants' domain expertise (Samarapungavan, Westby, & Bodner, 2006; Schommer-Aikins, 2008). Thus, experts familiar with the epistemic norms embedded in the domain may demonstrate domain- or subject-specific epistemic cognition, whereas nonexperts may have to rely on more general criteria to judge what counts as knowledge in a domain (Vedder, 2001). Regarding reading on the Internet, the notion of expertise may also be expanded to familiarity with the information technology itself, and we would like to see more studies on how both domain expertise and expertise in Internet information literacy may be related to epistemic cognition.

The studies presented in the above review included participants from the United States, and from Asian and European countries. Results indicate the same patterns of relationships between epistemic cognition and text comprehension across the samples. However, more cross-cultural studies are needed, as some studies showed cultural differences in students' epistemic cognitions both between countries (e.g. Hofer, 2008; Karabenick & Moosa, 2005) and within countries (e.g. Kuhn & Park, 2005; Schommer-Aikins & Easter, 2008; Strømsø, Bråten, Anmarkrud, & Ferguson, in press). For example, Strømsø et al. (in press) found that ethnic minority students' multiple-text comprehension was positively related to beliefs in justification by authority and negatively related to beliefs in justification by personal views and opinions, while no such relationships were demonstrated among ethnic majority students.

Another issue for future studies is how the development of epistemic cognition could be facilitated. Results from several studies indicate that readers' epistemic cognition may develop as a result of working with multiple texts. For example, Ferguson et al. (2013) demonstrated that students who read multiple conflicting texts changed their epistemic beliefs, whereas no change was observed among students who read multiple consistent texts. Thus, only the complexity of reading contradictory texts seemed to facilitate development of epistemic beliefs. Such contradictions are encountered frequently when reading on the Internet, and Tsai (2004) argued that the Internet can be perceived as an epistemological tool, such that using the Internet—with appropriate guidance and self-reflection on the part of the reader—can positively alter individuals' epistemic beliefs. For example, the confrontation with diverse perspectives and conflicting information on the Internet might foster beliefs about the complexity and tentativeness of knowledge and the need for justification of knowledge claims (Kammerer et al., 2015; Kienhues, Stadtler, & Bromme, 2011; Tsai, 2008). From this perspective, the reading of multiple contradictory texts—both printed and digital—does not only represent a challenge to the reader, but also an opportunity for guided development of epistemic cognition adaptive to the complexity of the information society.

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# 16

# THE ROLE OF EPISTEMIC COGNITION IN TEACHER LEARNING AND PRAXIS

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## INTRODUCTION

The purpose of this chapter is to discuss how teachers engage in epistemic cognition for both learning how to teach and teaching praxis. We begin with a definition of epistemic cognition, drawn from the recent literature (Chinn, Buckland, & Samarapungavan, 2011; Chinn, Rinehart, & Buckland, 2014; Greene, Azevedo, & Torney-Purta, 2008; Maggioni & Parkinson, 2008). Next, we present an integrated framework that highlights the role of epistemic cognition in teacher learning and praxis (Figure 16.1). This framework incorporates our previous work on teachers' beliefs about teaching knowledge (Fives & Buehl, 2010) and Chinn and colleagues' (2011, 2014) theoretical explication of epistemic cognition. We differentiate epistemic cognition for teachers based on the identified task (i.e. learning or teaching). Our integrated framework includes the domains of teacher knowledge under consideration, the processes of epistemic cognition, and epistemic outcomes or products. It is salient to note that we conceive of epistemic cognition as a domain- and topic-specific process, such that to think about knowledge one must consider the specific knowledge under consideration. Throughout our discussion of the framework, we provide relevant examples from recent studies of teacher epistemic cognition in the context of learning to teach and teaching practice. We close the chapter with conclusions and implications for studying epistemic cognition in relation to learning to teach and teaching praxis.

## DEFINITION OF EPISTEMIC COGNITION

Epistemic cognition is currently used as an overarching term that encapsulates the cognitive processes that include "all kinds of explicit or tacit cognitions related to epistemic or epistemological matters" (Chinn et al., 2011, p. 141) and "emphasizes knowledge and the processes involved in its definition, acquisition and use" (Greene et al., 2008, p. 143). Thus, epistemic cognition occurs when individuals consider the nature of domain-specific content (i.e. considerations of source, justification, structure, certainty/stability). As noted by numerous researchers, epistemic beliefs (i.e. beliefs about knowledge and knowing) are related to various learning processes and outcomes (e.g. text comprehension: Bråten & Strømsø, 2006; metacognition: Hofer, 2004; academic achievement: Hofer, 2000). Epistemic cognition emphasizes the processes individuals engage in while thinking about, developing, using, or mentally manipulating knowledge, whereas research in epistemic beliefs or personal epistemology emphasizes the relations between beliefs and outcomes.

Much of the work to date has focused on the epistemic cognition of students in the context of learning; however, epistemic cognition is particularly relevant for teachers. Indeed, we argue that the need for teachers to engage in epistemic cognition is exponentially higher than it is for students as teachers both learn and design contexts for the learning of others. That is, teachers must learn about various domains of knowledge through teacher preparation, professional development, and professional practice, and they influence the learning and epistemic cognition of their students through the epistemic climate created in the classroom (e.g. Feucht, 2010; Muis & Duffy, 2013). Thus, for teachers there are two salient tasks—*learning* and *teaching*—that require the implementation of epistemic cognition in order to achieve meaningful outcomes for themselves and their students. Moreover, the epistemic outcomes of learning and teaching tasks contribute to future learning and teaching, underscoring the importance of teacher epistemic cognition as a cyclical process. These tasks are described more fully as we articulate a framework that highlights the complexity of teachers' epistemic cognition.

## A FRAMEWORK FOR TEACHERS' EPISTEMIC COGNITION

Our framework for teachers' epistemic cognition elaborates on Chinn and colleagues (2011, 2014) framework of epistemic cognition by explicating the nature of the relations among the "network of interconnected cognitions" (Chinn et al., 2011 p. 142) and situating this process within the professional work of teachers. Figure 16.1 illustrates a framework for embedding teachers' epistemic cognition within a task-focused process. The left column of the figure depicts key components of a task-focused process that engages epistemic cognition whereas the right columns portray specific instantiations of these components. The dashed lines in the figure are for rhetorical purposes only; they allow us to direct the reader's attention to the appropriate segment of the figure in our discussion. We provide a brief overview of the framework before discussing the specific components in more detail. Throughout the elaboration of our framework, we use data from Bondy et al. (2007) and Stoddard (2010) to provide examples of, and support for, the various aspects of our framework.

As seen at the top of Figure 16.1, we propose that in considering teachers' epistemic cognition, one must first specify the task at hand (i.e. Task: learning or teaching) and the knowledge that is the focus (i.e. Domain). Because epistemic cognition does not occur in a vacuum, it is essential to identify the context for this process. We view task and domain as essential components of this context that together contribute to the goals or aims of the teacher in that situation. If the teacher has an Epistemic Aim (i.e. goal related to knowledge, understanding, or true belief; Chinn et al., 2011, 2014), he or she may engage processes of Epistemic Cognition, in which the nature of knowing and knowledge (e.g. source, justification, certainty; Greene et al., 2008; Hofer & Pintrich, 1997; Muis, Bendixen, & Haerle, 2006) is considered, weighed, and evaluated. The extent and quality of this epistemic processing is influenced by a variety of factors including the teacher's domain expertise, prior knowledge, existing epistemic stances (i.e. beliefs held

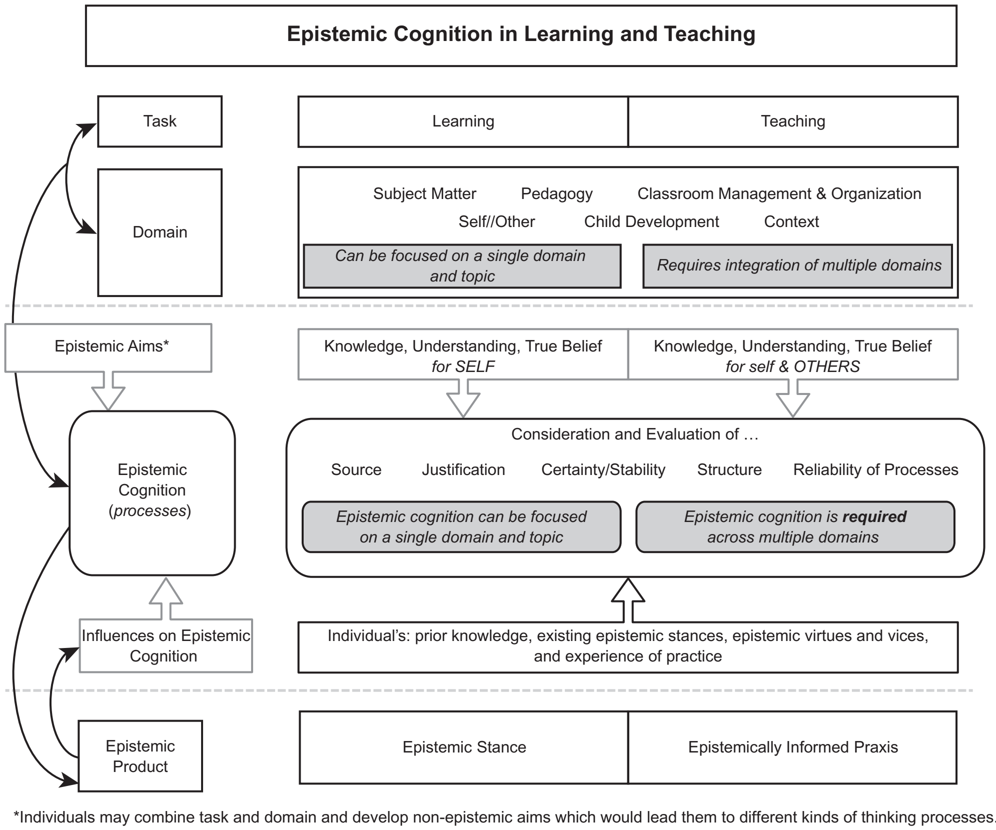


**Figure 16.1** A framework for epistemic cognition in learning and teaching.

about specific ideas, concepts, and information as well as the constructed meaning of the ideas, concepts, and information), epistemic vices and virtues (i.e. dispositions that aid or hinder the achievement of epistemic aims; Chinn et al., 2011), and experience of practice. Such epistemic processing then results in a specific Epistemic Product or achievement, as depicted by the arrow from Epistemic Cognition to Epistemic Product, which may serve as an influence on future epistemic cognition, as depicted by the arrow from Epistemic Product to the Influences on Epistemic Cognition portion of the figure.

To elaborate this framework, we draw exemplars from two investigations of teacher learning (Bondy et al., 2007) and practice (Stoddard, 2010) of the ways that epistemic cognition may be enacted for teachers. Bondy and colleagues (2007) presented an interview-based comparative case study of three prospective teachers (i.e. Bailey, Jill, and Fiona) engaged in their first year of a five-year elementary special education preparation program. The goal of this project was to understand how participants approached learning in this program. Analysis involved explicitly linking participants' epistemological beliefs, learning processes, and instructional contexts. Stoddard (2010) offered a collective naturalistic case study of two ninth-grade US history teachers (i.e. Mrs. Johnson and Ms. Simpson) with similar epistemic stances towards history and history teaching to explore "how teachers position students to media based on [the teachers'] epistemology and goals" (p. 156). Although neither study explicitly examined the participants' epistemic cognition, information used to describe the cases allows us to make some generalizations to our epistemic framework.

### *Task and Domain*

We address task and domain together in Figure 16.1 (above the first dashed line). Task and domain are essential to specify when considering teachers' epistemic cognition, as the teacher's perception of both that will play into his or her epistemic cognition, more so than the actual nature of the task or domain.

**Task**. In contrast to much of the work on epistemic cognition with students, teachers are in the unique positions of being both learners and agents who play a role in the learning of others. In the epistemic literature related to teachers, in some instances the focus is on teachers as learners (e.g. Bondy et al., 2007; Brownlee, 2004; Fives, 2011), whereas in others the emphasis is on how teachers' epistemic beliefs and cognitions relate to aspects of teaching (Olafson & Schraw, 2010; Stoddard, 2010). Thus, in considering teachers' epistemic cognition, it is important to first specify what the focal task is: learning or teaching.

With respect to the task of teacher learning, we take a broad view such that learning to teach does not stop at the end of one's teacher preparation program. Instead, teacher learning includes formal (e.g. preservice preparation, professional development programs) and informal learning experiences (e.g. personal reading, discussions with colleagues) in which teachers engage throughout their careers as a means to remain current in their content area and pedagogy (Hoekstra, Beijaard, Brekelmans, & Korthagen, 2007; Lohman & Woolf, 2001). Our exemplar study, Bondy et al. (2007), focuses on preservice teachers in their first year of a teacher preparation program in which they are engaged in coursework related to various topics (e.g. classroom management, child development, emergent literacy, English for Speakers of Other Languages [ESOL]) as well as field experiences.

Similarly, the task of teaching includes more than those instances teachers are in front of a classroom. For instance, teaching minimally involves (a) planning to teach, (b) instruction, (c) assessment of student learning, (d) classroom organization and management, (e) developing relationships with and among students and parents, and (f) attending to students' socioemotional and physical needs in the context of classroom life. In addition, teaching involves professional collaborations and reflection on practice (e.g. Feiman-Nemser, 2001). These tasks are illustrated in our second exemplar, Stoddard's (2010) collective case study where the teachers engaged in planning and implementing history lessons using varied forms of media (e.g. primary sources, documentaries, historical fiction films).

Inherent differences between learning and teaching necessitate distinguishing between the two. As learners, teachers are primarily focused on themselves with respect to what they understand and how the learning experience connects to their prior knowledge and, perhaps, their imagined futures. For instance, Jill, a preservice teacher in Bondy et al.'s (2007) study, seemed to make connections from course content and field experiences to her own personal learning of history, but did not connect the theory in the course content to either her current fieldwork or future experience.

In contrast, in teaching, the focus shifts to the learning of others. Thus, teaching should be for a specific purpose, be situated in a specific context, and consider the needs of the learners. For instance, in Stoddard's (2010) investigation, Ms. Simpson's evaluation of a documentary for use in her class reflected her consideration of the content portrayed in relation to the required curriculum, her instructional goals, the needs of her students, and the logistics of classroom organization (i.e. what can be accomplished during one class period). Although the overall epistemic cognition framework we propose can be applied to both learning and teaching, there are nuances within each component that need to be recognized and considered. Thus, in examining teachers' epistemic cognition, one must first name what the primary task is: learning or teaching. We recognize that learning and teaching are reciprocally related (i.e. a teacher's learning influences what and how he or she teaches; similarly, the act of teaching may contribute to a teacher's learning). However, for this chapter, we focus on learning and teaching separately.

**Domain**. In addition to the task, the knowledge that will be focused on as part of that task should be specified. In the teacher education literature, frameworks for and aspects of teacher knowledge have been articulated (e.g. Grossman, 1990; Shulman, 1987). In our own work, we queried teachers as to what *they* considered to be the knowledge needed for teaching and identified themes related to five types of knowledge: (1) pedagogical knowledge; (2) knowledge of children; (3) subject-matter knowledge; (4) management and organizational knowledge, and (5) knowledge of self and other (Fives & Buehl, 2008, 2010; Figure 16.1). The types of knowledge we identified in our teachers' responses aligned with many of the more theoretical or review based discussions (e.g. Grossman, 1990; Shulman, 1987). In the current framework, we have added a sixth area of domain knowledge, *context*, which is salient for learning and teaching. The ability to recognize, understand, and respond to the social, cultural, and physical context in which learning takes place is essential to learning and teaching. The relevance of context as a domain of teacher knowledge has been identified in theoretical (Shulman, 1987) and empirical work (e.g. Gholami & Husu, 2010).

The domains of teacher knowledge indicated in Figure 16.1 are by no means an exhaustive list, nor does Figure 16.1 fully illuminate the embedded and sometimes integrated topics and systems of knowledge that comprise the knowledge base for teaching. For instance, subject-matter knowledge includes knowledge of all possible content areas a teacher may teach (e.g. mathematics, science, social studies) and their related topics (e.g. addition, water cycles, battles of the American Revolution), whereas pedagogical knowledge includes the array of instructional practices and strategies that exist (e.g. cooperative learning, activation of prior knowledge), their specific instantiations (e.g. jigsaw, K-W-L charts) as well as an integration of how to teach specific subject-matter topics (i.e. pedagogical content knowledge; Shulman, 1987). This idea is echoed in the teacher education literature by Cochran-Smith and Lytle (1999) who stated, "teachers do not use knowledge one domain at a time but rather meld knowledge from many domains as they make judgments and reason about what to do in a particular context" (p. 257). Our purpose here is to map the key terrains of teachers' knowledge, and draw attention to the need to be specific about what knowledge is under consideration.

## EPISTEMIC AIMS AND COGNITION

Epistemic cognition is a process individuals engage in as they acquire and use knowledge (e.g. Greene et al., 2008). To engage in this process, individuals may access various beliefs about the nature of that knowledge. Thus, it is important to consider the epistemic belief dimensions that have been discussed in the literature as these serve as key scaffolds and methods for epistemic cognition. However, engagement in epistemic cognition is predicated on individuals having an epistemic aim. Moreover, teachers' epistemic cognition is likely influenced by a variety of additional factors (e.g. prior knowledge, epistemic vices and virtues, experience). We depict these components of our framework in the center portion of Figure 16.1 (i.e. between the two dotted lines). We begin with a discussion of the role of epistemic aims, then describe the processes and dimensions of epistemic cognition, and conclude by addressing the other influences on epistemic cognition.

### *Epistemic Aims*

Epistemic aims, defined as "goals related to finding things out, understanding them, and forming beliefs" (Chinn et al., 2011, p. 146) were identified as an important component in understanding epistemic cognition. Chinn and colleagues (2011, 2014) noted two reasons that such aims need to be considered. First, goals and aims determine individuals' cognitions and behavior. For individuals' to engage in epistemic cognition, they must first possess an epistemic aim (i.e. goal for knowledge, understanding, and or true belief). We differentiate between knowledge as discrete facts and pieces of information; understanding as conceptual meaning, connections, and cause and effect relations; and justified true belief as the reasoned evaluation of warrants and acceptance of them as evidence for truth, accuracy, or believability. Possessing an epistemic aim is important as individuals may adopt a myriad of goals that are unrelated to epistemic matters. Second, Chinn et al. (2011) indicated that knowing individuals' epistemic aims can help improve the explanatory and predictive power of epistemic cognition models. That is, individuals may hold similar epistemic beliefs, but behave quite differently based on their epistemic aims. Taking epistemic aims into consideration allows researchers and educators to better predict how individuals may engage in epistemic cognition in a particular context.

We see specific implications for epistemic aims in teachers' epistemic cognition. First, for teachers, epistemic aims can relate to either the task of learning to teach or to the task of teaching. In learning to teach, epistemic aims pertain to individual teachers' goals to acquire knowledge, understanding, and true belief related to teaching (Figure 16.1). For instance, in Bondy et al.'s study (2007), Bailey entered her teacher education program with the goal of acquiring practical tools and understandings that would enable her to be a successful teacher, whereas Jill entered the same program wanting to learn specific strategies to achieve her view of successful teaching. We characterize Bailey's epistemic aims as focused on gaining both knowledge of practical tools as well as a deeper understanding of teaching, whereas Jill's epistemic aim was for knowledge of specific strategies she perceived to be useful for teaching.

In the context of teaching, we expand upon Chinn et al.'s (2011, 2014) definition of epistemic aims to include goals related to assisting or scaffolding others (i.e. students) in acquiring knowledge, understanding, and true belief. In Figure 16.1, we have also included "self" under the task of teaching, but in lowercase letters, in recognition that, in teaching, a teacher may also be figuring things out and forming his or her own beliefs through that act of teaching, but the primary emphasis is on the students. In Stoddard's (2010) study, both teachers had goals related to helping students connect past and current events and issues with their personal experience, promoting active citizenship, and engaging "students in interpreting historical documents and images in order to understand different perspectives from the past, understand how the past affects their lives and drives their decisions today, and develop skills in critically reading texts and writing" (p. 158). Thus, they held epistemic aims for their students that reflected their beliefs about the domain of history and the process of historical thinking. These epistemic aims then guided the materials and activities they chose to use with their students. Given the focus of the study, there was no mention of the teachers' personal goals for themselves as learners.

Second, the inclusion of epistemic aims in our framework highlights that for teachers to engage in epistemic cognition, they must have an epistemic aim, for either themselves or their students. In both learning and teaching, teachers may adopt goals that are not epistemically oriented. For instance, Bondy et al. (2007) noted that Jill often "dismissed ideas that were outside of her views of teaching and what she should be learning in the program" (p. 74). Presumably, Jill's goal was to do what was necessary to pass the respective class, but she was not focused on acquiring the understanding or true belief of how the content related to her teaching. Thus, individuals can have goals that are not epistemic aims and, consequently, there is no need for them to engage in epistemic cognition. In contrast, Bailey demonstrated a willingness to "master content even when the practical utility was not immediately apparent" (Bondy et al., 2007, p. 72). Similarly, Mrs. Johnson and Ms. Simpson (Stoddard, 2010) reported using fiction films as a way to both engage students (i.e. non-epistemic aim) and assist them in forming alternative perspectives and applying conceptual understandings of history issues (i.e. epistemic aims).

Third, in addition to determining whether a teacher engages in epistemic cognition, the specific epistemic aim a teacher has in a given situation may influence how he or she engages in epistemic cognition. That is, aims for knowledge, understanding, and true belief may lead to different focus and depths of epistemic cognition. For instance, potential consequences of different epistemic aims in preservice teachers are observed in Bondy et al.'s (2007) study when Bailey (i.e. epistemic aim to acquire knowledge and understanding needed for successful teaching) actively attempted to make connections between knowledge learned in courses across semesters, whereas Jill (i.e. epistemic aim for knowledge of strategies she perceived as useful) rarely mentioned such connections, focused on learning specific teaching techniques, and disregarded courses that did not address those techniques she viewed as valuable. In terms of practicing teachers, Mrs. Johnson and Ms. Simpson (Stoddard, 2010) used some documentary films to provide students with common background knowledge, whereas other documentary films were used to "raise larger historical issues, to provide a counter perspective to traditional historical narratives, or provide evidence for inquiry or discussion of controversial historical events" (p. 161). Given the differences in these epistemic aims, Mrs. Johnson and Ms. Simpson were likely to engage in epistemic cognition less when films were meant solely to provide background knowledge or increase engagement, and more so when they wanted to offer alternative viewpoints and encourage students' deeper reasoning about historical events.

### *Processes of Epistemic Cognition*

Epistemic cognition in the context of learning and teaching involves individuals contemplating and evaluating knowledge with respect to specific epistemic matters (Chinn et al., 2011, 2014) as they "consider the criteria, limits, and certainty of knowing (Kitchener, 1983)" (Maggioni, VanSledright, & Alexander, 2009, p. 188). Although early models took a more developmental approach and described specific epistemic positions (e.g. realist, absolutist, multiplist, evaluativist; Kuhn & Weinstock, 2002), other programs of research have proposed that individuals possess beliefs about knowledge that exist within a multidimensional system (e.g. Hofer & Pintrich, 1997) and explored how these beliefs related to specific learning outcomes. In their discussion of epistemic cognition, Greene et al. (2008) discussed how these differences can be reconciled and articulated how various epistemic positions (e.g. realist, dogmatist, skeptic, and rationalist) relate to specific belief dimensions (e.g. simple/certain knowledge, justification of knowledge by authority, personal justification of knowledge).

In this chapter, we discuss some of the dimensions that have commonly been identified and discussed, clustered around the areas of beliefs about the nature of knowing and beliefs about the nature of knowledge (Hofer & Bendixen, 2012; Hofer & Pintrich, 1997), recognizing there is some inconsistency in the specific dimensions of beliefs that have been empirically identified (e.g. Buehl, 2008), and discussion as to whether some beliefs dimensions are epistemic or ontological (Greene et al., 2008; Olafson & Schraw, 2010). We are also informed by Chinn et al. (2011) who argued for the inclusion of considering the reliability of the processes used to achieve epistemic aims. That is, as a component of epistemic cognition the individual must also consider the reliability of the process used to construct or come to a knowledge claim. We agree that a consideration of how knowledge claims are generated is an essential element in making determinations about that knowledge and contributes to one's overall epistemic products.

Additionally, Chinn et al. (2014) reframed their 2011 model of epistemic cognition to the AIR model (i.e. Aims and values, epistemic Ideals, and Reliable process for achieving epistemic ends). In this new version, beliefs about justification and structure are collapsed into "epistemic ideals" used to judge knowledge claims, and beliefs about the source of knowledge and individuals epistemic vices and virtues are included as part of "reliable processes" that lead to epistemic aims. However, for the framework we present, although we include the same components, we do not follow the AIR model in how we see these components interacting in teachers' epistemic cognition. As we describe in the next sections, we view epistemic cognition as an active consideration and evaluation of all of these aspects: sources, justification, certainty, and structure as well as the addition of reliable processes, whereas we position the constructs of epistemic vices and virtues as influences on this process.

**Nature of knowing: Source and justification**. The *source of knowledge* is one dimension of individuals' beliefs about knowing with a long history in the epistemic literature (e.g. Braasch, Bråten, Strømsø, Anmarkrud, & Ferguson, 2013; Hofer, 2000; Perry, 1970; Schommer, 1990) that pertains to individuals' conceptions of where a knowledge originates. Source can also be viewed as a precursor to the dimension of beliefs about the *justification for knowing* or the mechanisms and standards individuals use in evaluating a particular claim (i.e. how individuals evaluate the use of evidence to determine if a claim can be considered true; Ferguson, Bråten, & Strømsø, 2012; Greene & Yu, 2014). Within the epistemic belief literature, researchers tend to focus on the sources of knowledge in relation to one's personal experience and to an external authority (e.g. Schommer, 1990). Similarly, for justification, researchers have typically focused on the personal justification of knowledge and justification by an authority (e.g. Hofer, 2000, 2004; Muis et al., 2006).

Recently, Greene et al. (2008) called for a model of epistemic cognition that focused primarily on the justification of knowledge (i.e. justification by authority, personal justification), whereas Chinn and colleagues (2011, 2014) have pressed for taking a broader perspective on epistemic cognition informed by perspectives from philosophy. Specifically, Chinn et al. (2011) discussed the need for consideration of multiple sources (e.g. perception, introspection, memory, reasoning, and the testimony of others) and justificatory standards (e.g. amount of data explained, coherence of explanation with existing knowledge and beliefs), analysis of both source and justification at a finer-level grain size, and recognition of the interactions among sources and the role of context when evaluations of knowledge are made. This broader approach entails probing individuals as to the multiple sources of knowledge and rules of inquiry used to justify one's knowledge, considering how sources interact and individuals use multiple standards to justify what they know in specific contexts, and acknowledging that reliance on the testimony of others (e.g. authority figures) may not represent a naive perspective as was originally portrayed in the early epistemic literature (e.g. Hofer, 2000; Perry, 1970; Schommer, 1990).

We concur that a broader approach is needed, particularly in relation to teaching as teachers are constantly considering the context and weighing numerous factors as they make instructional decisions. In our own work, we asked teachers about the source of their teaching knowledge and identified six themes related to the source of teaching knowledge: (1) formal preparation, (2) formalized bodies of knowledge, (3) observational and vicarious experience, (4) interactive and collaborative experiences, (5) enactive experiences, and (6) self-reflection (Buehl & Fives, 2009; Fives & Buehl, 2010). These identified themes reflect a greater diversity of sources than is typically assessed by measures in the educational psychology epistemic literature, and roughly align with the sources of knowledge discussed by Chinn et al. (2011, 2014).

It is not hard to conceive how these multiple sources may interact and or how multiple justificatory standards may be used. Mrs. Johnson's and Ms. Simpson's decision to include specific primary sources and films in their teaching of history in order to achieve specific epistemic aims (Stoddard, 2010) was likely informed by their evaluation of the source of the materials as well as the sources that promoted the use of such practices in teaching high school history. Additionally, they likely used multiple justificatory standards in their decision making including their prior professional development on the teaching of history with historical texts (i.e. formal preparation), their own knowledge of history from their undergraduate degrees (i.e. formalized bodies of knowledge) to judge the coherence and accuracy of the information, and their prior teaching experience (i.e. enactive experience). Further, some individuals may take an uncritical approach and accept the testimony of others, whereas others may consider the specific methods experts used to offer that testimony.

**Nature of knowledge: Certainty/stability and simplicity/structure**. With respect to beliefs about the nature of knowledge, beliefs about the *certainty or stability of knowledge* and *simplicity or structure of knowledge* are typically discussed. Empirically, researchers have often found that these dimensions are not distinct from one another (Hofer, 2000) and some have noted that they are more ontological than epistemic in nature (Greene et al., 2008). However, they both have a history within the philosophical and psychological epistemic literatures and are addressed separately here.

Beliefs about the certainty or stability of knowledge can be interpreted and presented in different ways. For instance, the focus can be on the extent to which one believes that knowledge is either absolute and finite, or tentative and continuing to evolve (e.g. Greene & Yu, 2014; Hofer & Pintrich, 1997; Schommer, 1990). Alternatively, Chinn et al. (2011) discussed the certainty of knowledge in terms of how well supported a knowledge claim is and referred to this as epistemic stance. Specifically, individuals may take a particular attitude toward an idea in terms of "believing it, doubting it, tentatively endorsing it, holding it as absolutely certain, or entertaining it as a possibility" (p. 142). In our framework (Figure 16.1), we include such positions as part of the outcome of epistemic cognition. When we queried teachers about the stability of teaching knowledge, we identified themes related to changes in knowledge with respect to the amount, direction (i.e. increase or decrease), quality of change, the topics that are changeable, and the reasons for changes in knowledge (Buehl & Fives, 2009). This offers additional support for the finer-grained analysis of epistemic cognition that has been called for by others (e.g. Chinn et al., 2011; Greene & Yu, 2014).

Beliefs about the structure of knowledge are typically discussed in terms of a continuum of believing that knowledge is simple (i.e. isolated and discrete) to believing that knowledge is complex (i.e. highly integrated and interconnected; Buehl, Alexander, & Murphy, 2002; Hofer & Pintrich, 1997). In their discussion of the structure of knowledge, Chinn et al. (2011) noted that structure of knowledge is actually multidimensional, with simplicity versus complexity being just one of these dimensions, and that a more specific structural forms should be considered. For instance, other possible structure dimensions include the universality versus the particularity of knowledge and the extent to which knowledge is deterministic or stochastic (i.e. predictable versus random or probabilistic). Specific structural forms include scientific mechanisms and causal structures. Thus, as with the other dimensions of epistemic cognition, more nuanced considerations and a finer grain size may be beneficial in future work.

Consideration of structure-related issues was clearly demonstrated by Bailey in Bondy et al.'s (2007) study. Specifically, as a learner, Bailey was characterized as continually working to connect what she was learning in her courses, both within and across semesters, with field experiences, and she also "re-examin[ed] the utility and significance of what might have seemed theoretical or impractical in a prior semester" (Bondy et al., 2007, p. 72). Thus, Bailey considered the interrelated nature of knowledge as she proceeded through her teacher preparation program. In contrast, Jill rarely sought to make connections between her coursework and field experiences, and tended to view what she learned in her coursework more in terms of specific assignments than an integrated body of knowledge.

**Reliability of processes for constructing knowledge claims**. Chinn and colleagues (2011), drawing from the philosophical theory of reliabilism, argued that epistemic cognition should include the evaluation of the *causal processes* used to achieve epistemic aims as reliable or unreliable. From this perspective, a belief or knowledge claim is justified if it is based on a reliable process of knowledge generation. Such reliable processes may vary by domain, for instance, in medicine an experimental design is needed to establish causality, whereas in studies of film or popular culture a cogent argument with examples from *Buffy the Vampire Slayer* may provide sound evidence to warrant a knowledge claim. Beliefs about four categories of knowledge formation are relevant for epistemic cognition: "cognitive processes, formal processes for conducting inquiry, interpersonal processes, and community processes" (Chinn et al., 2011, p. 161). The degree to which a learner or teacher considers the knowledge formation process of any new information to be reliable either for him/herself personally or as a means of generating information in the field at large will inform judgments as to the soundness and viability of the knowledge formed.

For instance, practicing teachers may be less trusting in a new strategy that is informed by "the research base" than they are by the same strategy when they observe and discuss it with colleagues in a professional learning community. Jill, in Bondy et al. (2007), clearly expressed a view that field experiences were the best way for her to learn about teaching. Thus, if her learning was not contextualized within classroom practice, she likely did not view the methods of learning (e.g. class discussion, lectures by instructors) as reliable means for developing her knowledge of teaching. In contrast, Bailey actively examined both the content and process of the curriculum she received in her program of study and evaluated more favorably the learning experiences that actively integrated theory and practice.

When considering the processes for knowledge construction and their reliability, it is important to determine whether the focus is on the construction of an individual's "k"nowledge or construction of socially shared "K"nowledge for a field of study. In the previous examples of Jill and Bailey, we highlight how they evaluated the process by which they were personally constructing knowledge (i.e. "k"nowledge). In contrast, Mrs. Johnson and Ms. Simpson are criticized by Stoddard (2010) for ignoring the "K"nowledge of historical thinking when evaluating and using textbooks, documentary films, and fiction films, in their classrooms. There seems to be a potential disconnect here, in that for the work of designing instruction for their students these teachers may have been focusing on the individual "k"nowledge construction for their students as opposed to ensuring that the "K"nowledge of historians was constantly evoked.

### *Influences on Epistemic Cognition*

Our framework indicates that epistemic cognition may be initiated by the identification of epistemic aims but that this process is also tempered by influences within the individual. Here, we highlight what we see as the most relevant of these influences, but acknowledge that others may exist. These influences include the individual's prior knowledge (domain and strategic), existing epistemic stances, epistemic vices and virtues, and experience of practice.

When evaluating the nature of knowledge through the processes of epistemic cognition, individuals' existing knowledge and beliefs (stances) are engaged. As new information is examined, individuals rely on their prior knowledge and existing beliefs about that information to evaluate its underlying epistemic dimensions (Bråten, Strømsø, & Samuelstuen, 2008). Thus, knowledge of the topic as well as knowledge of strategies to examine the epistemic nature of that information (Braasch et al., 2013), and the epistemic beliefs or stances developed through prior experience (Olafson & Schraw, 2010) are relevant to this process. For instance, Bailey's existing belief that knowledge is uncertain and integrated influenced how she engaged with the content of her preparation program such that she actively sought to make connections across courses, field experiences, and concepts (Bondy et al., 2007). The teachers in Stoddard's (2010) study illustrate how existing knowledge of students and context influence the epistemic cognition they engaged in when developing and implementing their instructional plans.

Chinn and colleagues (2011) sought to extend current models of epistemic cognition to include the influences of epistemic vices and virtues. Drawing from virtue epistemology (e.g. Zagzebski, 2009) and research in epistemic dispositions (e.g. Sinatra & Kardash, 2004; Stanovich, 1999), they argued that individuals possess context-dependent epistemic virtues and vices that can aid or hinder the achievement of epistemic aims. These virtues are described as "a learned, stable disposition that is (a) directed at epistemic aims … and (b) relatively efficacious in achieving these aims" (Chinn et al., 2011, p. 156). An epistemic vice, in contrast, inhibits the achievement of epistemic aims. Reviewing literature from other scholars, Chinn et al. (2011) offered a variety of potential epistemic virtues (e.g. open-mindedness, perseverance, sincerity, accuracy, intellectual courage) and vices (close-mindedness, dogmatism, wishful thinking, obtuseness, conformity) that can be intentionally learned and developed in teachers and students. However, dispositions in and of themselves are neither a vice nor a virtue but must be evaluated in the context of their use (Chinn et al., 2011).

In the context of learning to teach, Bailey and Jill seemed to be guided by the epistemic virtue of open-mindedness and vice of closed-mindedness, respectively (Bondy et al., 2007). The authors claimed that "Bailey had an analytic approach to learning that enabled her to be open to the potential learning within each course" (Bondy et al., 2007, p. 72). In contrast, Jill was described as having already determined what good teaching and discipline should look like, and consequently, ignored instances when her classroom observations conflicted with her coursework. Because Jill saw knowledge as discrete and isolated she could put the information into two buckets, coursework and real teaching: the former was taught at the university and could be ignored as the latter, gained from real classrooms that aligned with her existing beliefs, was to be emulated.

Teachers serve as models for students, and in doing so relay perspectives, beliefs, and modes of practice for engaging in academic content. Teachers' epistemic virtues and vices may be conveyed to their students through a variety of explicit and implicit paths that contribute to the epistemic climate of the classroom. Explicitly, teachers model for students how to ask and respond to questions about the nature of content; they provide or limit opportunities for students to question the text or other sources of content; and they support, or limit, students' intellectual courage. For instance, how a teacher responds to a student who has completed a problem using an alternative method conveys to the student and the class the extent to which intellectual courage is supported in the classroom. Implicitly, teachers make a myriad of decisions "behind the scenes" that students may never get to see. For instance, Mrs. Johnson and Ms. Simpson (Stoddard, 2010) make intentional decisions about perspectives on content to incorporate into their instruction, the topics and materials they will use to engage students in historical thinking, and the use of materials merely as "vats of information to be consumed without question" (p. 161) in order to quickly relay content and meet curriculum standards. Students are not aware of such decisions but they likely will influence how and when students engage in historical thinking, as well as their views of knowledge in the domain of history.

Teachers' experiences of/in practice may also be a particularly meaningful influence on epistemic cognition, especially when multiple domains and topics of knowledge are under consideration. During preservice preparation, future teachers are exposed to a large array of content (e.g. pedagogical and subject matter) but have a limited schema to house that information and few strategies for evaluating it within the context of actual classroom practice. In contrast, when practicing teachers are presented with learning opportunities, the integration of content to schema may be far richer due to a larger schema for teaching or it may be limited by their current perceptions of context. Similarly, experience in the classroom may lead teachers to limit their epistemic cognition in favor of less cumbersome cognitive practices. This limiting of epistemic cognition is evidenced when Mrs. Johnson and Ms. Simpson do not engage students in historical thinking with textbooks, documentaries, and fiction films in the same way they do with primary source materials. Although Stoddard (2010) is critical of them for this, we view this as a consequence of their prior teaching experience and understanding of contextual demands.

## EPISTEMIC PRODUCTS (STANCE/PRAXIS)

When individuals strive to meet epistemic aims, epistemic cognition results in epistemic outcomes (Chinn et al., 2011). Thus, if the aims are to develop understanding, knowledge, and/or true belief, then epistemic products take some form of these goals. With respect to learning and teaching, we suggest that the epistemic outcomes can be described as developing an *epistemic stance* in the case of learning and *epistemically informed praxis* in the case of teaching.

### *Epistemic Stance*

Chinn et al. (2011) use the term epistemic stance to refer to "the attitudes that people take with respect to an idea, such as believing it, doubting it, tentatively endorsing it, holding it as absolutely certain, or entertaining it as a possibility" (p. 142). In this application, the notion of stance refers to a specific idea, concept, or piece of information. Others have conceptualized epistemic stance as a broader set of beliefs or developmental states that individuals hold toward knowledge in general (e.g. Kuhn, Cheney, & Weinstock, 2000), or within a specific domain of knowledge (e.g. history: Maggioni et al., 2009). In teacher education, Cochran-Smith and Lytle (1999) forwarded the construct "inquiry as stance" to "describe the positions teachers and others who work together in inquiry communities take toward knowledge and its relationships to practice" (p. 288). Inquiry as stance forwards a specific epistemic and practice-oriented perspective on learning and teaching that we see as one of many possible epistemic stances teachers may construct through learning and teaching experiences.

In the framework presented here, we align more closely with Chinn et al. (2011) and conceptualize the products of epistemic cognition as stances constructed in relation to specific ideas, concepts, and information. We extend the notion of stance, however, to include the constructed meaning about the idea, concept, or information as situated within the knower's cognitive schema. That is, we consider the epistemic product of learning to reflect the epistemic aim (i.e. knowledge, understanding, and justified true belief) of the idea/concept learned about as well as the perspective one holds about the nature of that knowledge. For instance, by engaging in epistemic cognition throughout her teacher education program, Bailey (Bondy et al., 2007) gained an understanding of how and why to use morning meetings in her future classroom and further developed her belief in the complexity and interconnectedness of teaching knowledge.

As epistemic products, stances are used in future tasks to facilitate thinking, learning, and teaching. Epistemic stances, once constructed, can ease teachers' cognitive loads and allow them to manipulate and consider the multiple domains of knowledge that are relevant to the learning or teaching task before them. Therefore, the development of sound epistemic stances related to domain knowledge is essential, as teachers may rely on these in their daily practice of creating foundational epistemic climates for learners, and may implicitly or explicitly share their epistemic stances with students in their words and actions.

### *Epistemically Informed Praxis*

In Figure 16.1, we indicate that epistemically informed praxis is the epistemic product for teaching-related tasks. Scholars in educational philosophy have debated and discussed the conception of educational *praxis* (e.g. Kemmis, 2012; Lima, 2013). These authors typically draw from philosophical sources to establish a definition of praxis and apply it to the field of education holistically. For instance, Kemmis (2012) derived the following by combining the perspectives of Aristotle and Marx: "'[e]ducational praxis,' therefore, may be understood in two ways: first, as educational action that is morally-committed and informed by traditions in a field ('right conduct'), and second, as 'history-making educational action'" (p. 894). Alternatively, Lima (2013) presented praxis as "the reassertion of human action for a more human world at the individual and social levels, where the simultaneous changing of circumstances and self-change occur through self-reflection, reflective action and collective reflective action (Freire, 1970)" (p. 284). Salient in both of these conceptions of praxis is *informed action* toward a meaningful goal.

From the perspective of teacher education and teaching, Cochran-Smith and Lytle (1999) argued that their construct of *inquiry as stance* could be enacted through a conceptualization of "teaching as praxis" (p. 290). Informed by the work of Freire (1970) and Britzman (1991), they argued for teaching as praxis that "involves a dialectical relationship between critical theorizing and action" (Cochran-Smith & Lytle, 1999, p. 291). In doing so, they sought to move the theory-to-practice conversation beyond the distinction of theory as too esoteric and practice as practical anti-intellectualism (Cochran-Smith & Lytle, 1999). From this perspective, praxis is conceived of as theoretically informed action that feeds into the formation of theory in an ongoing cyclical and interactive relationship.

We draw across these conceptions of praxis and narrow the scope to consider *epistemically informed praxis*. From the philosophical perspective, we recognize the importance of action toward the meaningful goal. In epistemically informed praxis, this goal is conceptualized as the quest for and achievement of epistemic aims both for and with others. We also recognize the relevance of *teaching as praxis* from teacher education, which emphasizes the ongoing interaction of theory and practice that is embodied in the lived *praxis* of teachers. Therefore, in our view, epistemically informed praxis in teaching is the enactment of instructional decisions informed by the process of epistemic cognition engaged in to assist others in achieving specific epistemic aims (i.e. knowledge, understanding, and justified true belief). In such praxis, teachers' selection of instructional activities and assessments are guided by considerations of the knowledge to be constructed by their learners, their understanding of the context and students, as well as their conceptualizations of pedagogical practices. Such praxis is clearly evidenced by Mrs. Johnson's and Ms. Simpson's selection and use of primary source documents to facilitate their students' active epistemic cognition as historical thinkers (Stoddard, 2010).

## CONCLUSIONS AND CONSIDERATIONS

In this chapter, we build on existing frameworks and research in epistemic cognition to extend that work to teachers as both learners and practitioners. The complexity and relevance of epistemic cognition for teachers is of paramount importance. The framework we offer illuminates the integrated components of epistemic cognition that require consideration and further development. Below we offer considerations for that future development.

As we continue to extend this framework to teachers, it is apparent that learning to teach requires a multi-domain approach that is revealed in teaching practice.

Our framework suggests that with respect to learning, teachers (i.e. preservice and practicing) can narrow their focus to one domain and topic. However, in the examples of Bailey and Jill learning to teach, it was evident that these preservice teachers were consistently faced with a multi-domain endeavor (Bondy et al., 2007). Even if the topic under study is relatively narrow (e.g. a professional development workshop or course lecture on cooperative learning) this information, for teachers, is typically considered in relation to other knowledge domains and topics (e.g. subject matter, child development, classroom management). Thus, as teacher learning experiences are developed the degree of integrated domain learning must also be considered.

Our framework emphasizes the importance of epistemic aims and the influences on epistemic cognition (e.g. prior knowledge, existing epistemic stances, epistemic vices and virtues, experience of practice) as primary drivers of the processes of epistemic cognition. What is missing from this framework is the role of the message learners or teachers are receiving or hope to send. Bailey and Jill both indicated that when their coursework emphasized practical applications of theory that connected to their lived experiences, they were more likely to engage in epistemic cognition (Bondy et al., 2007). Similarly, Stoddard (2010) argued that teachers Mrs. Johnson and Ms. Simpson failed to engage their epistemic beliefs when the "message" was in the form of a textbook, documentary, or fiction film. Thus, in addition to the components outlined in our framework, the nature of the message received may also influence the extent to which epistemic cognition is evoked.

If, as the existence of this Handbook suggests, epistemic cognition is the appropriate frame for understanding thinking about knowledge, more targeted research is needed to better understand, name, and explain this phenomenon in the actual practice of teaching and learning to teach. In particular, fine-grained descriptive studies, freed from the shackles of program evaluations and using informed conceptual frameworks and sophisticated qualitative methodologies (e.g. think-aloud protocols, extended observations, experience sampling methods) that collect multiple forms of data (e.g. self-report, field notes, reflections on practice), are needed to establish the viability of this work as a generative area of research when applied to teacher learning and practice.

Further, in conducting such research, researchers need to consider the context in which learning and teaching is occurring and recognize teachers may be making more informed decisions than it may appear at first blush to an outsider. For instance, Stoddard (2010) argued that "Johnson's and Simpson's pedagogy differed with regard to the four historical media in use and appears to be reflective of their personal beliefs about how the media represent the past, even if their choices seem incongruous with their overall beliefs about history" (p. 164). We disagree with his conclusion or at least strongly recommend that it be tempered. A close examination of the data Stoddard offered suggests that the differences in media use may have more to do with the epistemic aims the teachers had for their learners relative to each media source than their reasoned beliefs about the historical nature of each kind of media.

Stoddard (2010) also stated that "[h]istorians don't reserve their skills in analyzing and interpreting evidence only for primary sources…" (p. 166) and argued that students must learn to be like historians and apply these skills to all forms of media. Although historical thinking may certainly be applied to all forms of media, we argue that historians also do not have to concern themselves with designing diversified instruction for adolescents who range in ability, experience, and motivation, as a means to meet curriculum standards determined by a school board or state, while also insuring that students are safe, engaged, and developing social skills needed for society. Thus, before passing judgment on the teachers implementing practices that are not aligned with their beliefs about specific content, it is essential to consider their overall goals (i.e. both epistemic and non-epistemic aims) and the contextual demands that they face. If the goal is to promote more epistemically honest thinking in students, more attention is needed on how teachers can promote this in typical classrooms. In doing so, researchers should also consider their own perspectives and epistemic aims, recognize the limits of their viewpoints, and use their knowledge of epistemic cognition to share this information in a way that that will reach teachers and have a positive impact on the practice of learning to teach and teaching in the end.

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# 17

# INTERACTING EPISTEMIC SYSTEMS WITHIN AND BEYOND THE CLASSROOM

*Jeffrey A. Greene*



My first exposure to Perry's (1968) work hit me like a lightning bolt. At the time, while I was not so naïve as to think that students' personal epistemology was the sole determinant of their success in education, the model did align with my experience that some students just seemed more critical, with more sophisticated understandings of concepts, than others. I thought that if educators made personal epistemology development an explicit goal, then students would be more likely to display the kinds of argumentation (Iordanou, Kendeou, & Beker, 2016/this volume) and logical reasoning (Moshman & Tarricone, 2016/this volume) needed for high-level comprehension and critical-analytic thinking (Murphy & Alexander, 2016/this volume) across contexts. With time, the literature on epistemic cognition became more and more complex, with the introduction of multiple dimensions on which students could vary (Hofer & Pintrich, 1997; Schommer, 1990), domain-differences in epistemological understanding (Buehl, Alexander, & Murphy, 2002; Kuhn, Cheney, & Weinstock, 2000; Muis, Bendixen, & Haerle, 2006), useful but challenging insights from philosophical epistemology (Chinn, Buckland, & Samarapungavan; Murphy, Alexander, Greene, & Edwards, 2007), and empirical evidence of connections with other psychological phenomena (Hofer, 2016/this volume; Sinatra, Kienhues, & Hofer, 2014).

In parallel, researchers in disciplinary education were elucidating how epistemic cognition was intimately tied to the norms and practices within scholarly fields (Sandoval, 2012) such as science (Elby, Macrander, & Hammer, 2016/this volume), history (VanSledright & Magglioni, 2016/this volume), mathematics (Depaepe, De Corte, & Verschaffel, 2016/this volume), and literature (Lee, Goldman, Levine, & Magliano, 2016/this volume). Other scholars illustrated that epistemic cognition extended beyond formal learning contexts, and influenced phenomena such as the public's understanding of science (Bromme & Goldman, 2014), how jurors made legal decisions (Weinstock, 2016/this volume), and how people navigated and understood resources on the Internet (Strømsø & Kammerer, 2016/this volume). While these contributions have moved the field far from Perry's original scheme, they have not diminished my enthusiasm for the potential of epistemic cognition research and application.

However, they did open my eyes to a much larger, and somewhat more daunting, problem space than I had anticipated. I realized that some of the only things in epistemic cognition research that could rightly be called "naïve" were my beliefs that people's personal epistemology could be developed fairly easily, and that such development would have commensurate effects across domains and contexts.

The chapters in this section of the Handbook push on the boundaries of this problem space, by reviewing how epistemic cognition occurs within and beyond the classroom. By doing so, they illustrate that students and learners do not engage in epistemic cognition in a vacuum, but rather leverage their thinking, or not, throughout the many contexts of their lives. In addition, these chapters highlight that when people engage in epistemic cognition, they do so within multiple spheres of social influence. A better understanding of how people engage in epistemic cognition, and a better understanding of how to help them do so more effectively, must take into account the social aspects of epistemic cognition (Chinn et al., 2011). In this chapter, I describe the field of social epistemology (Goldman, 1999) and then argue that scholarship in this area provides a useful framework for understanding issues within and across the chapters in this section of the Handbook. Just as ideas from classical philosophical epistemology have informed scholarship in epistemic cognition (e.g. epistemic aims, reliable processes; Chinn et al., 2011), so can ideas from social epistemology.

## SOCIAL EPISTEMOLOGY

Classical philosophical epistemology has been accused of being too focused on individuals and their attempts to justify knowledge qua knowledge, without sufficiently acknowledging how such attempts occur within, and are influenced by, social contexts (Goldman, 2010). For example, people do not engage in their own deliberations about the truth-value, or lack thereof, of every knowledge claim they encounter. Indeed, as Chinn et al. (2011) discussed, it is not reasonable to presume that individuals could vet every knowledge claim presented to them; rather individuals depend upon others to do that work. This division of cognitive labor (Bromme & Goldman, 2014; Kitcher, 1993) is necessary for effective epistemic cognition in both academic (e.g. relying on peer review processes) and nonacademic settings (e.g. trusting governmental agencies that regulate motor vehicle safety). Goldman (1999) used the term social epistemology to refer to the study of how individuals interact with, and are influenced by, others when engaging in the pursuit of epistemic ends (e.g. knowledge, understanding, useful models; Chinn, Rinehart, & Buckland, 2014). This acknowledgement of the social aspects of epistemology has led to increased interest in two related phenomena: testimony and epistemic systems (Goldman, 2011).

### *Testimony*

In the literature on epistemic cognition, the recognition of the importance of social aspects of knowledge and knowing has led to a move away from characterizing justifications based on authority or testimony as naïve (Chinn et al., 2011; Greene, Azevedo, & Torney-Purta, 2008). Reliance on testimony to substantiate and act upon knowledge claims is necessary regardless of an individual's age (e.g. how infants rely upon adults to build knowledge; Clement, 2016/this volume), degree of expertise (Greene, & Yu, 2014; Samarapungavan, Westby, & Bodner, 2006), or context (e.g. academic versus nonacademic; Bricker & Bell, 2016/this volume). This realization of the importance of testimony does not undermine the basic idea found in many models of epistemic cognition that unquestioning faith in "omniscient authority" (Schommer, 1990, p. 499), without vetting the reliability of the source, is unlikely to lead to desirable epistemic ends. The real question is: How do people determine whether a particular source of testimony is reliable? Such questions have been the focus of the growing literature on source evaluation (e.g. Barzilai & Esher-Alkalai, 2015; Braasch, Bråten, Strømsø, & Anmarkrud, 2014; Bråten, Bråten, Strømsø, & Anmarkrud, 2011; Porsch & Bromme, 2011; Sandoval, Sodian, Koerber, & Wong, 2014). As the chapters in this section of the Handbook illustrate, today's world presents people with the challenge of vetting and reconciling an ever-growing number of possible sources, including teachers, the Internet, and museums (Bricker & Bell, 2016/this volume; Buehl & Fives, 2016/this volume; Strømsø & Kammerer, 2016/this volume). How people think about knowledge and knowing is certainly influenced by these sources of testimony.

### *Epistemic Systems*

Scholarship on social epistemology has brought to light another important social aspect of knowledge and knowing: epistemic systems (Goldman, 2011). Individuals can cohere, either intentionally or in an emergent manner, into epistemic systems (e.g. institutions, organizations) that endorse particular epistemic norms (e.g. substantiating particular knowledge claims qua knowledge), as well as particular epistemic procedures or practices (e.g. the scientific method, meta-analysis). Epistemic systems affect the behaviors and outcomes of both their members as well as those who interact with these systems. For example, as Weinstock (2016/this volume) has shown, the American legal system is an epistemic system, with its own norms (e.g. what is meant by "reasonable doubt" during a trial) and practices (e.g. legal reasoning). These epistemic norms and practices influence how members of the epistemic system behave (e.g. legal education, judges' actions) as well as what happens to laypeople that must engage with this epistemic system (e.g. people accused of a crime, juries). Education is another epistemic system, affecting both the students who matriculate through that system as well as the educators and other adults who participate in its continued activity and evolution. Epistemic systems can be evaluated in terms of their reliability in producing desired epistemic ends, and such evaluations should inform which epistemic systems individuals heed, and which they do not (Goldman, 2011). The debate regarding whether students should use Wikipedia is, in part, a question of whether Wikipedia is a reliable epistemic system in terms of producing and disseminating "knowledge."

Another epistemic system is science, writ large. Nature of Science (NOS; Osborne, Ratcliffe, Collins, Millar, & Duschl, 2003) research derives, in part, from the belief that students would benefit from an enunciation of the epistemic norms and practices of science. For example, epistemic norms in science are not "fixed" or "certain" (Hofer & Pintrich, 1997), and illustrations of this can help students to better understand scientific phenomena and practice. While NOS has been a contentious idea, with concerns that it can lead to educators oversimplifying the diversities and controversies in science (Allchin, 2011), many scientists and science educators have worked to develop NOS-informed common standards and foci (e.g. National Research Council 2012; NGSS Lead States 2013). These standards are one example of a product from this epistemic system.

Groups of scientists can come together as an epistemic system to make decisions about various knowledge claims in the discipline, such as when the Astronomical

Union decided to reclassify Pluto as a dwarf planet, rather than a planet such as Earth or Mars. Likewise, epistemic systems, such as the American Statistical Society (2015), can produce commentary upon the reliability of particular epistemic practices, such as null hypothesis statistical testing. The publicized norms and practices of an epistemic system have consequences, even in localized educational settings; when instructors choose a textbook, teach a method, or critique a student's logic, they most often do so based upon what particular epistemic systems (e.g. scholarly groups, training programs) have claimed was "normative" or accepted within a field.

These epistemic systems, and the norms and practices that they endorse, may be intentionally developed, but they may also emerge over time. Scholarly epistemic systems, such as the learning sciences (Sawyer, 2014), are not created in a single day; rather, over time individuals cohere into groups and develop their own norms that may eventually be more or less distinct from other epistemic systems (e.g. educational psychology). Likewise, epistemic systems continue to evolve, and there may be varying amounts of consensus around particular epistemic norms or practices within those systems. Most scholarly disciplines have a core set of foundational theories or ideas, as well as epistemic practices, which are rarely questioned or tested (Thagard, 2004). Few astronomers question the heliocentric model of the solar system. On the other hand, even within fairly narrowly defined epistemic systems there are debates about the reliability of various epistemic practices, and the knowledge claims that utilize such practices. For example, within the epistemic system of latent variable statisticians, there continues to be much debate regarding the proper ways to evaluate the adequacy (i.e. knowledge status) of structural equation models (cf. Hayduk, Cummings, Boadu, Pazderka-Robinsons, & Boulianne, 2007).

Thus, epistemic systems can influence both practice and education. However, the appropriate "grain-size" for conceptualizing and analyzing epistemic systems is not always straightforward or clear. Samarapungavan et al. (2006) have shown that epistemic cognition in subdisciplines of science, such as chemistry, can be quite specific and somewhat distinct from "science" as a whole. Therefore, it can be difficult to determine what the "epistemic system" of science really is. Is science, writ large, a coherent epistemic system whose norms and practices can be outlined and taught, through initiatives such as NOS (Osborne et al., 2003) instruction? Or, is it more appropriate to characterize particular subdisciplines of science, such as chemistry, as an epistemic system given the evidence of the specific ways that research chemists engage in knowledge vetting and creation (Samarapungavan et al., 2006)?

### *Social Epistemology as a Lens for Contexts*

Therefore, social perspectives on epistemology not only highlight the necessity of testimony as a form of justification (Chinn et al., 2011), but also provide a way of thinking about testimony from both individuals and epistemic systems. Importantly, social epistemology scholarship highlights that individuals make decisions about which sources and epistemic systems they deem reliable, and then those decisions influence their own epistemic aims, practices, and ideals (Chinn et al., 2014). Such decisions are likely to be influenced by both rational and nonrational factors (e.g. motivated reasoning; Sinatra et al., 2014).

The chapters in this section illustrate an additional nuance: to be successful in school, students must not only learn the epistemic norms and practices of a particular discipline (e.g. science), but also the norms of the local context in which the student encounters those norms and practices (e.g. a classroom, a museum, or the Internet). In essence, what "counts" as knowledge in a science classroom, and how knowledge claims are justified, are the result of sometimes complex interactions between multiple epistemic systems at differing levels of granularity: the science community, the science education community, the teacher in the classroom, and fellow students. Such interactions may lead to a particular set of accepted epistemic norms and practices in one science classroom, and very different ones in another. And those epistemic norms and practices may be very different than the ones that people experience outside of school, such as in museums, in the home environment, or on the Internet (Bricker & Bell, 2016/this volume). As the chapters in this section of the Handbook show, contexts in which people engage in epistemic cognition are influenced by multiple epistemic systems. The literature on social epistemology, therefore, leads to important questions for epistemic cognition researchers: To what degree do students intentionally, or unintentionally, navigate and reconcile the expectations of these various epistemic systems, and how does epistemic cognition, particularly issues of testimony, manifest in these various contexts?

## SOCIAL EPISTEMOLOGY INTERACTIONS BETWEEN CONTEXTS

Bricker and Bell's (2016/this volume) chapter on science learning across contexts did a wonderful job of illustrating how an individual's epistemic cognition can manifest differently in lab studies, classrooms, museums, and the home. These findings certainly have implications for how, and where, research on epistemic cognition occurs. Decontextualized tasks in artificial environments seem likely to elicit different kinds of epistemic cognition than inquiry science activities, or museum visits, an idea that advocates of situated views of epistemic cognition have long argued (Sandoval, 2012). The questions raised for me are: How are students making sense of the various epistemic systems that they encounter? How do students' interpretations of these epistemic systems influence their epistemic cognition in these contexts? How do students understand and navigate situations where multiple, conflicting epistemic systems are relevant?

The social epistemology perspective affords some hypotheses about how people experience these context differences. Interactions among epistemic systems can be conceptualized in an almost Bronfenbrenner-like (1979) manner (cf. Feucht, 2010). Within a science classroom, there are at least two epistemic systems at work. Science, as an epistemic system, exists at what Bronfenbrenner called the macrosystem, or the cultural context. In addition, the classroom itself is a kind of epistemic system, perhaps largely influenced by the teacher's epistemic cognition (Buehl & Fives, 2016/this volume). The classroom epistemic system exists within a student's microsystem, or the system of direct influences upon the student's context. However, the microsystem is the result of influences from several other higher-order systems in Bronfenbrenner's theory. An example of another relevant epistemic system is the exosystem consisting of science teachers and the district or state curriculum specialists, and how they interact to determine the science content to be taught and resources to be used. Bricker and Bell (2016/this volume) illustrated how context can be physical, social, and cultural spaces, and I would argue that different epistemic systems can be salient in each of these spaces. There is a need for much more research regarding how these multiple epistemic systems, at different micro-, exo-, meso-, and macrolevels, interact to create contexts like classrooms and museums, and how people perceive, understand, and navigate the many epistemic systems at play within those contexts.

Of course, the people within these contexts also bring with them some prior knowledge about epistemic norms and practices, even if much of this knowledge is tacit (Chinn et al., 2014). Students with some knowledge of the science epistemic macrosystem likely bring that to science museums, but as Bricker and Bell illustrated, to understand and evaluate the knowledge claims they encounter, they must also determine the epistemic norms and practices at play in the museum itself. A student's source evaluation behaviors in one context may differ dramatically from those enacted in another context, even when dealing with content from the same academic discipline. In Bricker and Bell's chapter, Brenda displayed very different epistemic cognition in the science museum as compared to her science classroom, which suggests that she interpreted these contexts differently, despite the common epistemic macrosystem. Bricker and Bell's recommendation for more research involving "the same people's epistemic cognition across contexts and over time, using a variety of methods" (p. 211) could be addressed, in part, by examining how students like Brenda make sense of different microsystems (e.g. the classroom versus the museum) that share a common aspect of the macrosystem (e.g. the science epistemic system).

Bricker and Bell (2016/this volume) illustrated numerous interactions between epistemic systems in their chapter, and one of the most profound, in my opinion, was their discussion of how Western school contexts can negate Native American students' epistemic cognition, and the epistemic systems that influence these students' epistemic cognition. In these instances, there was a direct clash between two epistemic systems: the one outside of school, and the one inside. Bricker and Bell made a strong argument that one desired outcome of education should be that students develop the ability to navigate these epistemic microsystems, and maintain autonomy and a critical perspective throughout. Ideally, of course, educators would be aware of the many epistemic systems at play in a particular context, and thoughtfully develop students' ability to understand and navigate those systems. One challenge is how to do that without encouraging a kind of vulgar relativism (Rorty, 1997) in students, where all views are seen as equally plausible and warranted.

## MISALIGNED EPISTEMIC SYSTEMS

Many citizens have only a partial, and often somewhat incorrect, understanding of legal systems. As Weinstock (2016/this volume) so aptly showed, Goldman's (2011) social epistemology scholarship is informed by, and directly informs research on, the epistemic cognition of legal reasoners. The common-law legal system of the United States is an epistemic system, with its own epistemic norms and practices. In addition, this epistemic system makes assumptions about laypeople, and their ability to understand and use these epistemic norms and practices when they serve on juries. Weinstock's chapter illustrates, in a most concerning way, how laypeople's folk epistemologies may deviate significantly from that of the legal epistemic system, and how the instructions and training provided to laypeople often does not resolve this incongruence. Differences between the epistemic ideals (Chinn et al., 2014) of the legal system and the laypeople who populate its juries may lead to significant variance in legal decisions, and decrease the reliability of the legal epistemic system in terms of producing desirable epistemic ends (i.e. correct verdicts). Such problems with reliability seem particularly likely if the epistemic ideal of "beyond a reasonable doubt" means one thing to a juror, and something very different in the legal epistemic system.

I was struck by the challenges regarding testimony that were illuminated by Weinstock's chapter: common-law juries are placed in a relatively resource-poor position to engage their epistemic cognition. The majority of juries' work, in terms of epistemic cognition, consists of source evaluation of the testimonials presented to them. Such source evaluation likely depends critically on the prior knowledge of the jury members themselves, as would be suggested by the epistemic cognition literature (e.g. Bråten et al., 2011). To use a fictional example, in the movie *My Cousin Vinny*, the vast knowledge of automobiles displayed by Mona Lisa Vito (i.e. actor Marisa Tomei) made her testimony so convincing to everyone in the courtroom, including the laypeople of the jury and the prosecutor, that the charges filed against the defendants were dropped. However, how could this vast knowledge be evaluated by laypeople; what kind of source evaluation could be done in an epistemic system where people could not seek out their own data outside of the courtroom? As Goldman discussed, the United States' legal system was designed to absolve juries of the responsibility of making judgments of expertise, but the likelihood of jury members accepting an expert's specific knowledge claims likely varies depending upon those jury members' amount of prior knowledge about the topics being adjudicated.

To take another perspective on this example, what if Ms. Vito were not a witness, but rather a member of the jury? How would her vast knowledge, directly relevant to the case, have influenced the verdict, if at all? Jury members are not allowed to share their knowledge except when deliberating among themselves. Would her knowledge have been as influential if it was shared in the jury deliberation room, and possibly seen as just one perspective among other laypeople selected for this case? As Goldman (2011) has discussed, the common-law legal model may not be the most reliable epistemic system for deriving true verdicts, and it is unclear how the background knowledge and folk epistemologies of the people who interact with that system, be they the more permanent members such as lawyers or the more transient jurors, affect the achievement of desirable epistemic ends.

While much of the research on legal reasoning to this point has focused upon how differences in epistemic development (Kuhn et al., 2000) relate to legal reasoning, social epistemology, and Weinstock's chapter, suggest additional avenues for generative research and recommendations for practice. Like the students in Bricker and Bell's chapter, individuals who serve on juries are implicitly asked to navigate between the epistemic systems that have shaped their prior knowledge and epistemic cognition, and the legal epistemic system. How much more reliable would the legal epistemic system be if it made the need for such navigation explicit, and provided laypeople with the tools to engage in such navigation? Just as classical philosophical epistemology was critiqued for a lack of attention to social epistemology, so might the United States' legal epistemic system be critiqued for its dependence upon individual legal reasoners, many of whom do not understand the epistemic norms and practices of that system. There is a great need for research on how prior knowledge and competing epistemic systems clash, and what can be done to help people navigate these clashes.

## SOURCING AND THE INTERNET AS AN EPISTEMIC SYSTEM

Clearly, one of the major challenges for modern learners, and education researchers, is how to best navigate and critically integrate the growing proliferation of online resources (Bråten et al., 2011; Greene, Yu, & Copeland, 2014; Strømsø & Kammerer, 2016/this volume). As Strømsø and Kammerer stated in their chapter, online texts often lack sufficient source information, making it very difficult to evaluate them as sources of testimony. This poses a tremendous problem for students, who depend so critically upon access to, and prior knowledge about, source information to engage in effective epistemic cognition (Goldman, 2011). Physical libraries and classrooms contain curated resources; someone has vetted the resources and determined them worthy of reference. On the other hand, the Internet is populated with resources, some of which are curated (e.g. the National Science Foundation's National Science Digital Library, http://nsdl.oercommons.org) and some not. When someone posts on their website that they are an "expert" there is often little information to either substantiate or refute that claim. Many people have mistaken beliefs about source information online, such as those about the ".org" domain. While originally intended only for nonprofit groups, this distinction has been dropped, meaning that any person or organization can use the ".org" domain, as well as the ".com" and ".net" domains, among others. Yet, many Internet users continue to believe that the ".org" domain is somehow more reliable, or less biased, than other domains. This is not true, but such beliefs persist, and likely influence Internet users' source evaluations (Goldman et al., 2010).

Strømsø and Kammerer (2016/this volume) reviewed important findings indicating that belief in simple and certain knowledge negatively predicted the quality of students' Internet searching and comprehension. It is reasonable to presume that Internet users who believe that knowledge is simple and certain are unlikely to see much need for source evaluation. Such behaviors seem akin to Kuhn's (Kuhn et al., 2000) argument that absolutists see little need for examining justifications, given their naïve views of knowledge and humans' access to it. One question to consider is the degree to which students who believe in simple and certain knowledge recognize different epistemic systems, if at all.

I was most intrigued by the Strømsø and Kammerer's review of research on Internet-specific epistemic beliefs. In the parlance of social epistemology, the Internet itself can be viewed as an epistemic system, and philosophers such as Goldman (2011) and Thagard (1997) have explored this idea. The Internet affords many advantages over traditional print methods of distributing knowledge, such as journals or books. The Internet can be updated when errors are discovered, or new information sheds light on previously argued knowledge claims. Knowledge claims can be distributed more quickly online, and the recent move toward posting datasets and other supporting materials online would seemingly help experts vet knowledge claims based on such materials (Thagard, 1997). Nonetheless, is the Internet a reliable epistemic system?

The Internet is large and diverse enough that claims about its reliability, overall, are not truly possible or likely helpful. However, it seems reasonable that learners, particularly those who are relative novices in a particular domain, may evaluate the Internet as an epistemic system, in other words in terms of its reliability as a source of knowledge for that domain, or for domains with which they are unfamiliar. From this perspective, it is not clear that the Internet is superior to other epistemic systems such as edited journals or handbooks, at least in terms of achieving desired epistemic ends. One particularly interesting phenomenon is that the Internet is both an epistemic system unto itself (e.g. people make knowledge claims online) as well as a means of distributing knowledge claims made by other epistemic systems (e.g. when a newspaper posts a summary of a peer-reviewed article, the *Stanford Encyclopedia of Philosophy;* Zalta, 2015). Here again, people have to reconcile among many potential epistemic systems (e.g. the Internet, the scholarly or non-scholarly domain that they seek to learn about, and the media).

Therefore, individuals' Internet-specific epistemic beliefs may take many forms. Some individuals may have domain-general beliefs about the Internet as a reliable source of knowledge claims. Other individuals may have domain-specific beliefs about the Internet as a reliable source for knowledge claims in particular disciplines (e.g. the Internet is a reliable source for historical knowledge, but not scientific knowledge). And some individuals may have quite nuanced beliefs about the Internet as an epistemic system, either unto itself or as a means of distributing knowledge claims from other epistemic systems. These beliefs likely interact with other forms of epistemic cognition to influence how individuals navigate, critique, and integrate information from online sources. Describing how people do, or do not, engage in epistemic cognition among varied epistemic systems is a seemingly generative area of future research.

## TEACHERS AND CLASSROOMS AS EPISTEMIC SYSTEMS

Buehl and Fives (2016/this volume) have written a chapter that truly pushes the field of teacher education and practice in new directions. They have identified several intriguing areas for future research. Within the context of scholarship on teachers and teaching, they have expanded Chinn et al.'s (2014) idea of epistemic aims to include not only teachers' epistemic aims when acquiring pedagogical and pedagogical content knowledge, but also the aim of assisting or scaffolding others to acquire knowledge. In this sense, epistemic aims can include social processes (i.e. a desire to help others engage in epistemic cognition, or not), which further highlights the potential contribution of scholarship on social epistemology to the epistemic cognition literature.

Clearly, social aspects play a critical role in teachers' epistemic cognition, such as when they determine reliable sources for pedagogical content knowledge. There are likely significant effects upon teacher learning based upon whether a particular instructor, professional development provider, or peer teacher is determined to be a reliable source. It would be intriguing to investigate how teachers make these source evaluations, how those evaluations influence their pedagogy, whether these evaluations have any influence upon how teachers instruct students in the social aspects of epistemic cognition, and whether source evaluations are updated based upon additional information (e.g. if new information suggests that a source previously determined to be reliable should be reclassified as unreliable).

As I mentioned when discussing Bell and Bricker's (2016/this volume) chapter, teachers create epistemic systems in their classrooms. As Buehl and Fives showed, teachers with varying epistemic virtues, vices, or aims (e.g. knowledge, understanding, avoidance of false beliefs; Chinn et al., 2014) may either explicitly or implicitly create very different epistemic systems, or what some might call epistemic climates (Feucht, 2010; Muis & Duffy, 2013). The classroom, like the Internet, is both an epistemic system in and of itself as well as a conveyor of knowledge and norms of other epistemic systems. To earn good grades, students, either consciously or non-consciously, often have to determine a teacher's desired epistemic ends in the classroom, and which epistemic norms and practices are privileged. A student may understand that there is a diversity of scientific methods (Osborne et al., 2003) but if that student's teacher sets up an epistemic system where only experimental data is deemed reliable, then the student must reconcile these two systems to determine what kinds of products and processes are rewarded in that classroom. Failure to sensitize to these potential interactions and differences between the epistemic systems at play in a student's microsystem may lead to misaligned epistemic cognition, and poor grades (Porsch & Bromme, 2011).

Teacher training programs are also epistemic systems, and as Buehl and Fives showed, teachers can vary in their assessment of the reliability of those systems. Nonetheless, teacher training programs almost certainly influence teachers' epistemic cognition. Some teacher training programs continue to emphasize discredited ideas, such as learning styles (Pashler, McDaniel, Rohrer, & Bjork, 2009). It takes a great deal of effort for pre service teachers to construct their pedagogy to accommodate multiple learning styles. When these teachers later learn that learning styles are not an effective means of differentiation, they may experience frustration (Goswami, 2006) and begin to doubt their teacher training program as a reliable epistemic system, such as Buehl and Fives' example of Jill, who ignored knowledge claims made in formal coursework. This unfortunate situation may result in a positive outcome if such challenges lead to teachers taking a more thoughtful and active role by engaging in epistemically informed praxis (Buehl & Fives, 2016/this volume). On the other hand, such challenges may lead to negative epistemic emotions (Pekrun & Linnenbrink-Garcia, 2012) that might promote a form of nihilism or vulgar relativism, where teachers view their profession as more akin to a set of intuited dispositions rather than as a profession. Such views would be unfortunate, given current pressures to enact evidence-based pedagogies and demonstrate the professional nature of teaching (Slavin, 2008).

## CONCLUSION

The chapters in this section of the Handbook have demonstrated that the recognition that a person's epistemic cognition is intimately entwined with the social and contextual factors in which that thinking occurs (Sandoval, 2012) has positively informed the field. To put it simply, context matters, and characterizing individuals' epistemic cognition without taking into account what they were asked to think about, in what setting, with what tools, and under what conditions, is a dangerous proposition. Epistemic cognition certainly does occur within and beyond the classroom, and reconciling among multiple sources of testimony, and epistemic systems, is likely a significant yet commonplace challenge.

An integration of ideas from social epistemology (e.g. testimony, epistemic systems) into epistemic cognition scholarship will likely benefit education researchers, just as the inclusion of means of justification and epistemic aims from classical philosophical epistemology has done (Chinn et al., 2014; Murphy et al., 2007). The need for a division of cognitive labor makes it essential that individuals develop the knowledge and skills necessary to evaluate others as sources of knowledge. At the same time, epistemic cognition research would benefit from taking seriously the role of epistemic systems in determining and disseminating epistemic norms and practices. At any particular time, individuals' context is formed by multiple interactions among many epistemic systems, and differences in epistemic cognition across contexts may be better understood by investigating how people do, or do not, actively reconcile differences across these systems.

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# Section IV

## Epistemic Cognition Interventions

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# 18

# TEACHING FOR EPISTEMIC CHANGE IN ELEMENTARY CLASSROOMS

*Lisa D. Bendixen*

## INTRODUCTION

Teaching for epistemic change in elementary classrooms is a relatively new area of study. In general, children's epistemic cognition was not considered in any serious way by researchers, and certainly not how their views of knowledge and knowing could or should be shifted in the classroom, until very recently (Metz, 2004). Current work, however, has convincingly challenged this more narrow view and provided a window into the abilities, complexities, and opportunities associated with children's epistemic cognition (Hofer & Bendixen, 2012).

The following chapter will review conceptual and empirical work that has focused on children's epistemic cognition. In addition, intervention studies that have attempted to change elementary-aged students will be reviewed in detail. Finally, theoretical and educational implications that stem from these works will also be discussed.

## DEFINITION OF EPISTEMIC COGNITION AND MODELS

There are a variety of definitions that exist regarding individuals' cognition about knowledge and knowing including reflective judgment (King & Kitchener, 1994), epistemological beliefs (Schommer, 1990), epistemic resources (Hammer & Elby, 2003), personal epistemology (Hofer & Pintrich, 2002), and epistemic cognition (Greene, Torney-Purta, & Azevedo, 2010a). Even though not all of the authors reviewed in this chapter use the same terms and definitions, epistemic cognition (EC) will be used as it captures the majority of the work that will be cited and it is consistent with more recent discussion regarding definitional accuracy. According to Greene et al. (2010a), EC focuses on students' cognition and it "emphasizes knowledge and the processes involved in its definition, acquisition, and use" (p. 143; see also Kitchener, 2002).

While there are a number of models related to the development of EC, only a few will be briefly described here because of their importance in the studies that follow and their usefulness in considering epistemic change. The developmental theory of Kuhn and colleagues (e.g. Kuhn & Weinstock, 2002) highlights the developmental patterns that are central to many of the developmental theories associated with EC. In general, the pattern of EC development has been described as occurring in three distinct forms of thinking about the nature of knowledge and the process of knowing. In the first form (i.e. objective/absolutist), views about knowledge are very simple and dichotomous; truth is judged based on an objective, external reality. The relativistic nature of knowledge (i.e. subjective/multiplist) is the focus in the second form of thinking where each claim is considered equally legitimate and, therefore, cannot be judged beyond mere opinion. The third form of epistemic thinking integrates the objective and subjective nature of knowledge (i.e. evaluativism) and considers how differing viewpoints can be judged based on established criteria (Kuhn & Weinstock, 2002). It is important to note that evaluativistic views of knowledge are qualitatively distinct from the previous two forms of thought. There are a number of empirical studies that support Kuhn's forms of EC (e.g. Mason, 2003).

Consistent with the Kuhn framework, Bendixen and Rule (2004) have proposed a process model of epistemic change. The focal point of this Integrative Model (IM) is the mechanism of change and it consists of three interrelated components: (1) epistemic doubt, (2) epistemic volition, and (3) resolution strategies. Epistemic doubt is a specific form of cognitive dissonance associated with questioning one's beliefs about knowledge and knowing. Epistemic doubt can be part of the impetus for epistemic change, but change also requires epistemic volition or the individual taking "responsibility" and action in terms of their EC. Resolution strategies (i.e. reflection, discussion with others, etc.) may then be implemented to obtain epistemic change. Other important components of the model include metacognition, peer interaction, and a supportive educational environment. In general, the components of the IM are considered to be reciprocal in that the individuals' EC and their environment are constantly influencing each other. A brief intervention study with university students by Kienhues et al. (2008), designed to challenge and shift domain-specific EC through refutational epistemological instruction, provided preliminary support for the IM. The aforementioned definition and models related to EC provide support for examining epistemic change in elementary students, and that is the focus of the remainder of this chapter.

## LITERATURE REVIEW

The following research studies investigating EC in elementary-aged students will be grouped by their focus on a particular academic discipline including science, mathematics, history, and language arts. For the purposes of this chapter, an academic discipline is considered to be a specific area of study with its own unique and corresponding content and methodologies (Buehl, Alexander, & Murphy, 2002; Muis, Bendixen, & Haerle, 2006). These disciplines were chosen because they represent the majority of the content areas included in most elementary education programs.

The chapter will briefly consider pertinent conceptual frameworks related to EC within each discipline and then move on to focus on empirical work that has been done. A distinction has been made in terms of studies that have implemented an intervention design and studies that have used other means to investigate children's EC (i.e. nonintervention) such as cross-sectional and interview studies. Intervention studies are highlighted because they give particular insight into potential processes of epistemic change and the educational strategies that may support it. Finally, the broader theoretical and educational implications of this body of work will be discussed along with suggestions for future research.

### *Science*

Research investigating EC within the academic discipline of science provides several illuminating findings in regard to children's epistemic change.

**Conceptual**. There are a number of general models and conceptions of the nature of science and science education. With the current chapter's goals of reviewing EC and students' understanding of science at the elementary level, certain frameworks and studies are described that seem most pertinent including those that consider the "epistemology of inquiry" (Lehrer, Schauble, & Lucas, 2008), "scientific argumentation" (Duschl, 2008, 2012), "epistemic practices in science" (Enfield, Smith, & Grueber, 2008), and "modeling and argumentation" (Lehrer & Schauble, 2005). For example, Lehrer et al.'s (2008) framework of the epistemology and pedagogy of scientific inquiry includes selecting appropriate scientific material for "ready accessibility to initial" and sustained inquiry, and opportunities for students to "struggle with arranging material means to serve inquiry" (p. 526). Their study of sixth-grade students during a year-long ecology unit provided support for their framework and the improvements made by the participating students in terms of their EC about the nature of science.

As will be discussed more in a later section, EC and argumentation are prominent players in current considerations of science education. As Ryu and Sandoval (2012, p. 494) stated, "One of the reasons argumentation has been promoted as a crucial feature of science instruction is its potential to help students understand epistemic aspects of science" (see also Duschl, 2008; Kuhn, 1993).

**Nonintervention Studies**. As compared to other academic disciplines, elementary students' EC within the academic domain of science seems to have generated the most empirical work to date. Kittleson (2011) examined the intersection of third-grade students' EC and the instructional context of two science units. The study spanned five months and included student interviews at three time points along with videotaped lessons. The findings revealed that students saw the importance of investigation in science but did not make a distinction between their own experiments in class and what scientists do. In addition, students conveyed an understanding that certain tests are appropriate for different purposes, as in their own experiments. Kittleson (2011) stressed the importance of what scientific activities communicate about the nature of science and how they are an opportunity to elevate students' EC.

In their study of 8- to 10-year-olds, Sandoval and Cam (2011) focused on a central aspect of EC, that of justifications for causal claims. During individual interviews, children's judgments about the "epistemic status" of various justifications were elicited through a set of four story problems about two characters deciding whether or not some factor caused an effect (e.g. if cars that use gasoline with a chemical additive get better mileage than cars that use normal gasoline). Results indicated that most of the "children had a loose ordering of the epistemic status of justifications with data being preferred, plausible mechanisms appealing and preferred to ambiguous data, and appeals to authority least preferred" (Sandoval & Cam, 2011, p. 383). In general, students preferred justifications that had credibility, and this credibility centered on the firsthand nature of the data (i.e. the person in question actually collected the data themself). According to the authors, this "objectification of evidence" or "seeing data as factual rather than constructed and open to interpretation" is an opportunity for science educators to challenge these more naïve aspects of students' EC.

Conley et al. (2004) examined if and how EC in ethnically diverse fifth-grade students changed over a 9-week "hands on" science unit. In addition, the potential moderating effects of gender, socioeconomic status (SES), ethnicity, and general achievement were investigated. EC was measured using a Likert-type survey with four knowledge dimensions focused on science: (1) Source (i.e. whether or not knowledge resides externally/internally), (2) Certainty (i.e. a belief in a right answer), (3) Development (i.e. whether science is an evolving subject), and (4) Justification (i.e. the role of experiments in justifying knowledge).

Results indicated a change to more sophisticated beliefs in the dimensions of source of knowledge and certainty of knowledge but not the other dimensions of development and justification. These findings were attributed to the "hands on" nature of the science unit in which the students participated (i.e. science kits that focused on explorations and observations) in contrast to a more inquiry-based approach to science learning (i.e. focus on argumentation and reflection). EC was not related to the other variables indicating that positive changes in EC can occur regardless of students' SES, ethnicity, gender, and/or overall achievement.

In a cross-sectional study, Mason et al. (2013) compared students' EC related to science in grades 5, 8, and 11 in relation to other variables such as achievement goals, science or domain knowledge, self-concept, self-efficacy, and achievement in science. Their generated model indicated that the fifth-grade students' EC had both a direct effect on science knowledge and an indirect effect through achievement goals. More specifically, fifth graders who viewed "science knowledge as hypothetical and changing" were more likely to score high on the domain test. In addition, "beliefs about the justification of scientific knowledge" had an "indirect effect on science knowledge via performance-avoidance goals" (p. 49). In other words, "the more students believe in experimentation as knowledge validation" in science the lower their goal of avoiding the demonstration of lack of ability and the higher their knowledge in science" (Mason, Boscolo, Tornatora, & Ronconi, 2013, p. 67).

Zhai et al. (2014) explored fourth graders' views of themselves doing science and how these views compared to "real" scientists. Based on student drawings, a questionnaire, and interviews, most students viewed themselves as doing science in terms of participating in hands-on experiments, learning from the teacher, completing a workbook, and being involved in social processes related to science. According to the students, real scientists tended to work alone and do more dangerous investigations. The evidence that elementary students were capable of distinguishing between school science and "real" science was seen as an opportunity for "science as inquiry" to be stressed in classrooms, thus developing students' EC further.

Yang and Tsai (2010) have developed a body of work that examines the role of EC in informal scientific reasoning in elementary through high school students in Taiwan. Their focus has been on individuals' scientific reasoning, including argumentation, about everyday, ill-defined problems (e.g. pollution, nuclear energy). For instance, Yang et al. (2005) investigated sixth-grade students' EC and their reasoning about two everyday science-related issues with conflicting information (e.g. one issue was the feasibility of earthquake predictions). Interview results indicated that 60 percent of the students felt that experts uniformly agree about knowledge, 30 percent recognized "fuzziness" in some knowledge domains, and 8 percent mentioned that agreement could be reached through discussion. Content analyses also revealed that the differing contexts of the dilemmas affected students' EC, especially their justification of knowledge.

**Intervention Studies**. Metz (2011) examined EC in two science classrooms of first-grade students using an "educational design experiment" where she developed and simultaneously investigated an innovative method of teaching science. The aims of this approach included teaching the goals of scientific inquiry, scaffolding big ideas, deep immersion in the domain of science, and shifting the responsibility of designing scientific investigations from teacher to students. The study took place over a two-year period and centered on a botany class and an animal behavior class. Trying to mimic the social context of the practice of scientific inquiry, instruction and scaffolding took place in large and small groups, along with children working quite often in pairs to develop scientific questions and study designs. Within the context of their own scientific studies the children displayed surprisingly sophisticated EC that included the uncertainty of their results and reasonable strategies to improve their designs.

Ryu and Sandoval's (2012) study examined "whether and how a sustained instructional focus on argumentation might improve children's understanding and application of key epistemic criteria for scientific arguments" (p. 489). Using the framework of situated epistemic cognition, they viewed the learning of scientific argumentation to take place through students' participation in activities that require it. Participants were students in a combined third- and fourth-grade classroom and their veteran teacher. The emphasis of instruction was group work, guided activities, and scaffolding that focused on students' understanding the criteria of good arguments (e.g. fostering classroom debates between competing claims). Throughout the lessons the teacher often asked questions like "How do we know what we know?" and "How do we convince others?" and made statements like "Back up your claim" to get the students "to think more about and develop shared ways of engaging in scientific argumentation" (p. 498).

Findings indicated that students showed great improvement in their ability to construct their own arguments and the use of evidence as justification. Through the norms within the classroom culture that were created, these students "came to understand the epistemic demands of scientific argument" (Ryu & Sandoval, 2012, pp. 512–513). Indeed, argumentation became embedded within the everyday goings on of the classroom. Ryu and Sandoval (2012) concluded that students doing science or allowing students a grasp of "real" scientific practice requires their sustained engagement in scientific argumentation and the epistemic criteria it involves.

Along these same lines, an earlier study by Herrenkohl and Guerra (1998) explored the effects of teachers assigning specific "intellectual roles" to students in fourth-grade classrooms as part of their science lessons (e.g. making or checking predictions, and connecting findings to themes). As the students took on these roles, the more classroom discussions, for example, became focused on important epistemic aspects of the task (e.g. critiquing fit of evidence to hypotheses). These studies demonstrate the possibility and value of establishing classroom scientific communities and how EC plays an important role in that development.

### *Mathematics*

The importance of elementary students' EC related to mathematics came into focus with Schoenfeld's (1985) groundbreaking piece in which the boundaries of mathematics learning were expanded to include the influences of beliefs, social cognition, and metacognition (for a review see Muis, 2004). Lampert (1990) went on to state that a common view of mathematics entails its certainty, quick answers, the following of teacher-driven and "correct" rules, and that "an answer to a mathematical question or problem becomes true when it is approved by the authority of the teacher" (p. 31).

**Conceptual**. Cobb and colleagues' conceptualization of "socio-mathematical norms" and "argumentation" and their "reflexive" nature provides much of the grounding for research associated with EC and mathematics learning and instruction (e.g. Cobb & Yackel, 1996). More specifically, classroom social norms in general (e.g. raise your hand to answer), mathematical classroom norms (e.g. what is considered a mathematically correct answer), and mathematical practices (e.g. agreed-upon procedures by teacher and students to solve mathematical problems) play key roles in research associated with EC and mathematics (De Corte, Op't Eynde, Depaepe, & Verschaffel, 2010). Several of the following studies used Cobb's socio-constructive framework in their investigations of EC and mathematics learning and instruction.

**Nonintervention Studies**. Lopez and Allal (2007) took an in-depth look at the microcultures of two third-grade classrooms in Switzerland. The year-long observational study of mathematical lessons focused on "the transition from additive to multiplicative reasoning and the progressive mastery of multiplication procedures" (p. 255). Teachers were two experienced primary teachers. Even though the authors did not discuss EC specifically, it was an important part of the socio-mathematical norms established in the two classrooms. Interestingly, the two classrooms displayed similar norms, but there were key differences as well. In essence, students' problem-solving proposals were "validated" more by the teacher in one class and more by peers in the other class, and the latter could be considered more advanced in terms of EC. According to the authors, this study further supported the situated nature of learning and teaching, in particular classrooms, and this was quite apparent at the classroom microculture level. In addition, the results speak to how different classrooms can be in terms of particular epistemic experiences.

In their survey study of grades 4 and 5, Muis and Foy (2010) found that elementary mathematics teachers' EC was a significant predictor of students' EC and achievement. For instance, teachers' views of mathematics knowledge as complex and integrated negatively predicted students' views that knowledge is certain and simple, and these students' more advanced EC positively predicted achievement.

**Intervention Studies**. An early intervention study by Verschaffel et al. (1999) examined a newly developed learning environment, based on new standards for primary mathematics education in Belgium. Four experimental fifth-grade classes consisting of 20 lessons were taught by regular classroom teachers familiar with the new program. In general, the new program included highly interactive teaching methods, realistic, complex and open math problems, a classroom culture and community created through small- and large-group discussions, metacognitive activities that encouraged students to reflect on their problem-solving strategies, and the shifting of teacher and student roles (e.g. the class as a whole evaluating and deciding upon optimal solutions). The experimental classes were compared with eight control group classes. According to the results, the experimental classes showed significant improvement in problem-solving performance, including spontaneous use of strategies stressed in the intervention classes, and a small but positive effect on children's beliefs about mathematics.

Mason and Scrivani (2004) did a replication of sorts of the Verschaffel et al. (1999) study just described. In addition to the replication, the study took place in Italy, where they focused more on establishing socio-mathematical norms in the classroom and took a closer look at individual students' mathematics-related EC. The study included two classes of fifth-grade students participating in an innovative learning environment (i.e. experimental) and two classes of 46 students in a traditional teaching environment (i.e. control). Results revealed that the elementary students immersed in the innovative learning environment out-performed the students in the control group on all assessments of mathematical problem solving and had more positive views of themselves as learners of mathematics. Overall, these studies have provided evidence for the positive effects of a community-focused learning environment in terms of mathematics learning and EC.

In a related intervention study, McClain and Cobb (2001) investigated a first-grade classroom that was implementing a learning environment in line with the previously described framework developed by Cobb and colleagues. The study lasted one school year and data sources included student interviews and video data of lessons during the first four months of the school year. This data was used, in particular, to assess how teachers established and developed the norms of the classroom. The analyses focused on norms such as what counts as an acceptable explanation, what counts as a mathematically different solution, and what counts as a simple and efficient solution. The findings revealed not only how these socio-mathematical norms were established but also how they were renegotiated over time. Again, students showed substantial gains in mathematical learning/problem solving as well as more sophisticated beliefs about mathematical knowledge (e.g. mathematical solution strategies can be negotiated and changed).

### *History*

In general, the importance of students' cognitive reasoning within the academic domain of history, often referred to as social studies at the elementary level, has a solid foundation (Limon & Carretero, 2000; VanSledright & Limon, 2006). More specifically, students "knowing history" and "doing history" are two major approaches to teaching history (Havekes, de Vries, & Aardema, 2010; Levstik & Barton, 2011). It is has been argued that systematically combining these two approaches will help students build higher-level understandings of history (e.g. Wineburg, 2000). In addition, these approaches have been linked to EC's role in students' historical thinking and learning (Maggioni, Alexander, & VanSledright, 2004).

**Conceptual**. Based on the work of Maggioni et al. (2004) and Reddy and VanSledright (2010) a framework has been developed to describe three epistemic stances in relation to students' historical thinking: (1) objectivist (i.e. history is an objective account of the past and the role of the student is to gather and accept information from textbook accounts), (2) subjectivist (i.e. historical interpretation of conflicting views is based entirely on opinion and the role of the student is either to accept an account regardless of evidence or make up their own view), and (3) criterialist (i.e. students take on more of a "historian" approach where multiple interpretations are possible and with a skilled use of evidence and criteria claims can be evaluated, accepted, or rejected).

**Nonintervention Studies**. Given the solid conceptual frameworks that exist, it is surprising that there are very few studies investigating elementary students' EC within the context of learning history. VanSledright and Frankes (2000) examined how historical concepts and research strategies were taught and made sense of in two fourth-grade classrooms with two separate teachers. Although they did not discuss EC specifically in their study, the inclusion of inquiry-based concepts (i.e. the focus of one teacher) and research strategies (i.e. the main focus of the second teacher) falls in line with the aforementioned EC frameworks. Data sources included classroom observations and teacher/student interviews over the course of a four-to-five-week unit on Native Americans. Findings revealed that both classrooms showed student gains in historical concept development and research strategies but, possibly due to a lack of instructional support in the classroom, several students acknowledged the uncertainty of historical knowledge but were uneasy about how to come to terms with it (i.e. subjectivist stance). For example, a student commented that diaries and notes about historical events "might not be true. What am I supposed to do with that?" (p. 277).

A study by Greene et al. (2010b) sheds additional light on EC and history. Using cognitive interviewing, they explored how three upper elementary and four secondary students' EC differed across mathematics (i.e. a well-defined academic domain) and history (i.e. an ill-defined academic domain). Both age groups of students saw mathematics knowledge as objective and factual. Similarly, one secondary student and one elementary student viewed history as comprised of "right or wrong" and static knowledge. Contrary to these views, the other two elementary students showed a "limited understanding of history's subjectivity, recognizing the role of opinions or interpretations of historical events" (p. 390). Finally, three of the secondary students displayed more sophisticated views of historical knowledge. In sum, this study reinforces the growing body of evidence that supports the idea that elementary-aged students can grasp the complexities of EC within the context of historical knowledge and thinking.

**Intervention Studies**. VanSledright (2002) took on the role of "researcher/practitioner" and taught social studies (i.e. early American history) to a diverse group of fifth-grade students for four months. A subgroup of eight children was chosen as "principal informants" to give a more detailed look at how the students were being influenced by the teaching. During this time two lessons were taught that stressed the "procedures for being a good historical detective" including reading conflicting accounts, analyzing documents, debating, and producing evidence-based arguments about what happened.

VanSledright (2002) developed a four-level coding scheme to assess how the students analyzed the documents and to capture their growth along a continuum of intratextual to intertextual levels of analyses. In Levels 1 and 2, intratextual analyses entail reading/rereading and checking details to make initial sense of the source (i.e. Level 1), and then move on to making judgments about whether or not the elements make sense and "internally cohere." In Levels 3 and 4, intertextual analyses include checks across different sources to corroborate details and to construct an initial interpretation of the event (i.e. Level 3). Finally, an evidence-based interpretation of the event is made based on critical evaluation of the source's reliability, etc. (i.e. Level 4). In general, all students demonstrated growth in terms of their historical thinking and EC. All of the fifth graders moved from a "reliance" on Level 1 and 2 analyses to the "history-specific" and critical analyses of Levels 3 and 4. The opportunity to "practice" or "do" history over the four months enhanced the students' capacity, for example, to identify the nature of sources (i.e. primary, secondary), check and corroborate evidence, and "achieve an awareness that some historical events raise questions that the available evidence cannot resolve" (p. 149).

More recently, Nokes (2014) reported on a year-long intervention study in two fifth-grade social studies classrooms (i.e. one gifted, one mainstream) where the researcher was responsible for teaching weekly document-based lessons. Small-group and whole-class discussions were important to each lesson along with instruction on historians' strategies, including the importance of primary sources (e.g. eyewitness accounts) in comparison to textbook accounts (i.e. a secondary source). Using the Maggioni et al. (2004) and Reddy and VanSledright (2010) epistemic stances framework described previously, findings indicated that students tended toward a more "historian" or "criterialist" stance including more of a focus on the importance of peer review and primary sources, a "mild skepticism" toward textbooks, and greater critical processing of historical questions and evidence. While not all of the students progressed at the same rate or reached the same level, all students, whether they were in the gifted or the mainstream class, showed significant improvement along these lines.

### *Language Arts*

Students' use of language and their participation in language arts (i.e. reading, writing, speaking, and listening), more specifically, are considered to be central vehicles for learning. Interestingly, very little research has been done on EC and literacy at the elementary level.

**Conceptual**. Learning to read and write in school entails not just the mechanics of these tasks but also students' involvement in the process of becoming literate. As students acquire "literate epistemologies" they "learn about language, knowledge, and themselves as literate individuals" (Johnston, Woodside-Jiron, & Day, 2001, p. 2). Discourse in the classroom, or the interactions and language used by individuals in groups, is also a key component in literacy development (Gee, 1996). One direction that research has taken in the area of language arts is to examine students' EC about literacy and how that may be influenced by teachers' EC and the classroom environments they create.

**Nonintervention Study**. Johnston et al. (2001) investigated the EC of fourth-grade students and their teachers during small and large group interactions around books that the students were reading and their writing. Two teachers who were determined to encourage different modes of classroom discourse and epistemological orientation, and their students, were selected to be the focus of the analyses. Drawing on the work of Nystrand et al. (1997), Perry (1970), and Belenky et al. (1986) one classroom was categorized as "monological" and "received" where the teacher was viewed as the primary source of knowledge related to literacy and where little teacher–student or student–student discussion occurred. Students' views about literacy in this classroom focused on technical competence and lack of agency/engagement in their own writing. In contrast, the other classroom was identified as "dialogical" and "constructed" where literacy knowledge was viewed as complex and context-bound and the role of the teacher was viewed as more of a guide than the sole authority. Not surprisingly, students in this classroom had a stronger sense of themselves as writers and stressed the value of shared knowledge production with their peers.

**Intervention Studies**. Within the context of language arts learning and teaching, Reznitskaya et al. (2012) examined the role of EC in "dialogic teaching" and argumentation in elementary classrooms. Briefly, dialogic teaching includes (1) an equal distribution of authority in the classroom where roles can shift during classroom discourse, (2) a reliance on open-ended/uncertain questions used to "inspire meaningful inquiry into new understandings," and (3) ongoing metacognition where the teacher guides students in the process and quality of their questions and judgments (p. 288).

The processes of argumentation support dialogic teaching and, according to the authors, students' EC reinforce their approach to reasoned argumentation (see also Reznitskaya & Gregory, 2013).

In Reznitskaya et al.'s (2012) study, a quasi-experimental design was used where two groups of fifth-grade students from 12 classrooms were compared in terms of their individual argumentation in literature discussions and whether or not knowledge of argumentation would transfer. The intervention group participated in a 12-week program (i.e. Philosophy for Children [P4C]), taught by trained individuals, that was consistent with dialogic teaching, and the control group took part in more typical literature discussions with their regular teachers.

Analyses revealed that students' literature discussions in the P4C classrooms "centered on questions that were contestable and cognitively challenging" where students were responsible for most of the procedural aspects of the discussions (Reznitskaya et al., 2012, p. 298). In contrast, discourse in the regular classrooms was predominantly monologic with the teacher at the center of discussions and with few exchanges of ideas among students. In addition, P4C teachers directed students to be more reflective of their argumentation, including relating their ideas to the arguments of their classmates, compared to regular classroom teachers.

Finally, results indicated that there were no significant differences among the two classroom types in terms of transfer from classroom discussions to individual argumentation tasks that were given. In considering this lack of transfer, even in the dialogic classrooms, the authors highlighted the importance of learning argumentation by doing (i.e. dialogic discussions) along with explicit instruction on argumentation, which none of the students received.

### *Summary*

Considered together, the previously described research on elementary students' EC offers a number of important takeaways, including further clarity on epistemic change and implications for learning and instruction. This section considers this body of work by comparing and contrasting the various studies and frameworks, extracting common themes found among them, and discussing ideas for future research.

In terms of children's EC and its change, the bulk of the studies reviewed investigated students in the upper elementary grades (i.e. fourth and fifth grade). Only a few studies looked at first through third grade (e.g. McClain & Cobb, 2001; Metz, 2011). Even though these younger students are not as cognitively advanced, there is much to learn from them regarding EC (e.g. first graders were able to attribute uncertainty to their own scientific experiments). Additional and careful research is needed in these lower grades and looking at even younger students may provide important insight into the origins of EC (e.g. Wildenger, Hofer, & Burr, 2010).

There was a fairly wide range of methodology represented in the research on children's EC including several interview studies, with some studies using more than one interview over time (e.g. Kittleson, 2011). Other studies used multiple methods (i.e. classroom observations, student and teacher interviews, surveys) and this provides researchers a chance to corroborate their data, which adds to the rigor of the research overall (Greene et al., 2010a). In general, intervention studies in this area are scarce, but the ones that exist offer rich detail into the EC of elementary students (e.g. Metz, 2011). Experimental/quasi-experimental intervention studies where intervention and control groups are compared are even more rare. These types of studies are greatly needed as they more directly assess children's experiences in educational settings such as their roles in argumentation and EC in a dialogic classroom (Reznitskaya et al., 2012). In addition, more use of discourse analysis would allow researchers to delve deeper into the microcultures within classrooms and the participating students' and teachers' argumentation practices (Ryu & Sandoval, 2012).

A few of the studies directly examined individual differences in students such as motivation, achievement goals, and/or self-efficacy (e.g. Muis & Foy, 2010). For example, Mason et al. (2013) found that students' EC "about the development of scientific knowledge had a direct effect on" their science knowledge, "whereas beliefs about the justification of scientific knowledge had a direct and an indirect effect via achievement goals on knowledge acquisition" (p. 49). How these constructs and others (e.g. emotion) factor into EC and its change would be important for future consideration (Reznitskaya et al., 2012; VanSledright, 2002).

The majority of the research reviewed was housed in a particular academic discipline. In contrast, Greene et al. (2010b) asked a small group of upper elementary students to distinguish between the areas of history and mathematics (see also Beghetto & Baxter's [2012] study that compared views of science and mathematics). Results indicated that these students recognized some of the epistemic differences between the two (i.e. mathematical knowledge was viewed as more factual and knowledge in history as more subjective). Although some work has been done along these same lines with adult populations (e.g. Hofer, 2000) additional studies could be done to further investigate this at the elementary student level. It is also important to note that, looking across academic disciplines, the studies had a number of things in common. For instance, many of the accounts of the roles of EC in argumentation and dialogic teaching were alike in terms of students taking control of discussions, wrestling with epistemic questions, using metacognition, and improving their performance (i.e. Metz, 2011; Nokes, 2014; Reznitskaya et al., 2012; Verschaffel et al., 1999). Serious consideration of EC and its change within and across academic domains is an important focus for future work, especially at the elementary level as teachers are required to teach all of these subject areas.

Elementary students partaking in argumentation with their teachers and peers was a specific focus of several studies (e,g., Yang & Tsai, 2010; Herrenkohl & Cornelius, 2013) and the framework developed by Kuhn and colleagues (e.g. Kuhn & Weinstock, 2002) seemed particularly helpful in examining student's EC within this context (e.g. Reddy & VanSledright, 2010; Reznitskaya et al., 2012; Yang, Tsai, & Lee, 2005). As was discussed previously, a combination of experiencing or practicing argumentation along with explicit instruction on it may lead to the transfer of these skills and EC to other topics and contexts (Reznitskaya et al., 2012). The point was also raised by Reznitskaya and colleagues (2012) that evaluativistic EC is more conducive to higher levels of argumentation because it stresses the comparison and judgment of various points of view based on evidence and logic (see also Kittleson, 2011). Therefore, having evaluativism as an EC goal for elementary students in the classroom would add to the clarity to the educational task at hand (Bendixen & Feucht, 2010).

According to the research, what does epistemic change look like in the classroom? In general, there is evidence to support the conceptual model of epistemic change described previously (Bendixen & Rule, 2004). Some studies support that this change happens gradually over time (e.g. Nokes, 2014) and much of the research supports that it is situated within a particular focus of study (e.g. Herrenkohl & Cornelius, 2013; Lopez & Allal, 2007; Ryu & Sandoval, 2014; VanSledright, 2002). Shifts in EC could also be seen when students were allowed to take on more of a leadership role in classroom discussions (e.g. Mason & Scrivani, 2004). In addition, if students were able to grapple and struggle with the "epistemic demands" of their science experiments (e.g. What evidence do I have that supports my hypotheses?), in solving their mathematical problems (e.g. Are there multiple strategies I can take?), in doing historical research (e.g. How certain is this diary account?), or in their writing (e.g. What can my peers teach me about my own writing?) epistemic change was very possible (e.g. McClain & Cobb, 2001; Nokes, 2014; Ryu & Sandoval, 2012). Future research should take an even closer look at students' epistemic change using more fine-grained approaches such as microgenetic studies and discourse analyses to delve deeper into its characteristics and mechanisms.

Based on the research evidence, it is clear that without the right kind of teacher, epistemic change and development in students would be very difficult. Children's EC is sensitive to instructional practices; teachers influence students' EC and potentially its change (e.g. Conley, Pintrich, Vekiri, & Harrison, 2004; Metz, 2011; Muis & Foy, 2010). There were many glimpses into what teachers can do to support epistemic change including instructional scaffolding. For instance, scaffolding was seen in teachers guiding students to the epistemic task at hand (i.e. convincing their peers, generating evidence), assigning different roles to students (e.g. note taker, posing questions, monitoring turn taking), and moving their authority out of the center of the learning task (e.g. Metz, 2011). In other words, teachers were instrumental in developing the microculture of the classroom including its norms, practices, discourse, and modes of participation (Johnston et al., 2001; Lopez & Allal, 2007). More empirical details centered on how teachers go about these complex tasks would be a key for other studies to pursue and this would certainly expand what is known in terms of teacher education efforts with epistemic change in mind.

In sum, there are a number of important implications, questions, and suggestions that stem from this body of work on children's EC and its change and that will be the focus for the remainder of the chapter.

## IMPLICATIONS

It seems that, in general, the questions and debates surrounding whether or not children have the cognitive and social wherewithal to understand and use EC in appropriate and often sophisticated ways can be put to rest. As can be seen in the work considered in this chapter, the more interesting and important questions are now moving toward how they can be advanced in typical elementary classrooms. In the following section theoretical and educational implications will be discussed in terms of teaching for epistemic change in children.

### *Theoretical Implications*

The recent change model proposed by Reznitskaya and Gregory (2013) is an important addition to the literature on children's EC because it incorporates much of what has already been done in the field both conceptually and empirically. The model is based on the necessary link between student cognition and classroom language or discourse. An important point is that not all communication patterns taking place in the classroom are equally effective. Dialogic patterns and teaching, as opposed to monologic (i.e. teacher-centered), "is a pedagogical approach that involves students in collaborative construction of meaning and is characterized by shared control over the key aspects of classroom discourse" (p. 114; see also Burbules, 1993; Duschl, 2008). This has also been referred to as "argumentation discourse" (Duschl & Osborne, 2002) and "argument-based learning" (Kelly, 2008). Research evidence is mounting that this type of classroom discourse aids in developing higher level thinking in students (e.g. Murphy, Soter, Wilkinson, Hennessey, & Alexander, 2009).

Dialogic teaching encompasses much of the theory and research that has been reviewed in this chapter. In dialogic classrooms (1) power relations are flexible, (2) learning communities are developed based on equality and various roles in directing classroom communication, (3) open-ended questions are asked and evaluated by members of the group, and (4) teachers are more knowledgeable than their students, but not "the boss," rather a leader of group activities (Reznitskaya & Gregory, 2013). As can be seen, this approach to teaching and learning is consistent with the work that has been done examining EC and its change in children.

Further, even more specific links to EC have been made by Reznitskaya and colleagues in terms of dialogic teaching. In their view, teachers and students need to develop EC that is consistent with dialogic teaching. In referencing the work of Kuhn, "multiplist and absolutist epistemologies are incompatible with dialogic teaching," which would be in concert with "evaluativist epistemology" (Reznitskaya & Gregory, 2013, p. 116) given its openness to judgments about different often competing claims. Similarly, Nokes (2014) stated that within the context of history education, students who approach primary sources with an objectivist or subjectivist epistemic stance cannot engage in historical thinking. These views would also fall in line with other discussions regarding the link between evaluativism and critical thinking (e.g. Bendixen & Feucht, 2010).

Reznitskaya and Gregory (2013) proposed a "testable" model of dialogic teaching and learning. Due to space limitations, only a few of its key components are mentioned here. Essentially, their model:

> accounts for learning processes and outcomes in a dialogic classroom for both individual students and a classroom community. Teachers with evaluativist epistemology create the necessary context for inquiry dialogue, supporting the use of normative participatory and discursive practices by classroom members. (p. 121)

There are a number of educational implications that can be discussed in terms of their work and some of these will be highlighted in the next section.

Another recent theoretical contribution that may help illuminate children's EC and its change is the model proposed by Chinn et al. (2011). Briefly, they have proposed a significant expansion of the dimensions of EC to include epistemic aims (i.e. goals for inquiry such as knowledge or truth), epistemic values (i.e. beliefs about the worth of different epistemic aims), and epistemic virtues (i.e. dispositions that are congruent with epistemic aims such as open-mindedness; see also Greene & Yu, 2014). This model would also be consistent with a more situated view of EC as has been discussed previously in this chapter (e.g. Ryu & Sandoval, 2012).

These recent theoretical models coupled with previous conceptions of EC provide a solid platform for future research and educational implications.

### *Educational Implications*

**EC and Argumentation**. Based on what has been reviewed, there is ample evidence to support the notion that argumentation and epistemic cognition are intimately tied to one another (Christodoulou & Osborne, 2014; Nokes, 2014; Ryu & Sandoval, 2012). In effect, one has to engage in argumentation and epistemic cognition to learn about an area of study and to have any chance in doing it well and/or at higher levels. So far, *doing* science, *doing* literacy, *doing* history, and *doing* mathematics entails students being involved in argumentation along with navigating the epistemic requirements of the situation and particular discipline. More broadly, it seems very likely that "doing" any subject area (e.g. writing) in any real sense would somehow be associated with argumentation skills and epistemic cognition. This could also be considered to be consistent with an "argument-based learning" approach (Duschl, 2008; Kelly, 2008; Washburn & Cavagnetto, 2013).

Why is discourse/argument among group members so valuable in terms of epistemic change? In essence, students' misconceptions, gaps in knowledge, and flaws in reasoning become visible to the group and these are "put to the test of public accountability" (Reznitskaya & Gregory, 2013, p. 117). In addition, by critiquing others' claims and warrants, further reflection and insight into one's own views become a possibility and these circumstances will likely lead to epistemic change (Bendixen & Rule, 2004).

**Changing Classroom Culture and Norms**. Changing EC in the classroom also coincided with changing the culture and norms within it. A few of the studies reviewed concentrated on how teachers established and continued to develop mathematical, historical, scientific, and literacy norms. This was done by the teacher explicitly instructing students about what the norms are (e.g. McClain & Cobb, 2001), modeling them (Nokes, 2014) and valuing them as a key component of daily classroom activities (e.g. Lopez & Allal, 2007). For example, early on in Ryu and Sandoval's (2012) study the teacher continually reminded the students: "Don't convince me. Convince them." The more the students started to shift the discourse to their peers the more they began to use EC independently and with sophistication.

**Time**. As a number of authors either stated or alluded to, quality interventions take time (Ryu & Sandoval, 2012; VanSledright, 2002) and, of course, teaching for epistemic change will have to take time as well. Learning the epistemic demands of the subject area and to practice argumentation within them and among peers needs to become more of a priority in elementary classrooms if they are to have a chance in affecting EC change. Similarly, to become proficient in reasoned argumentation and to "perceive, formulate and transfer important general principles of argumentation" (Reznitskaya et al., 2012, p. 302) takes prolonged practice.

**Teachers, Teaching, and Teacher Education**. There is growing discussion regarding the ways in which teacher education must address EC and its related components in the classroom (e.g. Bendixen & Feucht, 2010; Brownlee, Schraw, & Berthelsen, 2011). It is evident that what the teacher says and does, or does not, do is paramount in students' epistemic change in the classroom. In all of the successful interventions reviewed in the current chapter, there was a substantial shift in the role of the teacher from the center of learning activity to a more "co-construction" of knowledge by teacher and students and/or student-to-student construction (e.g. Christodoulou & Osborne, 2014). It is also paramount that teachers be attuned to the epistemic stances of their students (Nokes, 2014).

Similarly, scaffolding by the teacher was also another key component in changing EC. For example, Ryu and Sandoval (2014) saw a great deal of this in their intervention study and stated that scaffolding students' understanding of the criteria that good arguments or explanations meet was a must. More specifically, criterion-related scaffolds (1) structure elements of written or oral argumentation, and (2) structure students' activity in ways intended to promote argumentation. When and where to "fade" scaffolding is also an important consideration (McNeill, Lizotte, Krajcik, & Marx, 2006). Overall, these findings are in line with the dialogic teaching approach described by Reznitskaya and colleagues (2012, 2013).

One nagging question at this point is how much training does the typical elementary teacher have when it comes to understanding and conveying the epistemic demands of particular domain/subject areas? According to VanSledright and Frankes (2000), teachers need expertise in the various academic disciplines. Unfortunately, most elementary teachers are only asked to take a "smattering" of discipline-based courses as preparation to teach them. In history and probably other disciplines, there is increasing "subject matter demands" on elementary teachers to teach in more constructivist ways. Therefore, more teacher training that focuses on specific academic disciplines is important.

This lack of proper teacher training also leads to the problem of "pseudo-inquiry" or surface discussions in the name of constructivism or dialogic teaching discussed in this chapter (Reznitskaya & Gregory, 2013; Windschitl, 2002). For instance, knowledge of the theory of constructivism alone without practical knowledge and training will stifle the chances of epistemic change. This, of course, raises fundamental questions in terms of the effectiveness of teacher education programs. Changing teachers' beliefs in terms of theory without giving them the practices that embody the theory will not be successful in the long run (Reznitskaya & Gregory, 2013).

In addition, how much training do teachers receive when it comes to the components of effective argumentation and dialogic teaching? It is critical that teacher education and professional development efforts make these aspects of teaching for epistemic change a priority, especially at the elementary level where teachers are expected to understand a variety of academic domains. On a more positive note, Nokes (2014) predicts that because of these new expectations for elementary teachers, a "pedagogical shifting" is likely to occur, but this change will be gradual/incremental. Even if the change is gradual, it will still yield positive effects for students.

**Academic Discipline Differences and Similarities**. In looking across the studies within this chapter that focused on EC and argumentation in mathematics, history, science, and language arts, one can see that there is some important overlap among the disciplines. Some would argue that the disciplines are varied enough in their epistemic demands that to concentrate on their similarities would not be fruitful (e.g. Fischer et al., 2014). On the other hand, some see the value in using argument as a "tool" for integrating various disciplines. For example, Washburn and Cavagnetto (2013) see science and literacy as a "natural fit" and that being scientifically literate goes beyond reading science textbooks:

> Rather, it is the ability to comprehend, interpret, analyze and critique texts and actively engage in the discourse of science. …Additionally, language (particularly the construction of and critique of evidence-based explanations and arguments) has been identified as an essential aspect of doing science (Ford, 2008). (p. 129)

These argumentative abilities would include writing as well as listening and speaking skills (e.g. verbal debates). As was discussed, peer-to-peer argumentation was also a key indicator of success and epistemic change in a number of the intervention studies reviewed. This particular integration between science and literacy has already received some support (e.g. Hand, 2008).

More generally, could argumentation that includes EC be a tool to integrate across most, if not all, academic disciplines? Reznitskaya and Gregory (2013) support this notion and propose that there are “field-invariant” characteristics of argument that include “the general structure of generating hypotheses in response to well-formed questions and testing those hypotheses with evidence and arguments in order to arrive at the most reasonable conclusions” (p. 119). What counts as acceptable and unacceptable evidence, for example, will likely be domain-specific, but the implications of this are interesting: “Because this knowledge of argumentation is abstract, learners should be able to show positive transfer to new situations – both within and among domains.” (p. 119). If argumentation is a tool for higher levels of learning and epistemic change in elementary classrooms, then this should be communicated to teachers as part of their training and supported in their continued professional development.

## CONCLUSION

Promoting epistemic change in elementary classrooms through dialogic teaching and argumentation offers exciting and important benefits to students and their teachers. It seems that epistemic change in elementary classrooms happens through day-to-day collaborations with peers with the guidance of a knowledgeable teacher. If this approach to learning and instruction does indeed become more standard fare in the elementary classroom, the societal benefits will be far reaching in terms of equipping future citizens for the complexities of their world.

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# 19

# CHANGES IN PRESERVICE TEACHERS' PERSONAL EPISTEMOLOGIES

*Jo Lunn Brownlee, Gregory Schraw, Sue Walker, and Mary Ryan*



## INTRODUCTION

While much has been written about the relationship between personal epistemologies and learning-teaching approaches, outcomes, and intentions, little has focused specifically on these relationships in the context of teacher education. This chapter addresses changes in preservice teachers' personal epistemologies by overviewing this emerging body of research and arguing for a new approach to conceptualizing and supporting changes in personal epistemologies based on reflexivity. The overview includes definitions of key concepts and research traditions that have been used since the 1970s and a discussion of the emerging role of epistemic justification as a key mechanism of change in the process of belief development.

## DEFINITIONS AND TRADITIONS

Epistemology refers to a theory of knowledge and rationality (Feldman, 2003). Hofer (2002, p. 4) defines personal epistemology as being "concerned with the origin, nature, limits, methods, and justification of human knowledge." Philosophical accounts of epistemology traditionally distinguish between kinds of knowledge (for example, propositional or evidential) and justification of knowledge claims (for example, strong or weak knowledge-supporting arguments). Research on teacher beliefs assumes that individuals hold a set of beliefs that affect their classroom choices and practice.

Progress over the last 30 years in understanding personal epistemology has given rise to four different traditions and nomenclature, namely epistemological development, epistemic beliefs, epistemological theories, and epistemological resources. In this chapter, we use the term "personal epistemology" because it provides an umbrella term that encapsulates these diverse traditions. The *epistemological development* tradition has focused on how personal epistemology changes across hierarchically ordered stages from absolutist (knowledge is absolute and transferable), to multiplist (knowledge is comprised of personal opinions) and finally evaluativist (knowledge is contextual, constructed, and evaluated based on evidence) (Kuhn & Weinstock, 2002). These positions reflect a range from *naive* to *sophisticated* beliefs. A number of similar developmental models evolved in the 1980s, due in part to the continuing legacy of Piagetian developmental psychology. These models have been criticized, however, in terms of whether development is strictly stage-like and whether stages are domain-general.

An alternative tradition arose during the 1990s that focused on a set of independent, multidimensional beliefs; we refer to this as the *epistemic beliefs* tradition. The term *epistemic belief* refers to a specific belief about some aspect of knowledge that is part of a broader epistemology. Schommer (1990) was the first to describe personal epistemologies as a set of autonomous beliefs, which consisted of five separate dimensions that she referred to as *certain knowledge* (i.e. absolute knowledge exists and will eventually be known), *simple knowledge* (i.e. knowledge consists of discrete facts), *omniscient authority* (i.e. authorities have access to otherwise inaccessible knowledge), *quick learning* (i.e. learning occurs in a quick or not-at-all fashion), and *innate ability* (i.e. the ability to acquire knowledge is endowed at birth). There is some debate in the field about the extent to which the latter two dimensions are reflective of epistemic beliefs. Schommer acknowledges that these two dimensions reflect beliefs about learning (quick learning and innate ability) rather than knowledge or knowing (Schommer-Aikens, 2002). Research generally has failed to support the hypothesis of five independent beliefs.

Hofer (2000, 2004) proposed an alternative system of epistemic beliefs, which focused on four separate beliefs, subsumed under two general belief dimensions referred to as *the nature of knowledge* and *the process of knowing*. The "nature" dimension included two beliefs labeled *certainty of knowledge* (i.e. the degree to which one sees knowledge as fixed versus fluid and changeable) and *simplicity of knowledge* (i.e. the degree to which knowledge is viewed as individual facts versus complex, interrelated concepts). These beliefs are similar to those proposed by Schommer (1990). The "process" dimension included two factors called *source of knowledge* (i.e. the extent to which credible knowledge is self- or other generated) and *justification of knowing* (i.e. the rules and criteria that individuals use to evaluate knowledge claims). These beliefs differ from Schommer's (1990) framework in that they focus on cognitive processes used to evaluate knowledge claims, rather than beliefs about the "content" of knowledge per se. Research suggests that the five beliefs proposed by Schommer (1990) may not constitute independent beliefs and may incorporate ontological (i.e. beliefs about the nature of reality) rather than epistemological dimensions (Hofer, 2000; Schraw & Olafson, 2008). Specifically, Hofer has argued that beliefs about fixed ability are ontological in nature rather than epistemological.

The *epistemological theories* tradition focuses on general theories of knowledge that differ along a continuum of naïve to sophisticated worldviews. These models assume that an individual's personal epistemology is comprised of multiple beliefs that develop together as an integrated set of beliefs that comprise a unified belief system that affect one's assumptions about the acquisition, structure, representation, and application of knowledge. While different individual beliefs may change, each person's epistemic theory works as a holistic filter to justify knowledge and practice-based decisions. This category includes the *epistemic worldview* framework proposed by Schraw and Olafson (2008).

The term *epistemic worldview* (EWV) refers to an individual's collective beliefs about the nature, acquisition, and justification of knowledge. Three types of EWVs that lead to qualitative differences in the justification and application of knowledge have been discussed in the literature. A *realist* (also referred to as *absolutist* or *dualist*) position assumes that there is an unchanging, core body of knowledge that is best acquired through experts via transmission and reconstruction. A *relativist* position assumes that each learner constructs and justifies a unique knowledge base that is different but equal to other learners' knowledge. A *contextualist* (also referred to as *evaluativist*) position assumes that learners construct shared understandings in supportive social contexts using common, agreed-upon criteria for what constitutes legitimate knowledge.

The epistemic worldview framework distinguishes between personal epistemological beliefs and epistemological worldviews. Both personal epistemological beliefs and worldviews may be tacit or explicit (Schraw & Olafson, 2008), even though tacit beliefs affect cognition and action (Schraw, 2013). The former consist of specific beliefs about a particular dimension of knowledge such as its certainty, simplicity, origin, or justification. The latter consist of a nonindependent set of beliefs that collectively define certainty, simplicity, origin, or justification. Each adult has a set of personal epistemological beliefs that are included within an epistemological worldview, which also may include other related beliefs such as how epistemic beliefs are acquired and develop, and how these beliefs change over time. In contrast, the *epistemological development* tradition focuses on change in holistic beliefs over time and what internal (e.g. reflexivity) and external factors (e.g. teacher training and experiences) affect this change.

A more recent perspective is the *epistemological resources* tradition, which envisions personal epistemology as a context-specific set of epistemological resources, rather than developmental stages, or a set of individual beliefs (Hammer & Elby, 2002). In this view, children as well as adults construct multiple ways of knowing that vary depending on the domain, the specific context of learning, as well as the sociocultural setting and affordances that are relevant to the learning situation. One of the main goals of this framework is to suggest that personal epistemologies are highly variable between and within individuals depending on context. Learners may invoke different resources at varying times throughout a learning task and shift epistemological perspectives before, during, or after critical environmental changes.

Three main points are germane to these traditions. One is that researchers continue to utilize a variety of theoretical models to pose and address research questions related to teachers' personal epistemologies. Studies interested in factors that affect the development and change of personal epistemology often rely on developmental models, whereas studies interested in how specific beliefs affect teaching practices work within the epistemic beliefs tradition. A second point is that the theoretical landscape shows signs of diversifying rather than unifying. For example, the epistemic theories and resources models are relatively recent additions to the literature and represent new ways to understand personal epistemology, rather than substantive additions to existing models. Although these models make rich contributions to the existing literature, it is becoming increasingly unclear how researchers might reconcile and integrate the core assumptions of the four traditions into a unified theory that accounts for all epistemic phenomena. A third point is that traditions and research has gradually begun to focus on domain-specific personal epistemologies (e.g. the epistemological resources tradition) rather than domain-general beliefs, which are similar across a wide variety of domains (e.g. epistemological development tradition).

## JUSTIFICATION OF KNOWLEDGE

Research on teachers' personal epistemologies has changed in two important ways over the past decade related to justification of beliefs. By justification, we mean ways that individuals justify what they know, how they come to know it, and how they evaluate their own and others' knowledge claims (Hofer, 2004; Kuhn & Weinstock, 2002). One change is that researchers are less interested in validating the assumptions of the four traditions described above, and more interested in studying how teachers justify their beliefs. Schraw, Lunn et al. (in press) reviewed a variety of ways that individuals justify beliefs through observation, the expertise of others, consensual deliberation, and personal reflection. They argued that an implicit hierarchy exists within justification strategies with consensual deliberation and reflection being more useful. A second change is understanding how justification contributes to development, belief change, and corresponding change in classroom practices. This research suggests that explicit reflection on beliefs and assumptions promotes better justification and a greater likelihood of belief change, which in turn, promotes a change in classroom practices to constructivist-oriented teaching practices (Schraw, Lunn Brownlee, & Olafson, in press).

## WHY IS IT IMPORTANT TO CHANGE PRESERVICE TEACHERS' PERSONAL EPISTEMOLOGIES?

Promoting changes in personal epistemologies in preservice teacher education students is important, not only because of the connections between sophisticated beliefs and meaningful approaches to learning, but also because there is an emerging body of research that shows that such beliefs also influence teaching practices (Brownlee, Schraw, & Berthelsen, 2011). Kienhues et al. (2008) also argue that a focus on promoting sophisticated personal epistemologies is important in knowledge economies. It is important for preservice teachers to hold sophisticated personal epistemologies that can influence the depth of understanding they take from teacher education courses, the development of deep and varied knowledge systems for teaching, and the use of effective, informed decision-making across a range of contexts (Yadav & Koehler, 2007). These characteristics are clearly important not only for prospective teachers, but for all professions who need to negotiate challenging, ill-defined situations. We argue that promoting more sophisticated personal epistemologies in teacher education can promote quality teacher education and ultimately quality learning outcomes in the children for whom they will ultimately be responsible in their teaching careers.

### *Personal Epistemologies and Preservice Teachers' Approaches to Learning*

Personal epistemologies have an effect on the way in which individuals learn through their influence on the extent to which meaning is made and understanding developed (Hofer, 2002). To date, we have strong evidence to show that an individual's personal epistemologies influence learning strategies and learning outcomes in preservice teachers (Muis, 2004). Personal epistemologies filter how preservice teachers experience learning in teacher education courses and engage in meaningful approaches to learning about teaching (Fives & Buehl, in press; Many, Howard, & Hoge, 2002; Peng & Fitzgerald, 2006; Yadav & Koehler, 2007). Meaningful approaches to learning involve deep or holistic learning strategies (Ramsden, 2003 in Thompson, Pilgrim, & Oliver, 2005) and signify a conception of learning that is focused on meaning making (Marton, Dall'Alba, & Beatty,1993). Deep or holistic learning strategies focus on organizing ideas in ways that allow links to be made to prior knowledge, building personal meaning and promoting critical thinking through evaluating evidence from a range of sources. In contrast, surface or atomistic learning strategies make few connections between topics and theories and focus on surface level meaning. A common result of surface approaches to learning is rote learning, which signifies conceptions of learning that are less focused on meaning (Marton et al., 1993; Ramsden, 2003 in Thompson et al., 2005).

There is increasing evidence that meaningful approaches to learning are associated with more sophisticated personal epistemologies. For example, Bondy et al. (2007) found a relationship between preservice teachers' personal epistemologies and approaches to learning such that preservice teachers with more sophisticated personal epistemologies were more likely to make connections between ideas and be open to multiple perspectives. In addition, research by Bråten and Strømsø (2006) with first-year Norwegian preservice teachers indicates that personal epistemologies may also be related to critical thinking, which is one dimension of a deep approach to learning. Specifically, Bråten and Strømsø's findings demonstrated that preservice teachers' beliefs about the speed of knowledge acquisition were related to their ability to use critical thinking when evaluating Web-based resources. Muis (2004) described these more sophisticated personal epistemologies as availing due to the fact that they are supportive or availing of deep approaches to learning.

In summary, this body of research demonstrates that preservice teachers' personal epistemologies influence their learning by the way in which they are related to their approaches to learning. This is clearly important in understanding the ways in which preservice teachers experience their teacher education courses and develop the skills that they will need as they enter the teaching profession.

### *Personal Epistemologies and Preservice Teachers' Pedagogical Practices*

Constructivist teaching practices should encourage students to construct their own understandings and it is expected that classrooms should promote the development of more sophisticated personal epistemologies. However, we know much less about the relationship between personal epistemologies and pedagogical practices than we do about personal epistemologies and learning (Kang, 2008). Nevertheless, there is an emerging body of research that has explored personal epistemologies and preservice teachers' pedagogy.

Kang (2008) explored the relationship between personal epistemologies and pedagogical practice with 23 preservice science teachers by looking specifically at personal epistemologies, instructional practice, and teaching goals. Her findings indicated that not only were preservice teachers' personal epistemologies related to their teaching goals, but that their personal epistemologies were also related to the classroom pedagogy they enacted in order to achieve those goals. In particular she noted that preservice teachers who held more constructivist personal epistemologies also embraced more constructivist teaching goals in science classrooms.

Similar findings have been noted in the context of literacy teaching. For example, Yadav and Koehler (2007) found that preservice teachers' personal epistemologies were linked to their views about what comprises effective pedagogy in teaching literacy. Specifically, those preservice teachers with more naïve personal epistemologies (innate ability) were likely to advocate for the use of a modeled reading strategy whereby teacher modeling of reading was followed by children sharing books with their peers. In contrast, those preservice teachers who did not believe in innate ability favored pedagogies that encouraged children to find answers for themselves. They were also more likely to believe that errors can provide effective learning experiences within the context of literacy learning. Similarly, preservice teachers who believed that knowledge was simple endorsed pedagogical practices that emphasized behavior management whereas those preservice teachers who saw knowledge as complex had less of a focus on classroom control and believed in letting children work things out for themselves.

Collectively these studies demonstrate that preservice teachers' personal epistemologies are related to their pedagogical practices and that more sophisticated beliefs are linked to constructivist pedagogies. Preservice teachers with more sophisticated beliefs appear more likely to use pedagogical practices that encourage children's independent thinking and knowledge construction.

## CHANGING PRESERVICE TEACHERS' PERSONAL EPISTEMOLOGIES

While changing personal epistemologies in preservice teachers is agreed to be an essential component of teacher education programs, how these changes take place is still very much an emerging field of research in teacher education. Parkinson and Maggioni (in press) described how our existing understanding of how to promote change falls under one of two categories—a focus on higher order thinking or on explicit reflection about personal epistemologies. They describe higher order thinking as an approach to thinking that includes self-efficacy, effortful learning, and a view of knowledge as evidence based. In teacher education Parkinson and Maggioni suggest that preservice teachers can be encouraged to participate in higher order thinking by being exposed to contradictory ideas and theories. They also argue that, in addition to higher order thinking, preservice teachers need to be encouraged to reflect on the nature of such contradictory knowledge, in other words their own personal epistemologies. This approach to teacher education helps preservice teachers to engage in critical rather than technical approaches to teaching practices. A focus on contradictory ideas and theories, to some extent, reflects conceptual change theory, which is a useful way in which to understand how changes in personal epistemologies might take place.

### *Conceptual Change Theory*

The theory of conceptual change has much to offer the field of personal epistemology change in preservice teachers. Bendixen (2002) argued that the conceptual change process enables personal epistemologies to change, which reflects an overall process of resolving disequilibrium or doubt. She interviewed undergraduate students and found that a key reason for change was epistemic doubt or disequilibrium: "First came a trigger for doubt, second the experience of epistemic doubt began, third a resolution of doubt occurred, and finally new beliefs were developed or former beliefs were reaffirmed" (Bendixen, 2002: 203). Specifically, individuals must feel a certain disequilibrium by which their current beliefs are not considered appropriate. Next, individuals must be able to make sense of the new beliefs followed by being able to actually use these beliefs in practice. Finally these new beliefs must then be found to actually be useful in some way. The students in Bendixen's study reported that developing a sense of independence and experiencing beliefs that differed from their own were important in inducing disequilibrium.

A range of recent longitudinal research with preservice teachers also points to disequilibrium as a mechanism for belief changes throughout teacher education programs. Sosu and Gray (2012) investigated changes in Scottish preservice teachers' personal epistemologies over a four-year education degree (year 1 $n = 112$ and year 4 $n = 71$). An epistemic beliefs survey was used to measure personal epistemologies and teaching behaviors (competence) were interpreted using students' field experience results (14-week placement). The course was designed to confront students' beliefs about a range of teaching and learning matters. This confrontation involved exposing students to a diverse range of teaching and learning perspectives. They were also required to participate in research throughout the course. The authors argued that elements of the course induced cognitive dissonance (or disequilibrium), which led to changes in "beliefs about ability, sources of knowledge, certainty knowledge and learning process" (p. 88).

In Australia, Walker and her colleagues tracked preservice teachers throughout a four-year Bachelor of Education. Using the Epistemological Beliefs Survey (Kardash & Wood, 2000), students in the thrid year reported more sophisticated beliefs that learning is not a quick process, knowledge is integrated, and knowledge is uncertain (Walker, Brownlee, Exley, Woods, & Whiteford, 2011), and in the final year they believed more strongly that effort rather than ability contributed to successful learning and that knowledge is uncertain (Walker, Brownlee, Whiteford, Exley, & Woods, 2012). Twenty students were also interviewed in the fourth year to determine their perceptions about why changes took place. While some students suggested that engaging in university life, field experiences, and maturation prompted belief change, a number of responses indicated that challenging learning experiences were significant in this process. Specifically, some students referred to reflection, disequilibrium (diverse theories and opinions), deep understanding, and gaining further knowledge as mechanisms for changes.

Like Walker and her colleagues (2011, 2012), Rodríguez and Cano's (2007) longitudinal research pointed to an increase in sophistication of personal epistemologies over the course of a teacher education program. They noted that students ($n = 81$) became more sophisticated in their personal epistemologies, as measured by the Epistemological Questionnaire (EQ), as they progressed through their course, although their approaches to learning did not follow the same trajectory. They suggested that the course seemed to "induce a small but favorable change (both cross sectional and longitudinal) in students' learning experience. Tertiary education seemed to 'transform' students' learning experience as they progressed from first to last year, moving them towards more constructive views of knowledge and ways of learning" (p. 661). The intervention focused on promoting constructivist learning environments rather than a focus on explicit reflection on personal epistemologies. However, at the very least it would be expected that such constructivist environments would promote challenging learning experiences that might invoke disequilibrium in students' beliefs.

While these longitudinal studies suggest that disequilibrium may be a mechanism for change throughout teacher education programs, there is growing evidence that short-term interventions may also support conceptual change in preservice teachers' personal epistemologies. One way in which disequilibrium can be fostered in order to change personal epistemologies is through the use of refutational texts (Kienhues, Bromme, & Stahl, 2008). These texts aim to challenge personal beliefs with scientific evidence. "It is a two-sided text that makes the reader question prior conceptions and become dissatisfied with them. The refutational text always includes at least some new factual information because conceptual change encompasses not only a reorganization of pre-existing knowledge but also an integration of new knowledge." (Kienhues et al., 2008, p. 549). Kienhues et al.'s study of German psychology and education students investigated the extent to which personal epistemologies changed after experiencing either a refutational text or direct instruction. In the refutational text intervention, students were asked to read a text that focused on the effectiveness of DNA fingerprinting. Next they were asked to read a text that challenged the DNA research. In the direct instruction intervention, facts about DNA fingerprinting were presented to students. They found that the students with less sophisticated personal epistemologies who experienced the refutational text developed more sophisticated beliefs. The students who held more sophisticated beliefs and experienced direct instruction actually developed more naïve beliefs throughout the intervention. "All research groups except the naive refutational group revealed changes towards a more naive view" (p. 545). Kienhues et al. argued that epistemic doubt, epistemic volition (motivation to remove disequilibrium), and strategies that resolve doubt (such as reflection) are all part of the process of changing personal epistemologies (based on research by Bendixen & Rule, 2004). Like Bendixen (2002), they also argued that an essential characteristic of conceptual change frameworks is that they focus on how "a discrepancy between existing beliefs and new experiences may lead to dissatisfaction with present concepts" (p. 549).

Other research also supports the effectiveness of refutational texts in promoting changes in personal epistemologies (Gill, Ashton, & Algina, 2004). One hundred and sixty-one elementary preservice teachers were randomly assigned to one of two groups. The intervention group experienced refutational texts with augmented activation in which students were forewarned about the conflicting text while the traditional group experienced a text that simply exposed the facts to the students (expository text). This short-term intervention showed that the preservice teachers who participated in the refutational and augmented tasks experienced greater belief change than the group who experienced the expository texts.

Overall the research related to short- and long-term interventions with preservice teachers supports Parkinson and Maggioni's (in press) claims that interventions that induce disequilibrium (higher order thinking) have the potential to promote changes in personal epistemologies. However, in addition to preservice teachers engaging in higher order thinking by wrestling with contradictions in theories, there is also a need to reflect explicitly on personal epistemologies in this process. We argue that the process of conceptual change for personal epistemologies requires explicit reflection as a core process.

### *Explicit Reflection on Personal Epistemologies*

Although the literature on changing preservice teachers' personal epistemologies is still emerging, it is clear that many studies advocate for explicit reflection on personal epistemologies as a way to promote change (for a review see Brownlee et al., 2011). Parkinson and Maggioni (in press), in their review of intervention studies that focused on changing preservice teachers' personal epistemologies, also reported that explicit reflection was described in many studies as an important way in which to facilitate belief change. They earlier referred to this focus as engaging in "epistemological moves" where it is important to "direct students to what counts as knowledge and appropriate ways of obtaining that knowledge in the specific situation" (Maggioni & Parkinson, 2008, p. 453).

Reflecting on what counts as knowledge and how to obtain knowledge, that is, one's personal epistemologies, involves a process of metacognition. Such metacognition underlies the processes of higher order thinking (wrestling with contradictions) and reflection on personal epistemologies that was advocated by Parkinson and Maggioni (in press). Muis (2007) also supported the idea that metacognitive or self-regulated learning processes are important for changing personal epistemologies. This mechanism of self-regulated learning or metacognition underpins the focus on explicit reflection. Adibelli and Bailey (in press) also argued that preservice teachers, in engaging in explicit reflections on personal epistemologies, are in effect probing what they understand about the nature of knowing and knowledge.

A range of studies points to the need to engage preservice teachers in explicit reflection on their epistemic beliefs in order to promote changes in such beliefs. Charalambous et al. (2009) investigated changes in preservice teachers' personal epistemologies in the field of mathematics. They expected that engaging preservice teachers in a particular historical content related to mathematics would encourage them to consider the epistemic dimensions of mathematics education and promote changes in such beliefs. The data showed that the preservice teachers experienced a decline in sophisticated personal epistemologies (described as experimental beliefs). One conclusion drawn about the lack of change was related to students' perceptions that the intentions were not made clear. This suggests that a lack of explicit reflection on personal epistemologies for mathematics may have been partly responsible for a lack of change.

Valanides and Angeli (2005) randomly assigned 126 US preservice teachers to interventions designed to promote personal epistemologies and to promote reflection on critical thinking. The three interventions, lasting 65 minutes each, included general (teach thinking separately to subject), infusion (explicitly teach and reflect upon thinking skills, engage in dialogue), and immersion (explicitly teach thinking skills, then use of Socratic pedagogy designed to enable students to evaluate their own thinking skills) conditions. While students' personal epistemologies changed in all three interventions, preservice teachers in the infusion intervention showed the greatest change. This shows that in addition to teaching critical thinking skills, it may be important to support preservice teachers to engage in reflection, argument, and monitoring of their own thinking processes, especially in the context of considering complex issues.

A body of research about explicit reflection on personal epistemologies has taken place in the field of science education. Some research has demonstrated changes in relatively short-term interventions. For example, Deniz (2011) implemented an intervention designed to change preservice teachers' ($n = 161$) personal epistemologies over a 4-week science course. Students were asked to reflect explicitly on their personal epistemologies as they progressed through an introductory science unit. This reflection took place in class discussions and in their written reflections. Deniz found significant and important changes across all four dimensions of Hofer's epistemological beliefs questionnaire (certainty and simplicity, justification, source, attainability of truth).

Güven et al. (2014) implemented a 7-week intervention with 20 preservice elementary teachers engaged in a science unit. Over the course of the intervention, the preservice teachers were asked to engage in reflective writing in journals after each learning session. The authors claimed that all dimensions of Schommer's epistemological beliefs (quick learning, innate ability, source of knowledge, simple knowledge) except for beliefs in certain knowledge changed. They believe that the use of journal reflections helped preservice teachers to "reconstruct their views and beliefs, organize how and what they learned, evaluate their learning, and become aware of new ideas and thinking" (p. 11). This would suggest that reflection on personal epistemologies was promoted through the use of journal reflections.

In somewhat extended interventions, Tsai (2006) also investigated changes in preservice teachers' personal epistemologies in the context of science education. Tsai (2006) examined the extent to which preservice ($n$ = 32) and inservice ($n$ = 36) teachers' personal epistemologies in science changed as the result of a science education course. The 4-month course (2 hours per week) for both groups of students involved a focus on philosophy of science (personal epistemologies in the context of science), conceptual change theory, class activities that enabled applications of theory to be practiced and presented to the group, and a focus on e-learning in science. They showed that preservice teachers were more likely to change their science-related personal epistemologies than inservice teachers, becoming more constructivist in their views.

Overall, the research reported in this section has shown that encouraging preservice teachers to reflect on their own personal epistemologies can be an important way in which to promote change in such beliefs.



### *Explicit and Implicit Approaches to Promoting Changes in Personal Epistemologies*

Another body of research argues that in addition to explicit reflection on personal epistemologies, teacher education programs may need to implicitly promote sophisticated personal epistemologies through the type of curriculum and pedagogies adopted in teacher education programs. Brownlee et al. (2001) advocated for both an explicit and implicit focus on personal epistemologies in order to support changes in preservice teachers' beliefs. They implemented an intervention designed to change graduate preservice teacher education students' personal epistemologies. The intervention involved an explicit focus on personal epistemologies by asking students to discuss in class and reflect in journals about how readings on personal epistemologies were linked with the course content. In addition, the intervention provided an implicit focus on sophisticated personal epistemologies by using curriculum that modeled integrated knowledge. That is, the various educational psychology topics were connected throughout the course using the theme of personal epistemologies and the lecturer modeled approaches to teaching and learning that reflected a clear focus on evidence-based views of knowledge. Analysis of survey and interview data showed that students' personal epistemologies became more sophisticated over the year.

In science education, research has also focused on explicit and implicit approaches to promoting changes in personal epistemologies, often referred to as the nature of science (NOS). NOS refers to personal epistemologies about science concepts (Deniz 2011). Abd-El-Khalick and Lederman (2000) described two general ways of promoting changes in the NOS for preservice and inservice teachers, and students studying science in preparation for teacher education programs: implicitly focusing on "process skill instruction, science content coursework and 'doing science' …" (p. 673) and explicitly reflecting upon the philosophy or history of science.

Akerson et al. (2006) investigated changes in 17 preservice teachers' personal epistemologies in the context of science education using a similar approach. They argued that "it is not sufficient for students to have an understanding of only science content, but to also develop informed ideas for how scientists go about their work, along with the values and assumptions they make while developing scientific knowledge, or the nature of science" (p. 194). The preservice teachers were engaged in a range of weekly activities designed to develop science concepts and approaches to teaching science (with the lecturer pointing out the epistemic nature of the tasks). The intervention also involved the preservice teachers in weekly readings about teaching and NOS concepts, as well as asking them to explicitly reflect on their personal epistemologies (NOS). Using the Views of Nature of Science version B (VNOS-B) survey and semi-structured interviews they found that students views about the nature of science became more sophisticated over the semester; however, when surveyed 5 months after the completion of the course they noted some regression in beliefs. They argued that explicit reflection coupled with metacognitive strategies, in the context of teaching experiences, might be useful for sustaining changes in such personal epistemologies for science. Using a similar argument, Akerson et al. (2000) described how explicit reflection on the NOS situated in learning science content would help to change personal epistemologies and also "translate their NOS understandings into actual classroom practices" (p. 297). Essentially this body of research suggests that explicit reflection on the NOS needs to be coupled with a focus on science activities (students' experiences) in order to promote effective teaching practice. Moreover, this reflection on the NOS may need to take place within the context of preservice teachers' experiences.

### *Explicit Reflection in the Context of Classroom Teaching*

The role of explicit reflection and higher order thinking (experiencing contradictions and disequilibrium), as well as an implicit focus on curriculum and pedagogy, have been highlighted as ways in which changes might be promoted in preservice teachers' personal epistemologies. We now extend this argument by suggesting that such explicit reflections on personal epistemologies need to take place specifically in the context of teaching practices in the classroom. Rather than an implicit focus on curriculum and pedagogy as overviewed in the previous section, we will argue that classroom practice must actually be incorporated into the explicit reflection process.

In a recent volume by Schraw, Lunn Brownlee et al. (in press) that focused on new models of personal epistemologies for teacher education, a range of contributors argued specifically for explicit reflection on personal epistemologies to take place in the context of classroom practice. Adibelli and Bailey (in press) suggested that once preservice teachers have had the opportunity to engage in explicit reflection on their personal epistemologies, it is important to have the opportunity to experience teaching that reflects such beliefs. Fives and Buehl (in press) also suggested that explicit reflection needs to be coupled with teaching experiences that are reflective of sophisticated beliefs. Teachers may be more able to understand their own personal epistemologies through a process of explicit reflection on the relationship between their own beliefs and how these might be evident in their teaching practices (Schraw, Olafson, & VanderVeldt, 2011). Gholami (in press) argued that a useful way to promote change in personal epistemologies was through the use of dialogic teaching partners who provided a way in which individuals could reflect on classroom practice using both theory and practice.

It is possible that the level of sophistication of personal epistemologies may actually influence the extent to which preservice teachers are able to explicitly link such beliefs with teaching practice. Akerson et al. (2006) found that preservice teachers (completing a Master's degree), who developed and maintained sophisticated beliefs (evaluativistic in nature) as the result of an intervention that was focused on explicit reflection on personal epistemologies, were more likely to reflect on their beliefs using direct science teaching examples. Students with less sophisticated beliefs in science did not engage in such reflection on teaching practices. Based on this, Akerson et al. (2006) suggested teacher educators should use a combination of metacognition and explicit reflection, as well as explicit reflection about the NOS in their own science pedagogies. They argued that explicit reflection needs to relate to preservice teachers' actual teaching practices and personal epistemologies.

Hoan Cho and Huang's (2014) mixed method study of 23 US preservice teachers showed that reflective writing supported belief change in the context of teaching mathematics. Students were engaged in written reflections related to videos about mathematics teaching and learning. Their findings showed that the video-based reflections supported belief change in the domain of mathematics. They argued that videos could be useful in confronting personal epistemologies when they illustrate surprising student or teacher behaviors in real teaching contexts. Specifically, the authors showed that students with less sophisticated beliefs in mathematics were more likely to change their beliefs through the reflective activities. It seemed from this study that a focus on mathematics content and pedagogy as well as deep reflections on personal epistemologies were important for promoting change.

Overall, these studies suggest that explicit reflection should take place in the context of classroom teaching that reflects sophisticated personal epistemologies. This means that personal epistemologies and teaching practice may change if preservice teachers explicitly reflect on their beliefs in the context of teaching and have an opportunity to engage in teaching that is reflective of sophisticated personal epistemologies. Evidence-based reflections on beliefs that lead to changes in teaching practices can be informed by Archer's (2012) framework for reflexivity.

## A REFLEXIVE FRAMEWORK FOR CHANGING PERSONAL EPISTEMOLOGIES

Many of the studies reported in the previous sections of this chapter suggested that changes in preservice teachers' personal epistemologies might be supported through a process of explicit reflection on these beliefs. However, what is often missing from these claims is an explication of this process of reflection. In this section, we argue for a new way to consider such explicit reflection by drawing on Archer's (2012), Ryan's, 2014), and Ryan and Bourke's (2013) theory and research related to reflexivity (see also Lunn Brownlee & Schraw, in press). Reflexivity goes beyond the process of simple reflection in which the self (subject) contemplates an idea or concept (object). Instead, it "has the self-referential characteristic of 'bending-back' some thought upon self, such that it takes the form of *subject-object-subject*" involving internal dialogue (Archer 2012: 2). Reflexivity is always embedded in a particular context, and leads to changes in teaching and learning (Ryan & Bourke, 2013). In this way, reflexive processes can provide ways to interrogate how and why one takes particular actions, the implications of these choices on self and others, and what other options can be or will be pursued for a more sustainable and satisfying professional life. Reflexive processes are individual, yet they are always in mediation with the social. They constitute the ways in which individuals manage choices and make decisions in different contexts, that is, mediating one's own knowledge, beliefs, priorities, and expertise with the expectations and "normal" ways of working in a particular social context.

Four different modes of reflexivity have been described by Archer (2012): communicative, autonomous, meta-reflexive, and fractured. For communicative reflexives, decisions need to be confirmed and completed by others before they lead to action. For example, a teacher may need to check in with colleagues about any new pedagogical decisions. Autonomous reflexives, on the other hand, are clear about their pathway and goal and their deliberations lead to direct action, albeit sometimes misguided. For example, a teacher may have a focused goal about improving test scores in their classroom and all teaching centers around this goal. Meta-reflexives tend to critically analyze past deliberations and actions by themselves and others to make decisions that will best serve the common good. For example, a teacher may be concerned about test scores, but is also concerned about effective teaching and contextualized learning, so they develop strategies that balance test preparation with authentic and deep learning. Fractured reflexives, however, cannot use their deliberations to lead to purposeful action. Deliberation only serves to distress and disorient them, and they can't work out how to put things right or make effective decisions. For example, a teacher has no idea how to address low test scores: they know tests are reductionist but at the same time are high stakes, and they are unable to see how they could meet expectations of accountability and quality in such an environment. Archer (2012) suggests that individuals tend to develop and practice a particular mode of reflexivity, which may change at different times in their lives, but often stems from their experiences growing up. She contends that meta-reflexives are more able to negotiate the demands of our rapidly changing, incongruous world where there is no blueprint for action. This contextual influence suggests that other experiences (such as reflexive strategies) can be introduced to shift modes or at least to manage modes for more considered decision-making and action.

Links can be made here to personal epistemologies. For example, an absolutist (Kuhn & Weinstock, 2002) may engage in autonomous reflexivity (Archer, 2012), having certain knowledge and a singular goal to pursue, unconnected with others' knowledge or goals (Hofer, 2004); a multiplist (Kuhn & Weinstock, 2002) would be likely to seek and value personal opinions of others (Hofer, 2004) as a communicative reflexive (Archer, 2012); and an evaluativist (Kuhn & Weinstock, 2002) may be likely to critically analyze possibilities and choose the most appropriate (Hofer, 2004) for self and others as a meta-reflexive (Archer, 2012). The latter is indicative of a sophisticated personal epistemology, which is connected to meaningful learning.

A range of steps are involved in this meta-reflexive process. Adapting Ryans (2014), Lunn Brownlee and Schraw (in press) argue that the following steps might explain how the meta-reflexive process might be adapted to promote changes in personal epistemologies for teachers.

1. Start with an issue of concern for the individual or group (for example, how one's personal epistemologies "fit" [subject] with teaching practices that are mandated in a climate of high accountability [object]).
2. Reflect on one's own capacity to engage in reflexivity (beliefs in one's capacity to engage in this reflexive process and enact change for more satisfying and sustainable pedagogy for self, students, and school community).
3. Weigh up many points of view (What does the research say about effective teaching strategies for this context? What strategies are being suggested, for example, for test preparation?).

4. Use critical thinking as part of the reflective process (How can my personal epistemologies guide effective teaching practices yet also meet accountability requirements in this context?). Steps 3 and 4 relate to the final "subject" component of "subject-object-subject." That is, teachers analyze how teaching practices align with their personal epistemologies.
5. Make strategic decisions (What is the best way forward, weighing up my own concerns and beliefs with the expectations of this particular context?).
6. Enact these strategic decisions within the classroom (How can I collect evidence that my decisions are effective?).

The six-step process of explicit meta-reflexive practice offers a new theorization for supporting changes in preservice teachers' personal epistemologies (Lunn Brownlee & Schraw, in press). There is a need to make such reflexivity explicit for preservice teachers (Ryan, 2014), just as we argued earlier for the case of explicit reflection on personal epistemologies. Rather than relying on explicitly reflecting on one's personal epistemologies (subject-object) as often presented in the literature, reflexivity would involve preservice teachers engaging in subject-object-subject dialogues to promote changes in personal epistemologies and teaching practices (Lunn Brownlee & Schraw, in press). This bending back process would take the form of preservice teachers contemplating their personal epistemologies (subject) and how these relate to teaching practices (object), and then bending back on self by evaluating multiple teaching perspectives and how these practices calibrate with their personal epistemologies (subject). This would ultimately be expected to lead to resolved action and possibly changes in personal epistemologies. The argument is that such reflexive internal dialogue that is embedded in classroom teaching practice is more likely to lead to changes in both personal epistemologies and teaching practices. In the bending back, subject-object-subject process of reflexivity, we argue that preservice teachers can be taught how to calibrate their teaching practices with personal epistemologies leading to resolved action (Lunn Brownlee & Schraw, in press).

Preservice teachers could be helped to engage in calibration of personal epistemologies and practice through a process of explicit reflexivity. Maggioni and Parkinson (2008) argue "that it may be possible to train teachers to calibrate the accuracy of their epistemic cognition and teaching practices for a specific discipline through providing feedback on the difference between believing and doing, thus improving both epistemic and metacognitive monitoring and subsequent strategy use" (p. 458). As we have argued, Maggioni and Parkinson believed that simply focusing on reflection on personal epistemologies is not enough to invoke change. It is important to support calibration of beliefs with practice (Maggioni & Parkinson, 2008) and this we believe is informed by explicit reflexivity.

In conclusion, we advocate for a new framework that includes reflexivity as an extension on explicit reflection for personal epistemologies. Within this new framework, preservice teachers can be supported to "bend back" and make pedagogical decisions that enable them to enact personal epistemologies in their teaching practice through self-object-self reflexivity. If preservice teachers are to develop sophisticated beliefs, they need to be guided in their inquiries into knowledge and the learning environment. Teachers can influence students' attitudes to learning and how they see knowledge (Weinstock & Roth, 2011), so teachers with naïve beliefs are less likely to promote higher levels of epistemological understanding and action for their students. We contend that only through awareness of the reflexive process can resolved action eventuate in which teachers model beliefs and plan instruction that can best promote deep learning in the classroom.

## FUTURE DIRECTIONS

As Maggioni and Parkinson (2008) note, the field of research into the personal epistemology of teachers is relatively young. There is even less extant research on changing preservice teachers' personal epistemologies. If, as we propose, explicit reflexivity is essential in order to invoke change in personal epistemologies through supporting calibration of beliefs with practice, then an explicit focus on the process of reflexivity is an essential component of teacher education courses. Research to date indicates that existing teacher education programs do not necessarily promote change in preservice teachers' personal epistemologies (Schraw, Brownlee, & Berthelsen, 2011). However, some in-depth interventions such as training in calibration (Maggioni & Parkinson, 2008) and a focus on explicit reflection on personal epistemologies (Brownlee et al., 2011) demonstrate that belief change across the course of an education degree is possible. Reflexivity, or subject-object-subject internal dialogues (Lunn Brownlee & Schraw, in press), in classroom contexts combines the processes of explicit reflection and calibration through bending back on self and evaluating teaching practices in the light of personal epistemologies. Longitudinal research focusing on belief change in preservice teachers through structured interventions with a focus on reflexivity in classroom contexts is essential to move the field forward. Given that the core business of teachers is related to knowing and learning, teacher education courses must support changes towards more complex beliefs in order to facilitate approaches to teaching that promote meaningful learning in children. An explicit focus on reflexivity in preservice teacher education is one way to do so.

We also assume that reflexivity is a core agent of belief change that fits comfortably into any of the traditions discussed in this chapter, as well as broader models that discuss the relationship between epistemology and self-regulated learning (Greene, Azevedo, & Torney-Purta, 2008; Greene, Muis, & Pieschl, 2010). For example, it fits very closely within the developmental (Bendixen, 2002; Kuhn, 1991) tradition. In addition, almost all models of personal epistemologies include some discussion of change that centers around internal (e.g. reflexivity) and external (e.g. teacher collaborative discussion) reflective processes. This includes belief change within specific instructional contexts such as science (Deniz, 2011; Kang, 2008), mathematics (Muis, 2004), and geography (Thompson et al., 2005), as well as more general beliefs about scientific models (Pluta, Chinn, & Duncan, 2011). Epistemological worldviews also appear to change based on reflexive processes and teacher action research (Schraw, Olafson, & VanderVeldt, 2011), in part, because reflective processes have been shown to be an important component of belief change for novice and expert teachers (Sosu & Gray, 2012).

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# 20

# DIVERGING INFORMATION AND EPISTEMIC CHANGE

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Nowadays it is beyond dispute that epistemic cognition plays an important role for formal and informal learning. Therefore, it is worth investigating how epistemic cognition that is advantageous for understanding, interpreting, and evaluating knowledge claims can be fostered. Research and theories on epistemic change focus on this question. What we wish to highlight in this chapter is what epistemic change is and how it can be brought about. The studies we will review and draw conclusions from are mainly studies with adult participants, and the epistemic change found in these studies was prominently the outcome of short-term interventions. Specifically, we focus on how diverging information can influence epistemic change. We will consider all information that implies that knowledge about science-related topics (i.e. the natural sciences, the social sciences, and the humanities) might be conflicting or contradictory as diverging information. In this regard, we will also briefly review literature on the interplay between epistemic cognition and diverging information, mainly from the research tradition of multiple documents literacy. At the end of the chapter, we will outline implications for theory, research, and practice, including the consideration of epistemic cognition as rather generative. This generative nature of epistemic cognition implies that people activate a specific set of cognitive elements when evaluating a knowledge claim, such as more or less specific epistemic beliefs, but beyond epistemic beliefs also topic-related content knowledge and knowledge about the research methods of a specific field, all influencing epistemic cognition. It is important to underline that we focus on epistemic change rather than epistemic development; the difference being that while the former might occur more rapidly and might be easier fostered by epistemic interventions, maturation plays an important role for the latter.

## THEORETICAL BACKGROUND

### *Terminology Used in this Chapter and Foci of the Chapter*

In this chapter, we will focus on empirical work and theoretical considerations about people's, mostly adults', cognition about the nature of knowledge and knowing.

Thereby we will draw on research that has been conducted under different terms, such as epistemological beliefs, epistemic beliefs, personal epistemology, epistemic cognition, and epistemic resources, among others. Although the terminology used differs, we do not want to raise our voices too loud in (hastily) shouting for a unified terminology—as using the same term might obliterate the existing methodological and conceptual differences and different theoretical underpinnings in the research field. Instead, we will explain why and how we use the terms we agreed on.

Whenever we refer to people's cognition about the nature of knowledge and knowing, we will use the term epistemic cognition (Chinn, Buckland, & Samarapungavan, 2011). This term is increasingly used in current literature as an umbrella term for the beliefs people hold about the nature of knowledge and knowing (e.g. Hofer & Pintrich, 1997), often termed epistemic beliefs, and how these beliefs are applied when dealing with knowledge claims or open-ended issues (although not all researchers employ the same definition of epistemic cognition; see Sinatra, Kienhues, & Hofer, 2014). Epistemic cognition can be more or less advantageous or productive in specific contexts. That is, depending on the context, it can either be advantageous (knowledge about the fundamental structure of the universe is uncertain) or disadvantageous (knowledge about gravity is uncertain) to believe in the tentative nature of knowledge (Sinatra et al., 2014). Therefore, adaptive epistemic cognition that takes into account the specificity of differing topics and contexts is needed (Ferguson & Bråten, 2013).

By epistemic change we refer to changes in epistemic cognition. Most often, such changes are determined by pretest–posttest comparisons of epistemic cognition. Such epistemic change can be traced back to a specific impetus, such as an educational intervention. That is, epistemic change might occur quite rapidly and does not depend on cognitive maturation. Furthermore, the direction of epistemic change might not necessarily be progressive (i.e. positive, or more advantageous), as also changes toward less advantageous views can occur.

Finally, we will use the term diverging information to refer to all types of information that present different, apparently conflicting, viewpoints to the information consumer. That is, we will consider various kinds of information as diverging information. Such information may be written or oral, and it may be available in a concurrent or consecutive manner. We will, for example, consider both information accessed on the Internet that at first reading appears to be conflicting, where the recipient has to find out to what extent the different pieces of information are really conflicting, as well as newspaper articles or texts in textbooks that discuss different viewpoints on one topic, as diverging information. For the purpose of this chapter we argue that situations in which one encounters conflicting information in a more consecutive manner should also be considered as diverging information, for example when students are introduced to different models that explain a single topic in school or university (i.e. learn one model in session A, and another in session B, leading to the experience that the two models are not fully compatible).

## *Diverging Information*

As outlined above, we consider information that implies that there are conflicting or contradictory knowledge claims about science-related topics as diverging information. In information or knowledge societies, people come across such information on a daily basis. As an example, our work, study, and social lives seem to center around gaining new information about an array of topics (Goldman, Lawless, & Manning, 2013;

Rapp & Braasch, 2014). Further, the combination of advanced computing capabilities and connectivity encapsulated in modern technologies, such as smartphones and the Internet, along with societal developments, such as freedom of information laws, have contributed to a world that thrives on the exchange of information (e.g. wikileaks.org). Information and knowledge are "produced" and disseminated at a faster rate than ever before. In short, increased accessibility to technology, in combination with a lowered threshold for publication, is one important example of the increased availability of diverging information (e.g. Stadtler & Bromme, 2014).

**Diverging information and epistemic cognition.** This availability of diverging information necessitates an acknowledgement, on behalf of those that are dealing with the information, of the complexity of the knowledge that is being presented and the knowledge domain to which it belongs, the authored nature of the information one is likely to meet, accepted methods of justifying or accepting knowledge claims, and an understanding of the variance in argumentation forms depending on the given reading context. In sum, it demands advantageous and adaptive epistemic cognition on behalf of the information consumer (Alexander & DRLRL, 2012). Before presenting and discussing the use of diverging information in influencing epistemic change, we would like to take a brief look at the role of epistemic cognition in the comprehension of such information.

People's understanding of diverging information has been quite extensively considered in research from a text processing perspective, such as the documents model proposed by Perfetti, Britt, and colleagues (Britt, Perfetti, Sandak, & Rouet, 1999; Perfetti, Rouet, & Britt, 1999), who were interested in the different cognitive challenges that the comprehension of multiple contra single texts presented. While single text comprehension may be achieved by developing a superficial and text-bound representation of the surface features of the text (i.e. the so-called text-base), and an integrated understanding of the situation that is described in that text in light of the reader's prior knowledge (i.e. a so-called situation model; Kintsch, 1988), things become more complex when readers are faced with more than one text. For example, instead of meeting a single and comprehensive account of an issue, students engaging in multiple accounts of an issue are more likely to discover agreements and discrepancies between the different accounts, which increases the importance of source information, such as author credibility, publisher, date, and context. Thus, according to Britt and colleagues, readers create mental models that allow them to gain an integrated understanding when engaging in the reading of diverging information, such as multiple information sources. In addition to a text-base and situation model for each text, two further structures are created by the successful reader engaging with multiple texts. The first of these structures reflects the reader's comprehension of the overall situation as described in the text set (i.e. a situations model). The second reflects how each of the texts relates to the other texts and also contains information about the source of each text (i.e. an intertext model; Rouet, 2006). The intertext model is assumed to facilitate construction of a global, or overall, meaning for the texts. As noted above, it represents source information for each text, relating to form, author, goals of the author, and intended audience, and also links such source information to text content within each text (i.e. helping the reader to remember what claims were presented by which corresponding author).

Since the comprehension of multiple texts and divergent information seems to be a more complex task than comprehension of single texts in the traditional sense, and since learners' epistemic cognition has been shown to be particularly salient in complex learning situations (Spiro, Feltovich, Jacobson, & Coulson, 1991), we assume that epistemic cognition plays a greater role in the comprehension of divergent information than when reading single, nondivergent texts (Bråten, Strømsø, & Ferguson, in press). Further, research related to the comprehension of multiple texts and its interplay with epistemic cognition may exemplify what types of epistemic cognition might be advantageous for evaluating (multiple) science-based knowledge claims, and therefore shed light on what adaptive epistemic cognition means. Until recently, epistemic cognition did not figure prominently in traditional, information-processing based theories of text comprehension (cf. Alexander & DRLRL, 2012). Bråten et al. (2011) forwarded an integrated model of epistemic cognition and multiple text comprehension. The integrated model is an empirically based heuristic that details specific links between the four dimensions featured in Hofer and Pintrich's (1997) well-known epistemic beliefs model and the representational structures included in Britt and colleagues' (1999) documents model.

Hofer and Pintrich's (1997) model points to two dimensions describing individuals' beliefs about the nature of knowledge and two dimensions describing beliefs about the nature of knowing. The two dimensions concerning the nature of knowledge refer to the relative certainty, or tentativeness, and simplicity, or complexity of knowledge, and the two dimensions concerning the nature of knowing refer to the source of knowledge (e.g. internal sources such as reasoning and logic, or external sources, such as different authorities) and justification for knowing (e.g. basing one's claims to knowledge on internal or external sources), with each of these four dimensions being described in terms of a continuous, rather than a dichotomous scale. Bråten et al. (2011) proposed that in multiple text reading situations, cognitions about the certainty and source of knowledge are likely to influence readers' intertextual model construction. First, believing in knowledge as something that is more evolving and tentative should be associated with defining the multiple text task as an exploration of different information sources and inclusion of uncertain information. Second, believing in experts as a source of knowledge might lead to higher trust in information in the texts, as well as less reliance on one's opinion, and the establishment of source-content links. At the same time, the beliefs that individuals hold about the structure or simplicity of knowledge and the justification of knowledge claims are likely to influence readers' building of the situations model. For example, a reader that believes that knowledge is complex is likely to display more cross-text elaboration and overview generation in developing an integrated understanding of the matter than a reader that believes that knowledge is simple. Moreover, a strong belief in the importance of justifying knowledge claims through cross-checking and rules of inquiry would be conducive to greater use of metacognitive strategies and more criteria to justify knowledge claims, as well as more active use of argument schema to organize the mental model of the situation (see Bråten et al. [2011] for a more detailed account).

The work outlined above indicates that epistemic cognition influences how well individuals are equipped to deal with diverging information. Thereby, it also implies that it is worth investigating how advantageous epistemic cognition can be fostered. Research on progress and change in epistemic cognition can contribute to this aim.

## *Epistemic Change*

Various research studies from educational and developmental psychology have investigated the progress and change of epistemic cognition, indicating that epistemic cognition can be more or less advantageous (e.g. for learning and comprehension) in given situations (e.g. Bendixen, 2002; Chandler, Boyes, & Ball, 1990; Kienhues, Stadtler, & Bromme, 2011; Muis & Duffy, 2013).

Models grounded in a developmental approach (e.g. Baxter Magolda, 2004; Chandler et al., 1990; King & Kitchener, 1994; Kuhn & Weinstock, 2002) focus on change in epistemic cognition in relation to social and cognitive development or intellectual development in general, mostly across adolescence and early adulthood. Such models postulate that an individual's cognition about different epistemic aspects (e.g. certainty of knowledge, justification for knowing) is closely related to one another and coherent, so that it can be assigned to one stage of a set of hierarchically organized developmental stages that are characterized by a particular way of thinking. The progression from one stage to another is connected to age and educational level (e.g. Kuhn & Weinstock, 2002) and is often described as a rather arduous endeavor (Chandler, Hallett, & Sokol, 2002).

Disparate models, predominately from an educational psychology perspective, highlight a multidimensional system of independent beliefs in their conceptualization of epistemic cognition (e.g. Jehng, Johnson, & Anderson, 1993; Schraw, Bendixen, & Dunkle, 2002). This approach was put forward by Schommer (1990), who suggested that multiple beliefs need to be considered to gain a deeper understanding of epistemic cognition. These beliefs do not necessarily change synchronically so that individuals can simultaneously hold more or less advantageous views on different dimensions as well as regarding different disciplines (Hofer, 2000) or even topics within disciplines (Bråten, Strømsø, & Samuelstuen, 2008).

Despite broad agreement that epistemic cognition can be more or less advantageous, the mechanism of change that might account for such differences has largely been ignored in the research literature. As Rule and Bendixen (2010) summarized, "many of the developmental theories […] refer indirectly to a mechanism of change but do not describe it in great detail" (p. 97). Generally, it is widely assumed that change is promoted by social and academic experience (Weinstock & Zviling-Beiser, 2009), especially experiences that are incongruent with the individual's assumptions and thereby provoke a reconsideration, reinterpretation, or rejection of prior assumptions (e.g. King & Kitchener, 1994). Comparable considerations can be found in the literature on conditions for conceptual change (e.g. Dole & Sinatra, 1998).

Epistemic doubt, which implies a cognitive disequilibrium accompanied by questioning one's cognition about knowledge and knowing (Bendixen & Rule, 2010), has been singled out as part of an impetus for epistemic change. Chandler (1987) differentiated case-specific doubt, attached to a concrete conviction, and more emotionally demanding generic doubt, a wholesale threatening challenge which in the extreme "calls into radical question the prospect of any kind of trustworthy knowledge whatsoever" (Chandler, 1987, p. 139). That is, such longer lasting generic doubt addresses individuals' underlying values and norms and thereby, especially, allows for the emergence of new views. On the other hand, case-specific doubt might be easier to introduce and resolve. In the integrative model for personal epistemology development, Rule and Bendixen (2010) also proposed that epistemic doubt is necessary for epistemic change, but that doubt does not necessarily lead to progression. They furthermore considered epistemic volition, which implies directed effort, and resolution strategies, such as reflection or social interaction, as necessary components of a mechanism of epistemic change.

**Promoting epistemic change: The role of diverging information.** Promoting epistemic change is not only an educational goal because it might benefit learning, such as learning from multiple information sources, but also because it is an important prerequisite for participation in a knowledge-based society (Bromme, Kienhues, & Stahl, 2008; Sinatra et al., 2014). Various researchers have suggested that the introduction of controversies may encourage learners to evaluate contrasting perspectives and, thus, foster advantageous epistemic cognition (e.g. King & Kitchener, 1994), but they do not provide empirical evidence to support their suggestions. Nevertheless, it is likely that being confronted with diverging information might elicit epistemic doubt, which could be resolved by changing one's epistemic cognition.

Only a few studies have empirically tested instructional interventions deliberately designed to elicit epistemic change. These can be divided into two sets of studies. The first set of studies has focused on experiences of the knowledge building process, such as experiences within constructivist, hands-on science courses, to foster epistemic change (Conley, Pintrich, Vekiri, & Harrison, 2004; Muis & Duffy, 2013). The rationale behind such interventions has been to exemplify that knowledge is evolving and subject to revision, that different viewpoints may exist, or that experiments bring up differing results. The other set of studies has investigated the influence of more direct exposure to controversial knowledge or conflicting perspectives on epistemic change. In such short-term intervention studies, participants have been presented with divergent information, such as texts from the Internet or newspaper articles that, more or less directly, point to controversies between knowledge claims. For example, Kienhues et al. (2008) found that participants who read a short text describing the uncertainties and difficulties of DNA fingerprinting, highlighting how knowledge in genetics develops over time, showed shifts in their epistemic cognition. In comparison to the pretest, participants indicated that they believed more in the complexity and variability of knowledge in genetics after reading the text. In another set of studies, Kienhues and Bromme (2012) underlined the role of experiencing cognitive conflict for epistemic change. In those studies, the authors created two versions of a newspaper article about two experts who controversially discussed the benefits and risks of a fictional anesthetic. The first was a neutral version where the discussion of the experts was displayed as neutral and fair, and the second was a contentious version where affectivity and asperity were included. A pre–post comparison revealed significant changes in epistemic cognition for both conditions, but more importantly, there was a significant interaction between the pre–post comparison and condition (neutral versus contentious). Specifically, in the contentious condition, participants showed less change than in the neutral condition. Because the neutral condition presented the conflict as topic-inherent, it probably led to cognitive conflict, which was an impetus for epistemic change. In the contentious condition, however, participants could perceive the conflict presented in the newspaper article as interpersonal. This alternative explanation for the conflict probably led to less cognitive conflict and, thus, reduced the need for epistemic change.

In another set of short-term intervention studies, where participants read various texts, such as short newspaper articles or articles on websites, they were required to discover for themselves that information was diverging and conflicting. To exemplify, in one study (Kienhues et al., 2011) participants dealt with preselected websites on cholesterol to aid a fictitious friend's decision making about a medical treatment. These preselected websites comprised either conflicting or consistent claims on the causes and treatment of high cholesterol. Dealing with this divergent and consistent information evoked different epistemic cognition. For instance, the group that read conflicting information was less likely than the group that dealt with consistent information to believe that it was possible to find a single best solution to the medical problem. In the same vein, Ferguson et al. (2012) investigated undergraduates' epistemic cognition while reading conflicting information sources on climate change by analyzing their utterances from the perspective of Bendixen and Rule's (2004) mechanism of epistemic change. That study showed that undergraduate students displayed signs of epistemic change while reading diverging information. No conclusion regarding causality was warranted by the data, however. That issue was addressed by Ferguson et al. (2013), who randomly assigned students to the reading of conflicting or consistent documents on the unsettled health issue of the dangers and benefits of sun exposure for the purpose of giving a class presentation. In that study, group differences in students' epistemic cognition, assessed by the Justification For Knowing Questionnaire (Ferguson & Bråten, 2013), before and after reading (i.e. at a two-week interval) showed that the reading of conflicting rather than consistent information resulted in higher scores on judgments concerning the tentative and complex nature of the topic in the texts, as well as a stronger realization of the need to cross-check knowledge claims across different sources. Moreover, the students that showed epistemic change also outperformed the other group in terms of their ability to comprehend the complex issue that was discussed in the texts.

While the studies outlined so far have focused on short-term interventions, there are also some studies of fairly long-term interventions (i.e. for several weeks or months). In these studies a richer set of information has been provided over the course of instruction, for example in science classrooms or university courses. In such courses, diverging information on a specific topic might not necessarily be presented in a straightforward manner but might also occur between the different lessons that are taught. For example, over the course of one semester, Muis and Duffy (2013) investigated the effectiveness of an intervention to foster epistemic change. This intervention included the use of constructivist learning approaches such as the use of different ways to solve a problem, or critical evaluation of presented information. The intervention also emphasized comparisons of different types of information, thereby drawing attention to conflicts among knowledge claims. Results indicated shifts in epistemic cognition for the participants in the intervention group (e.g. over the course of the semester these participants adopted more constructivist beliefs about how knowledge is justified), while the epistemic cognition of the participants in the control group stayed the same over the semester. Results also indicated that epistemic change was gradual, that is, that changes appeared over time rather than immediately.

Schüssele et al. (2014) conducted an intervention to elicit epistemic change using a Learning by Design approach. In that intervention, student teachers with a focus on physics or other subjects, respectively, were asked to produce a hypertext on the topic of light in two parallel courses, with the underlying aim being that the production of the hypertext should enhance students' elaborations of the content presented in hypertexts (e.g. Stahl, 2009). Students were asked to read divergent science texts that introduced different models of light and conflicting viewpoints as the basis for their hypertexts. They had five 2-hour sessions in regular university courses to collaboratively produce their hypertexts. Results showed significant differences in the pre–posttest assessments of epistemic cognition. Physics students, in particular, showed epistemic change in that they viewed knowledge in physics as more uncertain, changing, and socioculturally embedded at posttest, and also were able to construct more elaborated arguments in support of their views.

## IMPLICATIONS FOR THEORY, RESEARCH, AND PRACTICE

So far, we have summarized research on diverging information, the interplay of diverging information, such as multiple documents, and epistemic cognition, and empirical evidence that confronting individuals with diverging information can elicit epistemic change. This evidence often points to rather spontaneous and rapid shifts in epistemic cognition. In particular, it indicates that being confronted with complex and conflicting information can force individuals to change their epistemic cognition. In the following, we focus on why and how reflection about such information might elicit epistemic change, and outline implications for theory. Finally, we will discuss implications for research and practice.

### *Implications for Theory*

We have argued that epistemic doubt can be considered an important impetus for epistemic change. Diverging information is likely to raise epistemic doubt. Diverging information on a specific topic exemplifies that knowledge about that topic might be disputable. Kienhues et al. (2008) refer to this as the exemplary principle. Hence, diverging information may introduce a new and conflicting viewpoint to individuals' epistemic cognition, that is, the notion that knowledge is not always certain, stable, or clear. This notion, in turn, may lead to some form of cognitive conflict or epistemic doubt, which can be solved by epistemic change. Furthermore, diverging information may telescope the process of epistemic change. For example, Ferguson et al. (2012) argued, with reference to Vygotsky (1978), that developmental processes that usually take longer, such as changes in epistemic cognition, might be compressed in short time periods in experimental settings. That is, exposing individuals to diverging information might accelerate epistemic change.

Moreover, the very fact that epistemic change may seem to be rather spontaneous indicates that epistemic cognition is neither stable nor coherent. Quite the opposite, individuals can quite easily adjust their epistemic cognition. This implies that epistemic cognition should not be conceptualized as a system of more or less stable beliefs, which is consistent with the idea that individuals may not have well-elaborated beliefs about knowledge and knowing regarding most science-related topics (Kienhues et al., 2011). In consequence, the findings on epistemic change discussed in this chapter also imply that epistemic cognition needs to be conceptualized as rather context-dependent and flexible.

Buehl and Alexander (2006) defined epistemic cognition as complex, multidimensional, multilayered, and interactive. They argued that many characteristics of knowledge and characteristics of beliefs about knowledge should be seen as comparable because of mutual influences between knowledge acquisition and epistemic cognition. Thus, if knowledge has to be defined as complex, multidimensional, multilayered, and interactive, then there is no reason to assume that a construct such as epistemic cognition should be simple. Such ideas led to theoretical approaches that view epistemic cognition as varying between different contexts and which assume that different cognitive elements might operate in any given situation (e.g. Bromme et al., 2008; Chinn et al., 2011; Louca, Elby, Hammer, & Kagey, 2004; Stahl, 2011). To exemplify, Bromme and colleagues (2008) and Stahl (2011) focused on how judgments about knowledge claims arise, and assumed that individuals activate different cognitive elements in reference to specific scientific information within a specific learning context. That is, individuals may activate *epistemic beliefs* existing on a general, a discipline-related, or even a topic-related level. Presumably, how differentiated an individual's epistemic beliefs are depends on prior exposure to questions regarding the nature of knowledge and knowing of a specific discipline or topic. Further, *topic-related knowledge* contributes to an elaborated judgment about a knowledge claim. Another element that can be activated to influence epistemic judgments is *knowledge about the research methods* in a discipline, as the ways of producing and justifying knowledge are specific for a certain discipline (Stahl, 2011). For example, while proofs are important in some disciplines, they are not possible in other disciplines. Yet another cognitive element that might come into play is *ontological assumptions* about the discipline. These are assumptions about the "reality" and "truth" of different disciplines. The assignment of topics or research questions to certain disciplines is based on such assumptions, as well as on *personal experiences*, that is, the know-how or experience-based knowledge a person has in a field.

To summarize, the generative nature of epistemic cognition described above can explain why epistemic cognition is not necessarily stable or coherent, and why rather spontaneous and rapid shifts in epistemic cognition can occur. In epistemic cognition, different cognitive elements can be activated, and these can be more or less elaborated. The activation can be more or less automatic or conscious, and the elements presumably interact with each other and complement or compete with each other. As a result, epistemic cognition is context-dependent and flexible. This contextuality, nevertheless, does not mean that people's epistemic cognition is totally random or has no predictable processes, as it is likely that in similar contexts, similar elements will contribute to epistemic cognition (Sinatra et al., 2014).

**The generative nature of epistemic cognition and the role of diverging information.** In the light of the generative approach to epistemic cognition, confronting individuals with diverging information is a fruitful approach to foster epistemic change because it should foster reflections regarding some of the cognitive elements described above. For example, by dealing with new and conflicting information, epistemic beliefs may be changed due to the exemplary principle and epistemic doubt outlined above. However, epistemic cognition can also be influenced by changes in individuals' topic-related knowledge, knowledge about research methods, ontological assumptions, or personal experience. For example, in the studies described previously, it is likely that individuals at pretest did not know much about the topic they were asked to deal with, and held rather undifferentiated epistemic beliefs regarding that topic. In consequence, their epistemic cognition was rather superficial and not well elaborated. At posttest, however, individuals may possess an enriched set of elements that they can draw on when making judgments about the nature of knowledge and knowing due to the information they have dealt with (e.g. they may have gained more knowledge about the topic or research methods). As a result, their epistemic cognition might change. That is, the role of diverging information in epistemic change can be to provide the "raw materials" upon which more elaborated or advantageous epistemic cognition can be built. This differentiates the present model from the model of epistemic resources proposed by Hammer, Elby, and colleagues (e.g. Louca et al., 2004). While those authors also pointed to the context dependency of epistemic cognition, they focused on epistemic resources that are already present and simply need to be activated. The generative approach to epistemic cognition rather assumes that these resources or elements are changed and enriched by dealing with diverging information and then contribute to the contextuality of epistemic cognition.

### *Implications for Research and Practice*

The implications for theory sketched above go hand in hand with implications for research and practice. We and others have proposed that epistemic cognition and epistemic change should be considered in a more contextualized manner. For example, Sandoval (2012) pointed out that epistemic cognition needs to be studied much more as a situated activity, which includes how epistemic cognition is influenced by social and material resources. One of these resources, which we have focused on in this chapter, is diverging information. However, further empirical evidence is needed to gain a better understanding of how diverging information influences epistemic change. We have provided suggestions concerning the potential role of diverging information for epistemic change. These suggestions could be the object of further empirical studies.

Further research is also needed to better understand what fosters or hinders epistemic change. For example, whether epistemic doubt is necessary or only beneficial is still unanswered. In addition, it is likely that individuals might sometimes lack epistemic volition or adequate resolution strategies, even though epistemic doubt has been elicited. Potential instructional strategies to support such volition and resolution are worth investigating (Bendixen & Rule, 2010). Experimental research designs could shed light on what fosters epistemic change best, depending on the specific context and different "prerequisites" (e.g. differing content knowledge), as it is likely that different people will profit differently from different interventions (Barzilai & Zohar, 2012). Furthermore, the longevity of interventions to foster epistemic change should be assessed.

In sum, finer grained investigation of epistemic change is likely to be fruitful. This does not necessarily mean that all research on epistemic change should focus on qualitative data (but see Greene and Yu [2014], for arguments for a return to interview methods in research on epistemic cognition). To further understand epistemic change, measures such as questionnaires could be supplemented with qualitative approaches, for example more process-orientated instruments such as learning diaries (e.g. Kramer, Stahl, & Rieß, 2014) or interviews. The rough sketch of epistemic change that has been drawn by existing research can also be further colored by taking into account additional and related variables. For example, related motivational aspects (what Chinn et al. [2011] called epistemic aims) are important. Such motivational aspects might be of special importance for epistemic change, as they are for conceptual change (e.g. Sinatra, 2005). In their study on the effectiveness of an intervention to foster beliefs about knowledge in statistics, Muis and Duffy (2013) not only considered changes in epistemic cognition, but also motivation and the self-reported use of critical thinking and elaboration strategies.

Regarding implications for practice, evidence gained so far suggests that confrontation with diverging information is a fruitful instructional attempt to elicit epistemic change. That is, diverging information could be used in instruction that aims to foster an understanding of the nature of science-related knowledge. Such understanding is an important educational goal (Sinatra et al., 2014). Furthermore, comprehension skills should also include strategies for dealing with uncertainty (Greene & Yu, 2014). It would be interesting to compare an instructional attempt that focuses on confrontation with diverging information, and thereby provides direct practice in dealing with uncertainty, with more structured interventions that teach the philosophy of science.

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# 21

# EPISTEMIC CLIMATE FOR EPISTEMIC CHANGE

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In recent years, there has been increasing attention devoted to the need for individuals to be lifelong learners. The United Nations Educational, Scientific and Cultural Organization (UNESCO) identified the formation of lifelong learners as one of the most desired outcomes of education. Lifelong learning entails understanding what counts as knowledge in a particular field, as well as the methods and criteria that are used to construct it. Honing these skills is what allows individuals to evaluate new information and progress as learners throughout the lifespan. Thus, the role of educators today is to help students acquire new knowledge and assist them in developing their thoughts about the nature of knowledge and the process of knowing.

Personal epistemology, the umbrella term most often used to refer to individuals' personal ideas, theories, or beliefs about knowledge and knowing (Greene, Azevedo, & Torney-Purta, 2008; Hofer & Pintrich, 2002), is a field that has gained momentum within educational psychology since the 1990s. Research on personal epistemology has demonstrated that students' beliefs about knowledge and knowing relate to learning (Schommer, Crouse, & Rhodes, 1992), motivation (Buehl & Alexander, 2005), metacognition (Hofer & Sinatra, 2010), conceptual change (Mason, Gava, & Boldrin, 2008), and self-regulated learning (Muis, 2007), to name a few. Indeed, researchers agree that personal epistemology plays a role in learning, with wide consensus that more constructivist beliefs (e.g. beliefs that knowledge is complex, tentative, personally constructed, and justified through evidence) foster better learning processes and outcomes. Additionally, the development of epistemic beliefs is theorized to be the product of enculturation and cognitive demands that develop over time (Muis, Bendixen, & Haerle, 2006).

In our view, personal epistemology is best defined by Hofer (2001) as "an identifiable set of dimensions of beliefs, organized as theories, progressing in reasonably predictable directions, activated in context, operating as epistemic cognition" (p. 377). More specifically, epistemic beliefs are individuals' beliefs about the nature of knowledge and the process of knowing, whereas epistemic cognition refers to thoughts about the epistemic characteristics of knowledge in context. It is the interplay between personal beliefs, knowledge construction, and knowledge judgments that reflects epistemic cognition. For example, a learner may believe that knowledge claims must be critically evaluated (i.e. an epistemic belief). During learning, the learner may evaluate the trustworthiness of the source of information, and question the certainty of that knowledge claim, both of which are instances of epistemic cognition. As such, there is an inherent link between epistemic beliefs and their cognitive manifestations when engaged in learning (Sandoval, 2005).

To date, most research has focused on advancing understanding of how beliefs develop and how they relate to learning. Whereas research efforts have examined epistemic development as the slow and broad process of intellectual development, less attention has been given to the more specific process of epistemic change, which refers to variations in epistemic cognition that result from interactions with various contexts (Hofer, 2004). More broadly, epistemic change can refer to the gradual process of development over time (e.g. Kuhn, 1999), the short-lived changes in epistemological resources (Elby & Hammer, 2010), or the more specific changes in beliefs due to environmental factors. For the purposes of this paper, we focus on the latter.

With regard to environmental factors, recent research has considered the role that the epistemic climate plays in epistemic change (e.g. Muis & Duffy, 2013). Broadly, a learning environment's epistemic climate can be defined as the knowledge- and knowing-related facets that can influence or change students' epistemic beliefs and cognition, such as teachers' epistemic beliefs and values, pedagogical approaches, knowledge representations, educational materials, classroom activities, curriculum guidelines, and institutional policies, to name a few. Given that more constructivist epistemic beliefs are typically related to better learning processes and outcomes, researchers have developed interventions that focus on the knowledge- and knowing-related facets of the classroom climate to foster more constructivist beliefs in students (Muis & Duffy, 2013) and teachers (Gregoire Gill, Ashton, & Algina, 2004). For this chapter, we focus on the malleable factors and change agents that foster epistemic change in students.

Specifically, we have been given the task to review theory and research on epistemic change with a specific focus on the role of the epistemic climate, to highlight implications and challenges for educational research and practice, and to delineate methods designed to measure change as it occurs in classrooms. As such, to situate our review, we first provide a brief overview of the various theoretical perspectives (see Chapter 2 in this volume for a more detailed review of theoretical frameworks). Following this, we present a theoretical framework that delineates the specific mechanisms involved in epistemic change. We elaborate this framework by highlighting what we believe to be important factors for lasting change. Building from Feucht's (2010) definition of the epistemic climate, we broaden consideration of what the epistemic climate entails, and review and critique previous empirical work that focuses on epistemic change through direct interventions of the epistemic climate. Based on our review and following Ames' (1992) consideration of the classroom goal structure, we present a novel framework that details each facet of the climate that may foster change, which we refer to as PACES (i.e. Pedagogy, Authority, Curriculum, Evaluation, Support). We end the chapter with directions for future research.

## BRIEF OVERVIEW OF THEORETICAL FRAMEWORKS

Over the past few decades, three conceptual perspectives have delineated the territory of personal epistemology, namely a developmental perspective, a beliefs perspective, and a resources perspective. Each perspective contributes a unique take on the development of personal epistemology, the meaning of advanced epistemic thinking, and the role of context in shaping epistemic thinking. First, the developmental perspective (e.g. Baxter Magolda, 2004; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994, 2004; Kuhn, Cheney, & Weinstock, 2000) proposes qualitatively different and sequentially organized stages of epistemic development, which are well illustrated by Kuhn's model (1991, 1999, 2001). From this perspective, it is the coordination of the objective and the subjective dimensions of knowing that qualify the advancement of epistemic thinking from absolutist (i.e. objective), to multiplist (i.e. subjective), to evaluativist thinking (i.e. coordination of objective and subjective).

Epistemic beliefs frameworks posit that beliefs about knowledge and knowing develop at various rates along multiple dimensions (e.g. Hofer & Pintrich, 1997; Muis et al., 2006; Schommer-Aikins, 2002, 2004). Hofer and Pintrich (1997) proposed four dimensions: (1) the certainty of knowledge, ranging from the belief that knowledge is certain to the belief that knowledge is tentative; (2) the simplicity of knowledge, ranging from the belief that the structure of knowledge is simple to the belief that knowledge is complex; (3) the source of knowing, ranging from the belief that knowledge is passively acquired from authoritative sources to the belief that knowledge is actively constructed by oneself; and (4) the justification for knowing, ranging from the belief that one should rely on authoritative sources, to the belief that knowledge ought to be justified through the use of objective criteria for justification, such as logical consistency. Frameworks developed within this perspective take into account variations in epistemic beliefs across disciplinary domains (e.g. epistemic beliefs about history versus epistemic beliefs about mathematics; Muis et al., 2006), or across topics within domains (e.g. epistemic beliefs about climate change versus beliefs about genetically modified foods; Strømsø, Bråten, & Samuelstuen, 2008).

Finally, the resource perspective, represented by the works of Hammer, Elby, and colleagues (Elby & Hammer, 2001, 2010; Hammer & Elby, 2002; Louca, Elby, Hammer, & Kagey, 2004), construes personal epistemology as fine-grained cognitive resources on which learners rely to apprehend knowledge and knowledge construction (e.g. *knowledge as propagated stuff*). Epistemic cognition is highly localized and shifts across knowledge items. The examination of contextual factors is paramount to the study of epistemic cognition, and is key in shaping epistemic advancement. Following Elby and Hammer (2001), Bromme and colleagues (Bromme, Kienhues, & Stahl, 2008; Bromme, Pieschl, & Stahl, 2010) suggested that epistemic sophistication should be conceived of as being context-sensitive and flexible when making epistemic judgments.

Taken together, these theoretical frameworks shed light on the nature of epistemic development and on the contextual factors that influence it. Of course, it is important to distinguish epistemic development from epistemic change. We define epistemic change to be a relatively swift but enduring adaptation in epistemic cognition in response to specific environmental factors designed to disrupt previous patterns of epistemic cognition. We differentiate this form of epistemic change from the slow, naturalistic intellectual development that is expected to occur for most individuals across the lifespan (e.g. Chandler, Hallett, & Sokol, 2002; Kuhn, 1991; King & Kitchener, 2004), and the quick but localized and presumably short-lived change in thinking or epistemological resources in response to specific contextual demands (Elby & Hammer, 2010; Hammer & Elby, 2002).[1] Ideally, epistemic change is in the direction towards enabling individuals to perceive greater complexity and tentativeness of knowledge and a more active role for themselves as knowers, which are often perceptions that are more consistent with the underlying epistemology of many scholarly domains and adaptive in many other complex knowledge-based environments (Muis & Franco, 2009). Despite the distinction between these lines of research, missing from the aforementioned frameworks is consideration of the specific mechanisms involved in epistemic change. To address this theoretical gap in the literature, within educational psychology, Bendixen and Rule (2004) and Gregoire Gill et al. (2004) proposed frameworks that specifically delineate under which conditions epistemic change may occur. Of course, other models have been proposed by scholars in other fields such as science education (e.g. Schwartz & Lederman, 2002), and mathematics education (e.g. De Corte, Op't Eynde, & Verschaffel, 2002), but we focus specifically on work in educational psychology. We briefly present Bendixen and Rule's (2004) framework next.

## EPISTEMIC CHANGE

Bendixen and Rule (2004) proposed an integrated theoretical model of epistemic beliefs to elaborate the specific mechanisms involved in belief change. In their model, Bendixen and Rule (2004) consider one causal mechanism that is comprised of three components: epistemic doubt, epistemic volition, and resolution strategies such as reflection, social support, and social interaction. They also describe what conditions are necessary for change to occur, and the emotions individuals may experience during belief change. For Bendixen and Rule, the catalyst for epistemic change is cognitive incongruity (see also Baxter Magolda, 2004; Hofer, 2004; King & Kitchener, 2004; Schommer-Aikins, 2004). Cognitive incongruity occurs when individuals encounter information that is inconsistent with their epistemic beliefs. For example, an individual may believe that knowledge about mathematics is certain. When faced with several ways to solve a problem that result in different answers, that same individual may begin to doubt his or her beliefs, which Bendixen and Rule call epistemic doubt. However, when confronted with conflicting information, some individuals may choose to ignore the information or reject it (Chinn & Brewer, 1993).

Although epistemic doubt is the first step towards epistemic change, it is not sufficient for change to occur. Bendixen and Rule (2004) suggest that change is more likely when individuals have epistemic volition, or the motivation to change one's beliefs. However, like epistemic doubt, epistemic volition does not guarantee change; individuals need to implement resolution strategies, such as reflection (e.g. reviewing the past, analyzing belief implications) and social support and interaction (e.g. argumentation between peers) for change to occur. Key to each phase in Bendixen and Rule's model is the role that emotions play in epistemic change. More specifically, the authors argue that the impact of both positive and negative emotions should be considered in epistemic change. The few studies that have explored epistemic doubt have reported emotions that include sadness, anxiety, loneliness, worry, fear, and confusion (Bendixen, 2002; Chandler, 1987), which indicates that negative emotions are a reality of epistemic change. Therefore, environments that are developed to foster epistemic change should take into consideration how the epistemic climate can positively support individuals during the change process. The following section explores the characteristics of the epistemic climate, and presents related research.

## EPISTEMIC CLIMATE FOR EPISTEMIC CHANGE

Feucht (2010) defines the epistemic climate as a context that encompasses different epistemic factors (e.g. the kinds of mathematics problems that are given to students) as well as processes (e.g. how they are taught to solve those mathematics problems) that interact to influence a person's epistemic beliefs. These factors and processes are situated within the micro, meso, and macro level of a person's environment (Bronfenbrenner, 1979; e.g. individual person, school, society) and include artifacts of the enculturation process (Vygotsky, 1978). Building from this, we define the epistemic climate as facets of knowledge and knowing that are salient in a learning or educational environment, that interact with and influence a learner's epistemic beliefs. Examples include teachers' pedagogical choices, authority structures in classrooms, curriculum, evaluation tools, and instructional supports, as well as teachers' beliefs (Duffy, Muis, & Foy, in press), students' learning strategies (Ferguson & Bråten, 2013), and epistemic emotions (e.g. curiosity, surprise, confusion; see Muis et al., 2015) that are activated during learning.

Within the broader educational research, several theoretical frameworks have been proposed to describe what factors should be considered within the epistemic climate that foster epistemic change (e.g. Bendixen & Rule, 2004; Hofer, 2001; Johnston, Woodside-Jiron, & Day, 2001; Louca et al., 2004; Schommer-Aikins, 2004; Steinbring, 1991). Due to space constraints, we are unable to describe these various models. Rather, what we present here is a unique theoretical framework that focuses specifically on malleable factors that can be readily incorporated into a classroom environment to foster epistemic change. Our goal is to provide a framework for intervention research that is guided by relevant empirical work. To situate our framework, given the focus on intervention designed to target epistemic change, we begin with an overview of the prevailing paradigm that grounded many of the studies we reviewed. We then present three exemplary studies to highlight key features of this research.

### *The Prevailing Paradigm for Epistemic Change Research*

The long tradition of research on conceptual change (Dole & Sinatra, 1998) has been used as a guiding model for many interventions on epistemic change in educational psychology (Ferguson & Bråten, 2013; Kienhues, Bromme, & Stahl, 2008; Muis & Duffy, 2013; Porsch & Bromme, 2011). Dole and Sinatra's (1998) Cognitive Reconstruction of Knowledge Model (CRKM) is one prolific example. According to Dole and Sinatra, the moment-to-moment cognitive engagement responsible for conceptual change is the product of learners' personal characteristics that interact with instructional messages of varying quality. One important personal characteristic is the learner's prior knowledge. A strong, coherent prior conception that also holds a learner's commitment is predicted to be far less amendable to revision than an unelaborated, fragmented conception that commands little to no devotion (Dole & Sinatra, 1998). Moreover, characteristics of learners' prior knowledge relate to the type of conceptual change instruction that is needed. Most researchers acknowledge differences in the nature of the degree of conceptual change, with the typical distinction being weak to radical change (Chi, 1992; Thagard, 1992; Vosniadou & Brewer, 1987). Chi (2008) proposes three levels of conceptual change according to three types of erroneous prior knowledge: revision of individual propositions, of mental models, or the perception of ontological categories, the latter being the most difficult shift.

Much of the epistemic change literature in educational psychology has been inspired by the notion that epistemic beliefs are mental structures analogous to concepts in conceptual change research. Similarly, the mechanisms for conceptual change, dissatisfaction predominant among them (Dole & Sinatra, 1998), are akin to those that

Bendixen and Rule (2004) have noted as necessary precursors to epistemic change, with epistemic doubt being a central factor. Further parallels have been found between the two areas of research, namely with regard to motivation and doubt resolution strategies. However, as Hammer and colleagues (Hammer & Elby, 2002; Louca et al., 2004) argued, the conceptual change model as applied to epistemic change does not offer a complete theoretical explanation of the epistemic change process.

Rather than thinking of epistemic cognition as a broad, unitary structure that is adaptive or maladaptive, Hammer and colleagues contend that epistemic cognition is composed of many fine-grained resources that individuals already possess that are activated or deactivated under specific circumstances, and at the wrong times in the case of maladaptive epistemic cognition. Elby and Hammer (2010) describe how a habitual pattern of co-activation between several related epistemological resources can emerge, which they refer to as an epistemological frame. Thus, they suggest that change does not require the replacement of a large, unitary cognitive structure, but does require a stable change in epistemological frames and, more specifically, a stable change in the pattern of activation of a network of epistemological resources.

Based on these theoretical considerations, among others noted above, we searched for articles that implemented an intervention via an epistemic climate designed to foster epistemic change. Although our review was not exhaustive, we included a wide variety of articles from different perspectives to assess what features of the epistemic climate might be conducive for epistemic change. For an overview of these studies, see Table 21.1. Due to space constraints, we are not able to review them in detail. Rather, in the following subsections, we present a survey of exemplary studies from the educational psychology literature that have experimentally attempted to induce epistemic change, some of which have largely followed the prevailing change paradigm. We chose these three studies given their variability in content, methodology, and instruments used to measure belief change. Then, we highlight the insights and oversights of this larger collection of studies, and describe an alternative framework that delineates important components within the epistemic climate that may foster epistemic change.

### *The Unexpected Impact of a Short-Term Intervention*

Kienhues et al. (2008) adopted a conceptual change approach through refutational texts to design their intervention. A refutational text explicitly identifies a common misconception, makes an argument for its inaccuracy, and provides the conventional scientific conception with supporting evidence (Tippett, 2010). Kienhues et al. focused on the questionable certainty of knowledge in science to promote epistemic doubt. The authors argued that the presentation of conflicting information in a refutational text would exemplify the notion of epistemic uncertainty, and that would foster epistemic change. Dubbed the exemplary principle, Kienhues et al. tested this hypothesis by randomly assigning 58 university students to one of two experimental conditions: the refutational text condition or the expository text condition. To measure epistemic change, they administered Hofer's (2000) Domain Focused Epistemological Beliefs Questionnaire (DFEBQ) and Stahl and Bromme's (2007) Connotative Aspects of Epistemological Beliefs (CAEB)[2] instrument before and after the experimental session.

Resulted were mixed and at times inconsistent with predictions. Specifically, when given the refutational text, students classified as espousing constructivist beliefs changed toward less constructivist views on the simplicity and certainty scales of the

**Table 21.1** Summary of empirical studies on epistemic change

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Akerson & Hanuscin (2007) | Experimental treatment: 3-year-long monthly professional development workshops on learning science; inquiry and regular on-site visits from support staff; explicit-reflective approach | Science education | Case study; in-situ professional performance | 3 elementary teachers | Open-ended questionnaires, interviews, observations of participants' teaching practices and other classroom artifact | Qualitative analysis |
| Akerson et al. (2006) | Experimental treatment: semester-long explicit-reflective approach on NOS via readings and assignments on NOS, and in-class hands-on activities related to NOS in the context of a Master's program | Science education | Case study; classroom based | 17 preservice elementary teachers | Pretest–posttest–delayed posttest (5 month delay)<br>Open-ended questionnaires, interviews, instructor/experimenter log notes; analyzed according to Perry's (1970) scheme | Qualitative analysis |
| Bell et al. (2011) | Experimental treatment: 2x2 design: explicit vs. implicit instruction on NOS; and standalone vs. embedded presentation of NOS; Semester-long inquiry activities, discussions, and debriefing | Science education | Quasi-experimental with control group; classroom based | 75 preservice elementary teachers | Open-ended questionnaires, interviews, classroom artifacts | Mixed-method: nonparametric statistics and qualitative analysis |
| Carter & Yackel (1989) | Experimental treatment: 8-week-long researcher-taught course designed to change negative beliefs and attitudes towards mathematics, with a focus on perseverance in the face of challenging problems, group work, small group discussions | Mathematics | Non-experimental, no control group, no random assignment; classroom based | Continuing education students, ranging from high school student to retirees | Pretest–posttest using qualitative data: students' work, writing, autobiographical writing, interviews, observation | Descriptive |

(*Continued*)

**Table 21.1** (Continued)

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Erickson (1993) | Experimental treatment in Classroom A: year-long traditional mathematics instruction including textbook-centered instruction, trial-and-error close-ended problem-solving, large group discussion only and independent work<br>Experimental treatment in Classroom B: year-long student-centered instruction, including problem-solving activities, cooperative work, real-life labs, large and small group discussions, independent practice, portfolio assessment | Mathematics | Quasi-experimental with no control group, no random assignment<br>Classroom based | Middle school classes | Pretest–posttest using Schoenfeld's (1989) Likert-type questionnaire | t-test, descriptive |
| Ferguson & Bråten (2013) | Experimental treatment: reading multiple conflicting texts on a controversial topic (sun exposure and health risks) | Science | Experimental laboratory based | 65 high school students (10th grade) | Pretest–posttest measurements using Ferguson et al.'s (2013) Likert-type Justification for Knowing Questionnaire | t-tests; cluster analysis (using a two-cluster solution) followed by a MANOVA, with follow-up ANOVAs |
| Ferguson et al. (2012) | Experimental treatment: reading multiple conflicting texts on a controversial topic (cell phones and related health risks) | Science | Experimental laboratory based | 51 undergraduate students | Think-aloud protocols during problem-solving and decision-making;<br>coded for epistemic dimensions using Greene et al.'s (2008) coding scheme, as well Bendixen & Rule's (2004) model of epistemic change | Descriptive |

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Gregoire Gill et al. (2004) | Experimental treatment: reading an epistemic refutation text passage presenting a rationale for constructivist epistemic beliefs for mathematics teaching, followed by a refutation of traditional beliefs about mathematics teaching<br>Control condition: reading a word scramble designed to activate, but not challenge, beliefs about mathematics teaching | Mathematics science | Experimental with control group and random assignment; laboratory based | 161 preservice teachers | Pretest–posttest measurements of general epistemic beliefs using Peterson et al.'s (1989) Cognitively Guided Instruction Belief Survey<br>Pretest–posttest measurements of beliefs about teaching and learning in mathematics using a Likert-type scale, researcher-developed instrument<br>Pretest measurement of general beliefs about the certainty and simplicity of knowledge using subscales from Schommer's (1990) EBQ | t-tests; path analysis |
| Higgins (1997) | Experimental treatment: year-long constructivist instruction: direct instruction and modeling of specific problem-solving skills, open-ended problems, group discussion, nondirective instruction, guided discovery<br>Control group: year-long traditional, lecture-based instruction, with no specific emphasis on problem-solving skills | Mathematics | Quasi-experimental with control group, no random assignment; classroom-based | 136 grade 6 and grade 7 students | Posttest measurement using Schoenfeld's (1989) Likert-type questionnaire; think-aloud protocol while problem solving; retrospective epistemic interviews | Unspecified statistical tests |

(*Continued*)

**Table 21.1** (Continued)

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Hynd-Shanahan et al. (2004) | Experimental treatment: 3-week long instructional intervention: direct instruction of learning strategies to read historical texts, engage in sourcing, contextualization, and corroboration of information. Multiple conflicting texts were used for student interpretation. | History | Non-experimental; classroom based | 13 college students | Pretest–posttest measurements through interviews, analyzed using a coding scheme based on Perry's (1970) scheme | Descriptive |
| Kienhues et al. (2008) | Experimental treatment: reading a refutational epistemological text highlighting the uncertainty of knowledge on a controversial topic (DNA fingerprinting) | Science | Experimental with control group and random assignment; laboratory based | 58 undergraduate students | Pretest–posttest measurements using Hofer's (2000) DFEBQ (Likert-type items) and Stahl and Bromme's (2007) CAEB (semantic differential items) | Split on epistemic beliefs; ANOVAs controlling for need for cognition, verbal intelligence, and prior knowledge in genetics |
| Kienhues et al. (2011) | Experimental treatment: reading conflicting information presented across 15 websites on causes and treatment of high cholesterol<br>Control condition: reading consistent information presented across 15 websites on causes and treatment of high cholesterol | Science | Experimental with control group; laboratory based | 100 undergraduate students | Posttest measurements of topic-specific epistemic beliefs using a researcher-developed questionnaire focused on beliefs about the certainty and simplicity of knowledge<br>Pretest–posttest measurement of medicine-specific EBs using Stahl and Bromme's (2007) CAEB | t-tests; contrast testing; repeated-measures ANOVAs |

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| | | | | | Posttest measurement of beliefs about sources and justification of knowledge using a research-developed Likert-type questionnaire | |
| Knefelkamp (1974) & Widick (1975) | Experimental treatment 1: 2-week long instructional intervention designed for students with a dualistic view of knowledge emphasizing relativism in course content and instructional methods; experimental learning | Humanities: course entitled "Themes of Human Identity" | Non-experimental; classroom based | 31 undergraduate students | Pretest–posttest measurements using Perry's (1970) scheme | Descriptive |
| | Experimental treatment 2: 2-week long instructional intervention designed for students with a relativistic view of knowledge, emphasizing commitment in relativistic and diverse content; vicarious experiential learning | | | | | |
| Lampert (1990) | Experimental treatment: year-long instructional intervention: discovery learning, open-ended problem, group discussion; emphasis on multiple strategies to problem-solve | Mathematics | Non-experimental, no control group, no random assignment; classroom based | 5th grade students (1 class) | Observations | Descriptive |

(*Continued*)

**Table 21.1** (Continued)

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Marra et al. (2000) | Experimental treatment: year-long project-focused, active learning course focused on process, communication, critical thinking skills, in addition to course content<br>Two control conditions: (a) students who were just about to complete the course, and (b) students who had not yet completed the course | Engineering | Experimental with control groups, random assignment; classroom based | 53 undergraduate students | Posttest measurements using Perry's (1970) scheme via semi-structured interviews | ANCOVAs, using prior achievement as a covariate |
| Muis & Duffy (2013) | Experimental treatment: 15-week-long constructivist instruction integrating modeling and scaffolding of critical thinking and constructivist self-regulated learning strategies<br>Control condition: 15-week long traditional instruction, lecture based | Statistics | Quasi-experimental with control group, no random assignment; classroom based | 63 graduate students | Five measurements were taken over 15 weeks using Hofer's (2000) DFEBQ | Four repeated-measure ANOVAs (one for each dimension of epistemic beliefs) |
| Porsch & Bromme (2011) | Experimental treatment: reading a text explicitly exposing the uncertain, complex, and evaluative nature of a scientific issue (coastal tides)<br>Control condition: reading a text exposing the static nature of scientific knowledge on a scientific issue (coastal tides) | Science: coastal tides | Experimental; laboratory based | 265 secondary school students | Pretest, posttest, and delayed posttest (4 weeks after the intervention) measurements of epistemic beliefs using Stahl and Bromme's (2007) CAEB | Repeated-measure ANOVAs; ANOVAs |

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| | | | | | Pretest–posttest measurements of beliefs about the amount of sources necessary using a researcher-developed questionnaire<br>Pretest–posttest measurements of beliefs about source appreciation and change in source appreciation using a researcher-based questionnaire | |
| Schwartz & Lederman (2002) | Experimental treatment: 2-year-long explicit presentation and guided reflection on aspects of NOS via instruction, discussion, questioning, and activities in the context of a Master's program | Science education | Case study; classroom based and in-situ professional performance | 2 beginning secondary science teachers | Open-ended questionnaires (i.e., VNOS), interviews, observations of participants' teaching practices and other classroom artifacts to measure knowledge, intentions, and instructional practices based on conceptions of the nature of science | Qualitative analysis |
| Stephensen & Hunt (1977) | Experimental treatment: semester-long instructional intervention based on constructivist and supportive learning, cognitive conflict, dissonance, and challenging students' beliefs<br>Control condition: semester-long traditional instruction | Social science | Quasi-experimental with control groups, no random assignments; classroom based | First-year undergraduate students | Pretest–posttest measurements using Perry's (1970) scheme | Descriptive |

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**Table 21.1** (Continued)

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Valandies & Angeli (2005) | Experimental treatment: reading a text presenting opposing views on a controversial social topic ("Are American values shaped by the mass media?"), as well as dyadic discussions. Three conditions: (a) general approach to critical thinking instruction, (b) immersion approach critical thinking instruction, (c) infusion approach critical thinking instruction (as per Ennis' [1992] model) | Social topic | Experimental with no control group; laboratory based | 108 undergraduate students | Pretest–posttest measurements using an adapted version of King and Kitchener's (1994) EBQ | Repeated-measure ANCOVAs |
| Verschaffel et al. (1999) | Experimental treatment: 20-week-long instructional intervention: constructivist learning, realistic, complex, and open-ended problem-solving, group discussions, group work; students encouraged to verbalize their personal beliefs, feelings, misconceptions, learning strategies in mathematic<br><br>Control condition: 20-week-long traditional instruction: direct instruction, demonstration of solution to well-defined problems; individual practice | Mathematics | Quasi-experimental with control group, no random assignment; classroom based | Grade 5 students: 4 experimental classes, and 7 comparable classes. | Pretest–posttest measurements using Verschaffel et al.'s (1999) Beliefs and Attitudes Questionnaire | Repeated-measure ANOVAs; factor analysis |

| Study | Intervention | Domain | Study type | Sample | Epistemic beliefs measurement | Data analysis method |
|---|---|---|---|---|---|---|
| Yackel & Cobb (1996) | Experimental treatment: year-long instructional intervention: inquiry-based teaching, group discussion, development of intellectual autonomy via viewing the teacher as the authority of knowledge to the student | Mathematics | Non-experimental; classroom based | Grade 2 students | Observations; interviews | Descriptive |

DFEBQ, but students with less constructivist beliefs did not change. When given the expository text, both groups changed toward a less constructivist view. The majority of these findings with the DFEBQ were in contrast to predicted changes and directions. Conversely, with the CAEB, when given the refutational text, less constructivist students espoused more constructivist beliefs on texture and variability, whereas students with more constructivist beliefs did not change. For the expository text condition, students with more constructivist beliefs adopted less constructivist beliefs, whereas students with less constructivist beliefs did not change. Results with the CAEB were consistent with researchers' predictions. Based on these results, Kienhues et al. (2008) concluded that evaluative associations about epistemic beliefs, as measured by the CAEB, may be more amendable to their intervention than epistemic beliefs measured by the DFEBQ. These results highlight the importance of instrument selection and of construct operationalization, and emphasizes the paucity of knowledge about the mechanisms and processes of epistemic change.

### *Epistemic Climate and Epistemic Change*

Muis and Duffy (2013) employed a quasi-experimental design to examine epistemic change over the course of a university semester. Sixty-three graduate students in two social science statistics classes were recruited to participate. To foster epistemic change along beliefs in the simplicity and certainty of knowledge, source for knowing, justification for knowing, and attainability of truth, one class was given constructivist instruction over the course of 12 weeks. Instruction included questioning to promote critical thinking,[3] comparing new material to prior knowledge, collaborating on problems in small groups, and evaluating and discussing the merits of alternative problem-solving approaches. The control class received instruction on the same content, including identical lecture material, assignments, and exams, but without constructivist teaching practices. Epistemic beliefs were measured at five time points over the course of the semester using Hofer's (2000) DFEBQ. Results showed that students in the constructivist intervention class reported more sophisticated epistemic beliefs beginning around the eighth week of class and the change process continued until the fifteenth week. Muis and Duffy concluded that epistemic belief change does not occur quickly but can be enduring with constructivist instruction as evinced by delayed administration of the DFEBQ three weeks following the last class. The authors also proposed that the change process resembled enculturation (Jehng, Johnson, & Anderson, 1993) wherein individuals came to perceive knowledge from the same perspective as those around them (Muis & Duffy, 2013).

### *Changes and Relations to Multiple-Text Comprehension*

Ferguson and Bråten (2013) analyzed secondary school students' epistemic change after reading multiple conflicting documents in science. The authors focused on beliefs about justification, and demarcated three subcomponents: personal justification, justification by authority, and justification by multiple sources. Ferguson and Bråten presented 65 students with five texts that presented partly conflicting evidence about sun exposure and health consequences. Epistemic beliefs about the justification of science knowledge were measured before and after reading with the use of a Likert-type questionnaire. The authors adopted a person-centered approach and employed cluster analysis to track changes in participants' epistemic profiles. They found that after reading, half of the students who initially reported a moderate belief in personal justification subsequently reported a low belief on this dimension and reported stronger beliefs in either justification by authority or multiple sources. Ferguson and Bråten's results show that beliefs about the justification of science knowledge are amenable to change from a short-term, text-based intervention. However, the authors did not rule out the possibility that participants were responding to the specific topic controversy rather than much broader beliefs about science, thus calling into question what construct changed.

### *Synthesis and Critique*

The three empirical studies reviewed represent researchers' attempts to change students' epistemic beliefs or cognition via some form of an intervention. However, they differ in characteristics that may be relevant for researchers designing future intervention studies. Specifically, these studies differed in their operationalization of the epistemic constructs of focus, the timescale of the interventions, and the type of intervention. These characteristics reflect broader issues related to fostering epistemic change, such as pedagogical choices, classroom authority structures, evaluation tools, and instructional supports, which we argue are aspects of epistemic climates that have important implications for epistemic change but that have been underexamined. Future success at fostering proficiency in epistemic cognition will be contingent on how these issues are resolved.

With regard to how epistemic beliefs were measured, although all epistemic in nature, the constructs differed in number, content, and level of granularity. The majority of studies we reviewed measured epistemic cognition using Likert-type questionnaires that predominantly measured individuals' beliefs about the simplicity and certainty of knowledge (see Table 21.1). Few employed think-aloud protocols, or interviews and observations to measure epistemic beliefs. Although the operationalizing of epistemic beliefs as broad and bipolar dimensions was still prominent in these studies, the inclusion of the CAEB and Ferguson and Bråten's (2013) more specific measure of beliefs about justification reflects a shift in theoretical assumptions that epistemic cognition may be more fine-grained and tacit than previously thought (see also Hammer & Elby, 2003). Given that multiple levels of epistemic cognition are likely active during learning, future research should continue this trend to examine how to change specific epistemic cognitive activities and leverage observational methods to complement self-reports. This requires measuring epistemic beliefs as they arise during learning, and employing methodologies such as trace methodologies and think-aloud protocols to capture epistemic cognition (Greene, Muis, & Pieschl, 2010).

Another point of convergence in the research we reviewed was the timescale of the studies. Indeed, over half of the studies opted for a short-term experimental session (e.g. Gregoire Gill et al., 2004; Porsche & Bromme, 2011). The endurance of epistemic change beyond the experimental session is infrequently assessed in the empirical literature. Therefore, it is unknown whether the changes observed in Likert-type responses were a temporary activation of constructivist epistemic cognition that will diminish over time. This issue speaks to the nature of the constructs that are being targeted for intervention and the nature of the course of change. Therefore, to address the issue of lasting change, more studies are needed to explore epistemic change over time, and to examine the effect of lasting change on learning processes.

Finally, the studies reviewed varied in terms of type of intervention employed. Whereas some studies employed text-based interventions, which reflect one aspect of the curriculum, others manipulated the pedagogical approaches used to foster epistemic change. We argue that text-based interventions are limited in the cognitive structures they target. As Chi (2008) suggests, text-based interventions may be unsuitable for deeply entrenched worldviews, particularly when the alternative worldview being proposed is radically unfamiliar to the reader. This contention may be relevant for change in epistemic cognition. Further, texts represent only one facet of the learning environment. Other aspects, like instructional supports for students' use of learning strategies, may be important to target for epistemic change. Classroom-based manipulation of pedagogy and scaffolding of tasks and evaluations have shown to be important vectors for epistemic change and important aspects for consideration in the design of interventions (Carter & Yackel, 1989; Erickson, 1993; Higgins, 1997; Hynd-Shanahan, Holschuh, & Hubbard, 2004; Lampert, 1990; Marra, Palmer, & Litzinger, 2000; Muis & Duffy, 2013; Verschaffel et al., 1999; Yackel & Cobb, 1996).

In summary, although these intervention efforts offer many empirical insights into epistemic change, many unanswered questions persist. Frequently, the intervention studies reported here employed single instruments that have been previously critiqued for an overly broad operationalization of epistemic cognition. Among the reviewed studies, intervention designs were often short in duration and neglected to measure long-term intervention impact. Lastly, the nature of the interventions reviewed was limited to one or two aspects of the epistemic climate (e.g. text-based curriculum), and potentially neglected other facets of epistemic cognition expressed in classrooms. The Muis and Duffy (2013) study represents a break from these prevailing intervention designs, yet future research should leverage elements from all studies reported here with important theoretical and methodological developments to advance knowledge about how to foster adaptive epistemic change.

### *Conclusion*

The prevailing paradigm for epistemic change is grounded in conceptual change research. This framing has led to advancement in understanding how interventions can be designed to foster change in epistemic cognition. However, if the field is to productively move forward, this paradigm needs to be complemented with additional theoretical developments. We propose such complementary models of belief change should incorporate multiple facets of learning environments. Rather than solely considering epistemic change as a problem of an indivisible cognitive representation that needs to be replaced, it is likely that epistemic change can be better considered as two complementary subproblems operating on different timescales requiring two different strategies for change: enacted epistemic cognitive processes and a larger cognitive structure of epistemic beliefs. This duality reflects empirical research that differentiates between epistemic thinking and beliefs (Barzilai & Zohar, 2012). Further, the distinction in timescale parallels the differences that Elby and Hammer (2010) note between epistemological resources activated in a particular context and epistemological frames that are formed out of habitual patterns of resource activation and that achieve structural stability across time through deliberate and repeated use. Consistent with the timeline for change described in our earlier definition, we contend that epistemic change needs to occur both at the level of enacted epistemic cognitive processes (i.e. change likely to be relatively quick) and larger cognitive structures of beliefs (i.e. change likely to require more time). Therefore, several different instructional strategies are required to promote enduring epistemic change.

In the following section, based on our review of the intervention research, we outline several manipulable aspects of classroom environments that may address these dual and interlocking aspects of epistemic cognition and beliefs. Specifically, we propose that the epistemic climate of a classroom can be a powerful vehicle for epistemic change. To this end, we describe and operationalize several manipulable structures and mechanisms of epistemic climates that may promote epistemic change.

## PACES: EPISTEMIC CLIMATE FOR EPISTEMIC CHANGE

In her seminal article on classroom goal structures, Ames (1992) described key features of a learning environment that make different types of achievement goals salient to students. As a consequence, these classroom goal structures elicit qualitatively different patterns of student motivation. She further proposed specific classroom structures that contribute to a mastery orientation (i.e. a focus on the development of understanding and mastery of content and skills) and how these classrooms structures relate to one another. Following Ames' lead, we propose key features of an epistemic climate of the classroom that foster epistemic change. Of course, the way that each feature is implemented in the classroom dictates the direction of change toward more or less constructivist epistemic beliefs. Additionally, as we note below, the features of change that we highlight must be coupled with a consideration of the emotions that students may experience during change, along with strategies that must be taught to support lasting change. As we elaborate below, most proposed features are empirically supported by the studies we reviewed. These features can be aptly abbreviated by the following acronym, PACES: Pedagogy, Authority, Curriculum, Evaluation, and Support. We detail each aspect in turn.

### *Pedagogy*

A central aspect of the epistemic climate is the pedagogical approach a teacher adopts in a classroom. In our review of the literature, approximately half of the studies developed an intervention through the use of constructivist pedagogy (e.g. Carter & Yackel, 1989; Erickson, 1993; Higgins, 1997; Hynd-Shanahan et al., 2004; Lampert, 1990; Marra et al., 2000; Muis & Duffy, 2013; Verschaffel et al., 1999; Yackel & Cobb, 1996). Indeed, much of the epistemic beliefs literature has focused on two broad types of pedagogy, constructivist versus traditional, and their role in students' epistemic beliefs (e.g. Muis & Foy, 2010). Briefly, constructivist pedagogy can be defined from several perspectives ranging from radical constructivism, which reflects an extreme individualistic perspective, to social constructivism, which is informed by Vygotsky's (1986) work (see Murphy, Alexander, & Muis [2012] for an overview). From a social constructivist stance, knowledge and knowing are shaped by cultural values and individual experiences. Examples of pedagogical approaches that fall within this framework include inquiry, apprenticeship, collaborative learning, knowledge building, and communities of practice, among many others. Despite differences across the various constructivist frameworks, one commonality among them includes the belief that "students construct their knowledge from individual and/or interpersonal experiences and from reasoning about these experiences" (Windschitl & Andre, 1998, p. 145). In contrast to constructivist-oriented classrooms, traditional modes of instruction reflect a teacher-centered approach, primarily involving lecture and an emphasis on transmitting decontextualized knowledge. These types of pedagogical practices allow little room for collaboration, application, or personally and/or socially meaningful construction of knowledge.

As for specific pedagogical approaches, we propose that productive epistemic change may be achieved when teachers explicitly highlight ambiguity, present varied interpretations and multiple perspectives, and provide opportunities for students to work together to co-construct knowledge. For example, teachers can repeatedly expose students to conflicting or paradoxical points of view, and ask students whether and how this conflict could be resolved. Teachers can further structure each point of view and analyze its components to identify what evidence each perspective brings, and whether evidence from one argument is better than another (Kloss, 1994; Marra et al., 2000). Teachers can also require students to provide justification for any point they raise, or any idea they reject, to highlight the importance of the justification process through valid evidence. Teachers can further engage students in group discussion wherein multiple student perspectives may be presented. Teachers should also pay special attention to the development of students' epistemic competence, that is, students' ability to recognize when it is not possible to critically evaluate knowledge claims (see Murphy et al., 2012). Additionally, when relevant for their domain, teachers can teach students the investigative process to discover scientific, mathematical, historical, political, or social scientific content for themselves after the teacher presents an underlying idea, concept, or construct.

Although the abovementioned is not an exhaustive list of potential pedagogical practices that may foster epistemic change, the general stance we take here is that teachers must make explicit the beliefs students should adopt, by showing the complexity and tentativeness of knowledge as well as multiple and active ways for its justification and evaluation, and support the development of those beliefs through repeated exposure to concrete examples. Of course, this also requires that teachers themselves espouse more constructivist beliefs given the link between teachers' beliefs and pedagogical practices, and teachers' beliefs and students' beliefs (Muis & Foy, 2010; Windschitl, 2002). We argue that it is not only what teachers do to engage students in learning, but also what teachers say and how they say it. Embedded in teachers' talk are epistemic messages that may also foster epistemic change in students. Moreover, the kinds of questions that teachers ask may play an important role in epistemic change. For example, if teachers ask questions that require students to state a definitive answer (e.g. "What is a t-test?"), students may receive the message that knowledge consists of unshakable facts. If, however, teachers ask a question that requires students to evaluate, reflect, elaborate, or justify (e.g. "Would you use a t-test under this condition, and why? Could another approach be appropriate in this context?"), then students may receive the message that knowledge depends on context, for example. Teachers' reactions to students' responses may also relate to the role of authority in knowledge construction. This is the second factor in our framework.

### *Authority*

A second central aspect to the epistemic climate is the role of the teacher as an authority figure. As previous research has shown, many students adopt the belief that teachers or other sources like experts or textbooks are the sole source of knowledge, and teachers' role is to hand down knowledge to students (see Muis, 2004; Muis et al., 2006). Interestingly, no studies we reviewed explicitly explored the role that authority plays in epistemic change. Rather, the role of beliefs about authority may have implicitly shifted through broader interventions designed to foster change (e.g. Muis & Duffy, 2013; Yackel & Cobb, 1996). Despite this lack of direct empirical evidence, we argue that to move students away from the perspective of teachers as sources of knowledge, instructors can lessen their authoritative role by providing students with opportunities to engage in free discussion, wherein students spend the majority of time talking and taking turns. This also increases students' reliance on peers' perspectives and contributions to knowledge construction (Kloss, 1994). Further, decentralizing the source and justification of knowledge from expert (i.e. teacher) testimony to the individual student and her peers exemplifies the need for students to take personal responsibility for constructing their own knowledge and evaluating its multiple sources.

As previously noted, when teachers ask questions, those that elicit definitive responses that are followed up with statements like "correct" or "wrong" may continue to foster the belief that the teacher has all of the answers, and that those answers can be identified with certainty. As such, it is important for teachers to ask students questions that push them in their thinking, and challenge students when they overgeneralize or use blanket appeals to authority. Of course, there are instances when reliance on authority is appropriate, but knowing when and why it is appropriate and not relying on blind acceptance is one step toward epistemic competence.

Coupled with constructivist pedagogical approaches like inquiry, students may begin to view themselves as sources of knowledge. This further requires that teachers should reinforce the legitimacy of students' personal views and experiences but, when those views and experiences are misguided or entail misconceptions, teachers need to be prepared to challenge and scaffold change of those misconceptions. One facet within the epistemic climate that may help change misconceptions is the curriculum, which is discussed next.

### *Curriculum*

In our review of the literature on epistemic change, approximately half of the studies focused on pedagogical approaches, such as constructivist approaches, to foster change. A second common interventional approach was refutational text or texts that presented conflicting information to students or teachers about various topics (e.g. Ferguson & Bråten, 2013; Ferguson, Bråten, & Strømsø, 2012; Gregoire Gill et al., 2004; Hynd-Shanahan et al., 2004; Kienhues et al., 2008; Kienhues, Stadtler, & Bromme, 2011; Porsch & Bromme, 2011; Valanides & Angeli, 2005). Although these studies were typically done in a laboratory-type setting, materials used to foster epistemic change should be taken into consideration in curriculum development. We define curriculum as the instructional content, materials, and resources used to achieve educational objectives. These objectives may include the skills, performances, attitudes, and values that students are expected to learn.

What might the curriculum entail that would foster epistemic change? As noted above, one approach that researchers have found to be generally effective is to use refutational texts, or texts that contain conflicting, contradictory, or paradoxical information. Of course, the level and amount of contradictory information or paradoxical evidence needs to be adjusted as a function of students' age and cognitive abilities. In general, however, we suggest that both beliefs about knowledge and knowing, as well as content and domain-specific epistemology (i.e. methods used within a specific domain regarding the advancement of knowledge and processes of knowing) be embedded within the curriculum. Methods might include the scientific method, the derivation of theorems and proofs, etc., coupled with related content. Content may include various perspectives, acknowledgement of the tentativeness of knowledge claims that are considered true today (e.g. "We used to believe that the world was flat…"), and open-ended problems that can be solved via multiple approaches. Research also suggests that activities or problems that students are given should be connected to the real world, rather than decontextualized, and appropriately challenging rather than quickly learned or solvable (e.g. Higgins, 1997; Muis, 2004).

To foster change about the source and justification for knowing, students should also be taught to evaluate sources of information (Hynd-Shanahan et al., 2004). Students can be taught to ask questions such as "When was the source published? Is it a scholarly peer-reviewed source, or something from popular press? Who is the authority and what are his/her credentials? Is the source of information from primary or secondary research?" Coupled with evidence regarding the quality of the claims made, students may begin to recognize what constitutes good sources of knowledge and processes for justification for each content area. Although it is important to develop curricula that are designed to foster epistemic change, it is just as important to develop assessment tools that are aligned with the curriculum. That is, if students are expected to think critically about content, and are presented with content that may be contradictory, then assessment tools and techniques that are used to measure learning must also reflect the same underlying epistemology. We describe this next.

### *Evaluation*

Assessment, whether in the form of assignments or tests, has been identified as a defining feature of student learning. Students' experiences and perceptions of evaluative tasks are closely related to their approach to learning, or the way they think about learning or studying (Entwistle & Entwistle, 1991; Ramsden, 1997; Struyven, Dochy, & Janssens, 2005). In other words, "most students will learn the forms of knowledge and develop the cognitive abilities that they are asked to demonstrate" (Scouller, 1998, p. 454). Given the link between assessment tasks and learning strategies, epistemic beliefs researchers have recently questioned how assessment practices may relate to students' epistemic beliefs (Chevrier, Muis, & Di Leo, 2015; Haerle & Bendixen, 2008; Muis & Gierus, 2013). The concern is that an increasing "assessment culture," too often answer-oriented, might communicate the idea that knowledge is objective and factual, thus promoting less constructivist views of knowledge (Haerle & Bendixen, 2008).

Haerle and Bendixen (2008) highlight the potential effect of different evaluative methods on students' epistemic beliefs. They suggest that assessment methods that overly focus on answers may enforce less constructivist epistemic beliefs by sending the message that knowledge is right or wrong, and by conveying the belief that knowledge is certain and simple. Empirical studies have also shown that different types of assessment tasks trigger more or less constructivist responses (Bromme et al., 2010; Pieschl, Bromme, Porsch, & Stahl, 2008). Whereas it might be audacious to claim that a given assessment task is "constructivist" or "not constructivist" simply by its format (e.g. multiple-choice test versus essay), empirical research has shown that more complex, less structured, or more challenging tasks elicit mental processes (e.g. knowledge elaboration, integration of new knowledge into prior knowledge, critical thinking) that are more aligned with constructivist learning (Bromme et al., 2010). On the contrary, tasks that are simple, overly structured, or that require only "find" and "memorize" operations elicit learning processes that do not align as well with constructivist views of learning.

Accordingly, we argue that if the epistemic climate includes more constructivist pedagogical approaches to foster epistemic change, then assessment practices that target learning outcomes must also be constructivist. How can teachers align evaluations with a constructivist pedagogy to help students understand the complexity of knowledge? We recommend that students be exposed to the assessment criteria, and that teachers explicitly link those criteria to facets of knowledge and knowing. Using Bloom's revised taxonomy (Anderson, Krathwohl, & Bloom, 2001), tasks can be ordered according to the complexity of the cognitive operations necessary for task completion. Less constructivist tasks include remembering and understanding content, whereas more constructivist tasks include applying, analyzing, evaluating, and creating content. To illustrate the different levels of complexity, Kloss (1994) suggests that students be provided a set of questions about the same content that illustrate the various levels of complexity. Teachers can provide scaffolding to help students develop answers to those questions, and then discuss as a class the nature of those answers to highlight the link between the answers and facets of knowledge and knowing. Further, the option for formative feedback on assessments may also highlight knowledge as a tentative, evolving construct rather than a fixed entity.

Undeniably, developing each aspect of the epistemic climate toward a more constructivist approach is not an easy task. It is likely that teachers instilling an epistemic climate as described above will meet student resistance, when the latter are asked to struggle with the ambiguity, paradox, and critical thinking required in this new learning environment. What was once seemingly black and white (e.g. "In mathematics, it's more known. What's known is known" [Muis, Duffy, Trevors, Ranellucci, & Foy, 2014]) would now be elusive, foreign, and most likely counter to their espoused epistemic beliefs. Students will likely struggle with these new expectations, and may find the requirement of critical thinking and rigorous analysis particularly taxing (Kloss, 1994). Indeed, we predict that teachers are likely to experience similar struggles as they shift the epistemic climate in their classroom and their own personal epistemic beliefs about teaching and learning (Windschitl, 2002). As Perry (1989) noted, every step in the change process involves not only the joy of realization but also of a loss of certainty and an altered sense of self. The cognitive incongruity that students experience may trigger epistemic doubt, anxiety, sadness, and confusion (Bendixen & Rule, 2004). As such, it is imperative that teachers support students through this change process, which is the last facet of our framework.

### *Support*

Undoubtedly, students may be uncomfortable when asked to think independently, offer their own opinions, or draw their own conclusions. Given that students typically believe that teachers have all the right answers, and should tell students what they "need to know" (Muis, 2004), teachers must be prepared to provide the support that students need during epistemic change. We define support as any scaffolding that teachers provide during the change process, such as explicit modeling of critical thinking or resolution strategies (Muis & Duffy, 2013), opportunities for students to discuss their beliefs, or acknowledgement of the negative emotional experiences that students may face during epistemic change.

First, students need the skills necessary to engage in critical thinking, to be able to grapple with conflicting evidence, and to evaluate various approaches to problem solving or sources of information. These skills can be directly taught through teacher modeling and student practice (Zimmerman, 2000). Students should also be provided opportunities to directly discuss their beliefs about knowledge and knowing, and whether teachers' expectations are consistent with their own. If students experience cognitive incongruity, teachers should acknowledge the legitimacy of their beliefs, and reinforce the idea that change is possible and fruitful. As Pintrich et al. (1993) noted, there are four conditions necessary for conceptual change to occur and, like others (Bendixen & Rule, 2004; Gregoire Gill et al., 2004; Muis et al., 2006), we agree that these four conditions are also necessary for epistemic change. First, individuals must be dissatisfied with current conceptions. Unless individuals have a good reason to abandon their beliefs, it is unlikely they will do so. Second, new conceptions must be intelligible; that is, individuals must be able to understand their new beliefs. Third, new beliefs must be plausible, such that individuals must be able to adequately apply their new beliefs. Finally, new conceptions must be fruitful for further inquiry. Coupled with the other facets of our PACES framework, teachers must make explicit connections between each component to ensure students understand the purpose and value of their new classroom epistemic climate.

Finally, teachers can help students through the negative emotional experiences by normalizing those experiences. That is, by sharing personal experiences with students about the change process (e.g. "I experienced this too. Everyone does, and it is normal to feel this way."), students may be less likely to feel alone. As Perry (1985) aptly stated, "Like all mourning, it is less costly when 'known' by another. When a sense of loss is accorded the honor of acknowledgement, movement is more rapid and the risk of getting stuck in apathy, alienation, or depression is reduced" (p. 108).

## SUMMARY AND CONCLUSIONS

Taken together, the majority of research that has explored facets of the epistemic climate for epistemic change has focused primarily on one component in isolation, such as the instructional approach, teachers' beliefs, assessment practices, or text-based curriculum, rather than their collective influence (cf. Muis & Duffy, 2013). Based on our theoretical framework, we suggest that researchers combine multiple facets of the epistemic climate to foster powerful and lasting epistemic change. By aligning pedagogical approaches with authority, curriculum, assessment, and support, we predict that epistemic change may be more rapid and longer lasting than has been demonstrated in past research. Of course, this task will not be easy for teachers to implement into their classrooms, nor will it be easy for researchers to measure.

Methodologically, measuring each facet of the epistemic climate, PACES, will require observational techniques to ensure implementation fidelity. Measuring teachers' and students' epistemic beliefs will also pose a particularly difficult challenge, as a sole reliance on self-reports should not be tolerated (Greene et al., 2010). Rather, epistemic beliefs should be measured through trace methodologies, and must entail some measurement of their expressed form via epistemic cognition. Epistemic strategies enacted during authentic learning tasks may be captured through think-aloud methodologies, and other processes that align with more constructivist beliefs, such as critical thinking, should also be assessed. Students' epistemic emotions may be another facet that is important to measure, given the relation of epistemic emotions to learning processes such as critical thinking and elaboration of content (Muis et al., 2015). Finally, the products that students create should also be evaluated to ensure alignment, which requires consideration of the types of assessments teachers use to measure learning outcomes. These demands are a tall order, but we believe future research that integrates these facets and triangulates multiple methodologies will provide a rich portrait of the epistemic climate necessary for productive and lasting epistemic change.

## NOTES

1 Although the stable, structural change in the collective co-activation of several related epistemological resources (i.e. epistemological frames) across contexts, as described by Elby and Hammer (2010), is more akin to our current definition of epistemic change.
2 The CAEB assesses two epistemic beliefs dimensions, texture and variability of knowledge, which closely but not entirely correspond to simplicity and certainty dimensions in Hofer's (2000) framework, respectively.
3 Throughout this chapter, we consider critical thinking as a higher-order thinking skill closely associated with metacognition and epistemic cognition. Kardash and Scholes (1996) proposed that epistemological assumptions that support critical thinking include the notion that not all problems have one right answer, that what is at one point held as true can change, and that what seems contradictory can sometimes come together in a new light. Critical thinking therefore requires a certain level of epistemic development.

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# 22

# EPISTEMIC COGNITION INTERVENTIONS

## Issues, Challenges, and Directions

*Ivar Bråten*



## INTRODUCTION

From an educational perspective, the four chapters included in the Handbook section on epistemic cognition interventions could be considered the icing on the cake. Thus, although educational researchers, policymakers, and practitioners may read about different perspectives on epistemic cognition, how epistemic cognition plays out in different contexts, and ways of measuring and modeling this construct with great interest, the questions that linger in their mind after studying those issues may boil down to a simple, yet somewhat disturbing and challenging one: "So what?" Fortunately, the four chapters that comprise this Handbook section bear evidence that epistemic cognition researchers have made considerable headway in understanding how more adaptive epistemic cognition may be promoted at different educational levels. The authors of these chapters not only review previous and current intervention work targeting students' epistemic cognition, they also raise a number of issues where further investigation is needed to move the field forward and clarify its educational implications. In this response chapter, I first note some salient commonalities among the four chapters included in this section and suggest that, despite this common ground, additional investigation is needed to clarify the underlying ideas and concepts. Second, I pose and discuss some issues that, based on my reading of the four chapters, I find particularly important to address for those wanting to design, implement, and evaluate interventions to change students' epistemic cognition. Finally, I suggest some directions to advance research on interventions for epistemic change.

## CHALLENGING COMMON GROUND

In this section, I want to challenge the common ground being taken by the chapter authors regarding three issues related to epistemic change. These concern the mechanism of epistemic change, the general importance of multiple perspectives, and the role of higher-order thinking in epistemic change. The three subsections that follow address these issues.

### *Mechanism of Change*

In reading through the chapters in this section, I was struck by the authors' shared adherence to Bendixen's (2002; Bendixen & Rule, 2004; Rule & Bendixen, 2010) description of the conditions and components of epistemic change. Thus, despite using somewhat different terms, they all seem to accept the view that under conditions where students feel that their thinking about the nature of knowledge and the process of knowing (i.e. their epistemic cognition) is inadequate in light of new information (i.e. "dissonance" according to Bendixen and Rule), a mechanism of change consisting of the three interrelated components of epistemic doubt, volition, and resolution strategies may come into play. While this is certainly a reasonable and potentially fruitful way to conceptualize the epistemic change process, which also accords quite well with work within conceptual change (Dole & Sinatra, 1998), it is important to note that this mechanism essentially lacks empirical backing. In particular, much more work using online data, in which the term "online" refers to learners' moment-to-moment processing while they perform a task (e.g. study a website to inform themselves about a particular issue; Anmarkrud, McCrudden, Bråten, & Strømsø, 2013), is needed to test and, possibly, revise the workings of the mechanism of change components posited by Bendixen and colleagues. For example, when Ferguson et al. (2012) had Norwegian undergraduates work with multiple conflicting documents on a controversial science issue, the mechanism of change components of epistemic doubt and resolution strategies were identified in think-aloud protocols. However, the postulated component of volition, that is, the intention and commitment to overcome epistemic doubt, was rarely observed in the data, and epistemic doubt and resolution strategies did not occur in any clear sequence, with resolution strategies both occurring in protocols where no doubt was observed at all and preceding epistemic doubt rather than following it. In brief, given that Bendixen and colleagues' framework seems to have become common ground for researchers seeking to understand epistemic change, much more work is needed to test its merits.

### *Multiple Perspectives*

A related notion that seems to cut across the four chapters in this section is that a good way to create cognitive dissonance and induce epistemic doubt is to have students engage with multiple perspectives on an event, topic, or issue. Thus, whether such perspectives are presented orally or textually, whether the perspectives are embedded in the same source (e.g. a refutational text) or are conveyed by distinct sources, whether the perspectives are presented concurrently or consecutively, and whether the perspectives are presented for a short or a long time, they are assumed to challenge students' epistemic cognition and instigate processes of epistemic change. This homage to multiple perspectives in educational settings may have a downside, however. According to the influential cognitive flexibility theory of Spiro and associates (e.g. Jacobson & Spiro, 1995; Spiro, Coulson, Feltovich, & Anderson, 1994; Spiro, Feltovich, Jacobson, & Coulson, 1991), gaining a rich and flexible understanding of a complex knowledge domain requires a "crisscrossing" of it from multiple intellectual perspectives. In this view, contrasting perspectives located in multiple sources may highlight the interrelated and web-like nature of knowledge and encourage students to assemble knowledge components for application in new situations (Jacobson & Spiro, 1995). It should be noted, however, that cognitive flexibility theory suggests that such crisscrossing requires adaptive epistemic cognition at least as much as it promotes it. Accordingly, in an early study exploring this issue, Jacobson and Spiro (1995) found that only students who preferred working with complex knowledge in multiple ways, and valued active learner construction of knowledge, were able to profit from the reading of multiple texts presented in a hypertext environment. Likewise, in a later study, Bråten and Strømsø (2006) found that students' epistemic cognition moderated the effects of working with multiple conflicting documents on their deeper understanding of a controversial issue, with only students considering knowledge to be tentative and complex able to benefit from this challenging learning environment, and with students displaying less adaptive epistemic cognition actually better off in terms of deeper-level comprehension when studying the same issue in a single, textbook-like source (see also Bråten, Britt, Strømsø, & Rouet [2011], for a more recent discussion of the epistemic cognition requirements of dealing with multiple perspectives located in different documents). Moreover, emerging theory and research on multiple document comprehension (Britt, Rouet, & Braasch, 2013; Goldman, 2004; Rouet, 2006) have clearly indicated that building an integrated understanding from source materials expressing diverse and even contradictory perspectives is a great challenge to individuals regardless of age, requiring a variety of personality, cognitive, and motivational resources in addition to those belonging to the epistemic realm (Bråten, Anmarkrud, Brandmo, & Strømsø, 2014). In brief, much more research is needed on how to adapt instruction focusing on multiple perspectives to the current resources of individual students to ensure that not only the best equipped ones are able to reap the potential benefits of such challenging learning environments, consistent with the Matthew Effect or "rich-get-richer" phenomenon described by Stanovich (1986). See Bråten, Gil et al. (2011) for further discussion of how students who are not yet ready to benefit from challenging tasks involving multiple perspectives may be supported through instruction directed towards the individual student or collaborating groups of students.

### *Higher-Order Thinking*

A third area in which there seems to be a general consensus among the chapter authors concerns the importance of higher-order thinking, such as reflection, critical thinking, and argumentation. Thus, such higher-order thinking processes, directed towards students' own epistemic cognition (e.g. reflection on epistemic beliefs), as well as the multiple perspectives they encounter (e.g. critical thinking to evaluate different perspectives), are generally seen as playing a major role in epistemic change within this Handbook section. How the relationships between those other higher-thinking processes and epistemic cognition should be conceptualized is currently not clear, however. Take argumentation skills, for example, which concern competencies in identifying and weighing positive and negative attributes of conflicting perspectives on a particular issue, taking relevant reasons and evidence for the different perspectives into account (Kuhn & Crowell, 2011). On the one hand, fostering such skills through instruction may be seen as a way to promote more adaptive epistemic cognition in students; on the other, adaptive epistemic cognition may be seen as a prerequisite for mastering argumentation tasks in the context of multiple perspectives (Bråten, Ferguson, Strømsø, & Anmarkrud, 2014; Bråten, Gil, & Strømsø, 2011). Indeed, several higher-order thinking skills, including argumentation, are sometimes described indistinguishably from epistemic cognition in current intervention work, which raises the question of what demarcates the boundaries between the constructs. For example, if researchers use the terms argumentation and epistemic cognition with considerable overlap in meaning, why is there a need to focus on epistemic cognition as a particular target for intervention? In brief, then, given that not all higher-order thinking processes should be considered epistemic cognition, which, arguably, would make the entire field of epistemic cognition as well as this Handbook superfluous, more conceptual and empirical work is needed to map the conceptual landscape and locate epistemic cognition in a causal network together with other (i.e. non-epistemic) higher-order thinking processes. In turn, such work could inform the building of viable instructional models in the aera of epistemic cognition intervention.

## FURTHER ISSUES OF CONCERN

In addition to the commonalities noted above and the challenges they imply, my reading of the chapters in the intervention section drew my attention to three essential issues in need of further clarification and investigation. These concern the building of empirically based, testable instructional models, the meaning of epistemic change, and the (non-) availability of sensitive measures. I address each of these issues in the following.

### *Instructional Models*

Arguably, the area of epistemic cognition intervention has, until quite recently, been essentially devoid of instructional models to guide interventions for epistemic change. In this regard, the chapters included in this section represent important steps in the right direction, yet signal that much work remains before available models provide precise tools for researchers and practitioners wanting to design and implement interventions for epistemic change. Thus, while the dialogic teaching model of Reznitskaya and Gregory (2013), which was discussed by Bendixen (2016/this volume), the 3R (Reflection, Reflexive thinking, Resolution) model proposed by Brownlee et al. (2016/this volume), and the PACES (Pedagogy, Authority, Curriculum, Evaluation, Support) approach elaborated by Muis et al. (2016/this volume) all build on relevant theory and draw on existing empirical work, the empirical support for several aspects of these instructional models is still quite meager. For example, the suggested effects of implementing the particular six-step sequence of "meta-reflexive practice" described by the 3R model (Brownlee, Schraw, Walker, & Ryan, 2016/this volume) on preservice teachers' epistemic cognition are thus far not documented, and the powerful and lasting epistemic change assumed to follow from the implementation of a range of features of an epistemic classroom climate (Muis, Trevors, & Chevrier, 2016/this volume) are yet to be seen. Moreover, these instructional frameworks describe very complex, multicomponential approaches to teaching for epistemic change that are hardly amenable to deriving specific testable hypotheses for experimental work (see also Sandoval, 2012). For example, the PACES approach of Muis et al. (2016/this volume) seems to require very different schools and classrooms in terms of educational practice, involving fundamental changes with respect to teaching, curriculum, assessment, etc. In comparison, successful interventions of varying length in a related area concerning student views on ability (i.e. implicit theories of intelligence) build on a precise conceptual model that guides randomized experimental studies designed to test specific hypotheses derived from the framework (Walton, 2014; Yeager & Dweck, 2012; Yeager & Walton, 2011), with these interventions also being effective at a large scale (Paunesku et al., 2015). As another example, the educational applicability of Zimmerman's (2000) well-specified model of self-regulated learning has been demonstrated in much intervention work (Bembenutty, Cleary, & Kitsantas, 2013). While such well-specified and testable instructional models are an ideal in the area of epistemic cognition interventions as well, the heuristic value of the instructional frameworks discussed in this Handbook section should not be underestimated. Among the heuristic advantages of the current instructional frameworks is that they may spark subsequent empirical work that has the potential to refine and specify those frameworks as well as the theoretical models on which the instructional frameworks build. In this way, empirical work inspired by the current instructional frameworks may also help to clarify underlying theory that, in turn, can provide a more solid theoretical foundation for thinking about ways to change epistemic cognition in instructional contexts. In particular, further conceptual work is needed to clarify such issues as the meaning of epistemic change and the suitability of measures for determining whether an effort to promote epistemic change was effective, which are the issues that I turn to next.

## *The Meaning of Epistemic Change*

A fundamental issue when building instructional frameworks for epistemic change is to clarify the meaning of epistemic change itself, that is, what kind of change the proposed instruction is intended to bring about. Presumably, epistemic cognition may change not only as a result of particular interventions but also as a result of individuals' interactions with the sociocultural context, both in and out of school. While the latter form of change, as described in models of epistemic development (e.g. Kuhn, 1991; Chandler, Hallett, & Sokol, 2002), denotes a long-term "naturally occurring" progression through stages that depends on social interaction across the lifespan, both in and out of school, epistemic change, as used in the intervention work described in this section (Kienhues, Ferguson, & Stahl, 2016/this volume; Muis et al., 2016/this volume), seems to denote a quicker, yet (hopefully) enduring change in epistemic cognition resulting from specific educational interventions designed to bring about such change. The relationship between the epistemic change brought about by particular educational interventions to change it and epistemic change as described in developmental models is far from clarified, however. For example, can the epistemic change that results from intervention work be described in terms of the same broad stages that feature in developmental models, such as a change towards evaluativist thinking (e.g. Valanides & Angeli, 2005), or are such changes better described as occurring along dimensions of independent domain-specific or topic-specific epistemic beliefs, such as stronger beliefs in tentative knowledge or the need to justify knowledge claims by multiple sources in relation to a particular domain or topic (e.g. Ferguson & Bråten, 2013; Kienhues, Stadtler, & Bromme, 2011; Muis & Duffy, 2013)? Other questions wide open for future research concern whether individuals' broad epistemic stances or worldviews (e.g. absolutist, multiplist, and evaluativist thinking; Kuhn, Cheney, & Weinstock, 2000) may moderate the effects of educational interventions for epistemic change, and whether more specific, restricted changes resulting from educational interventions may feed into and influence (i.e. change or accelerate) individuals' broadly based developmental trajectories.

The form of epistemic change that is focused upon in much of the current intervention work may not only be distinguished from long-term, naturally occurring epistemic development, but also from short-lived variations in epistemic cognition in response to specific situational demands, as described in the contextualist resource view of Hammer and Elby (2002; see also Elby & Hammer, 2010). In that view, students may respond adaptively or maladaptively to specific classroom tasks by activating and deactivating existing fine-grained epistemic resources without necessarily changing the epistemic resources themselves. The relationship between such situational variation and the epistemic change resulting from the interventions that are described in this section is also not clear, however. It is an open question, for example, whether the effects of brief exposures to multiple perspectives, which characterize some recent intervention work (Ferguson & Bråten, 2013; Kienhues et al., 2011), are better described as situational adaptations of existing cognitive (including epistemic) resources to specific task demands than as real changes in domain- or topic-specific epistemic cognition, as suggested by Kienhues et al. (2016/this volume) in drawing upon the "generative" perspective of Bromme et al. (2008). In turn, this raises the question of which resources or components are required for adaptive epistemic cognition to take place in a particular task context, as well as how the resources or components of situated epistemic cognition themselves may be changed to facilitate more adaptive epistemic cognition within and across particular task contexts.

Of course, different educational interventions may lead to different types of epistemic change. This means that rather than trying to circumscribe the form of epistemic change that can be expected from educational interventions per se, it may be more fruitful to try to detail the type of changes that may result from the implementation of the particular instructional model one has in mind, with such changes potentially ranging from broad enduring changes in epistemic stances or worldviews, as described within the developmental approach (e.g. Kuhn, 1991), to specific transient changes in the configuration of epistemic resources to deal with particular contextual challenges, as described by the contextualist resource view of Hammer and Elby (2002) and the generative approach of Bromme et al. (2008). Preferably, the extent to which the epistemic change that is likely to follow from the implementation of a particular instructional model can be expected to influence other types of epistemic change (e.g. whether context-sensitive transient changes can be expected to lead to more stable or general changes; Elby & Hammer, 2010) should also be delineated, as well as the consequences for academic performance that may ensue.

This leads me to a final point regarding the meaning of change that emerges from the chapters in this section. Too often has epistemic change in and of itself been the target of intervention work, and too seldom has the productivity of such change been investigated in terms of improved academic performance. For example, it is one thing to demonstrate that presenting students with multiple perspectives on a particular issue may induce them to think that knowledge regarding that issue, or even regarding the domain to which that issue belongs, is tentative and complex rather than certain and simple; it is another to demonstrate that such epistemic change is not only an expression of increased confusion or resignation but actually leads to more constructive task processing and better performance. On this background, the call by some chapter authors (Kienhues et al., 2016/this volume; Muis et al., 2016/this volume) for more intervention work that supplements data on epistemic cognition with performance data to investigate the extent to which observed epistemic change is reflected in better performance is timely and pertinent. The same is true of Brownlee et al.'s (2016/this volume) proposal that changes in preservice teachers' epistemic beliefs should be studied in conjunction with changes in their teaching practice (see Buehl & Beck [2015] for a recent discussion of internal and external factors that may support or hinder a connection between teachers' beliefs and teachers' practices). Of note is also that improved academic performance is not the only outcome of interest for research on epistemic cognition interventions. That is, of equal, and maybe even greater, interest are the potential benefits of such interventions for life outside school, for example for being able to judge the credibility of sources when encountering competing knowledge claims about controversial socio-scientific issues (e.g. climate change or the safety of nuclear power plants) in popular media, as well as for genuine participation in democratic discourse concerning how such issues can be solved. In any case, measures that can sensitively capture different types of intended and expected changes in epistemic cognition are highly needed.

### *The Need for Suitable Measures*

In reading the chapters included in this section, self-report measures of epistemic beliefs at different levels of specificity (i.e. ranging from domain-general to topic-specific) stood out as the most commonly used assessment tool for demonstrating epistemic change. These measures provide offline rather than online data, meaning that individuals' perceptions of their own epistemic cognition are assessed outside the context of ongoing task performance. Departures from this main route also exist, however, as especially evidenced in intervention work taking place in elementary school science, mathematics, and history classrooms. Thus, as reviewed by Bendixen (2016/this volume), a number of studies at that level and in those subjects have utilized a range of quite labor-intensive process-oriented data-collection procedures, such as interviews, think-alouds, observations, field notes, analysis of written work, and task performance (cf. Kelly, 2016/this volume; Mason, 2016/this volume), to document epistemic change. And, at the same time, several of the chapter authors in this section (Bendixen, 2016/this volume; Kienhues et al., 2016/this volume; Muis et al., 2016/this volume) call for increased use of more qualitative and process-oriented methodologies (e.g. interviews, observations, and think-alouds) in next generation intervention research.

So, what is wrong with using questionnaires in epistemic cognition intervention research? After all, much of what is known about epistemic cognition and how it is related to other constructs is based on this methodology. Of course, this response chapter is not a venue for critiquing the use of questionnaires in educational and psychological research in general, or in research on epistemic cognition in particular (see Kelly, 2016/this volume; Mason, 2016/this volume). One notable limitation in the context of epistemic cognition intervention research, however, is that these self-report measures were not designed for the purpose of testing whether efforts to change processes of epistemic cognition are effective or not. Rather, they were designed for the purpose of theory development, that is, for understanding the construct of personal epistemology (or, more specifically, epistemic beliefs) and testing relations between aspects of that construct and outcomes, for example, relations between beliefs about the certainty and simplicity of knowledge and academic achievement (e.g. Schommer-Aikins, 2004). The form of epistemic cognition that is targeted by such measures can therefore be regarded as more stable and global than the form of epistemic cognition that can be expected to change in many interventions. This may be particularly true when such interventions are relatively brief and target more easily modifiable and specific aspects of epistemic cognition, for example, students' consideration of the need to cross-check information sources when encountering conflicting perspectives on a given scientific controversy. In such instances, measures that assess behaviors that indicate adaptive epistemic cognition are needed, for example measures that involve choices between more or less useful information in a particular task situation (McCrudden, Stenseth, Bråten, & Strømsø, in press). Other options include measures that focus on cognitive processing as indicated by think-alouds or eye movements (Ferguson, Bråten, & Strømsø, 2012; Greene, Yu, & Copeland, 2014; Mason, Pluchino, & Ariasi, 2014), or on trace logs created by software (Greene, Muis, & Pieschl, 2010), for example in the form of navigation data (Mason, Junyent, & Tornatora, 2014). Of note is that a further advantage of such processing data, that is, in addition to the increased sensitivity to epistemic change, is that they may give insight into how potential improvements in performance as a result of epistemic interventions may be mediated by more constructive task processing.

In other instances, however, implementations of broad, long-term interventions for epistemic change may actually aim at changing more stable epistemic beliefs (e.g. the belief that knowledge in history mainly consists of a catalogue of facts) or even general epistemic stances or worldviews (e.g. a multiplist epistemic stance in which multiple conflicting perspectives are seen as equally valid), in which cases the use of self-report measures targeting such personal epistemologies seems more appropriate. Thus, the point is that the choice of measures to document epistemic change should reflect the type of change that is intended and expected based on a particular instructional framework (which, preferably, should be specified by that framework, as noted above). Such tailoring of measures to the type of change that is relevant to a particular instructional approach also increases the chances of using measures that are sensitive to the type of change that may follow from an approach.

Of course, in some instances, intervention researchers may want to use several types of measures that are differentially sensitive to different types of epistemic change, for example because they expect (or at least hope) that several types of changes may follow from the intervention (e.g. immediate productive adaptations to a particular task context as well as longer term changes in topic- or domain-specific beliefs). This makes different types of measures, for example cognitive processing measures (think-alouds or eye movements) as well as belief questionnaires, pertinent, with questionnaires possibly used for assessing long-term effects of the intervention. Dismissing one particular type of measure from the toolbox of epistemic intervention researchers at this point of time may therefore seem like a somewhat hasty solution (see Mason, 2016/this volume, for a similar conclusion).

## FUTURE DIRECTIONS

Based on the preceding discussion, I conclude this chapter with some future goals for research on epistemic cognition interventions. One of those is to further examine the basic conditions and components of epistemic change, currently conceptualized in terms of dissonance, epistemic doubt, volition, and resolution strategies (Bendixen & Rule, 2004). Presumably, a firmer grounding of this preliminary view, which much current intervention work seems to build on, will require analyses of online, that is, processing data, for example in the form of think-alouds collected over an extended period of time while individuals engage with meaningful tasks that challenge their current thinking about knowledge and the process of knowing.

A second goal is to examine more closely the effects that presenting students with multiple perspectives on a topic or issue may have on their epistemic cognition. Particular challenges for this research will be to study potentially differential effects of varying presentation formats (e.g. multiple perspectives embedded in the same source versus multiple perspectives voiced by distinct sources) and the extent to which the effectivity or efficiency of this approach may vary with individual differences and students' level of learning within a domain (i.e. introductory versus more advanced levels). Additionally, the longevity and transfer of epistemic changes potentially fostered by working with multiple perspectives should be assessed in future research.

A third goal is to study relationships between epistemic cognition and other pertinent twenty-first century higher-order thinking skills, such as cognitive reflection, unbiased reasoning, critical-analytic thinking, and argumentation. For example, both longitudinal studies where a hypothesized model is tested over an extended period of time and experimental studies where certain variables are manipulated for the purpose of assessing changes in other variables may contribute to unraveling causal relations between such variables.

A fourth goal is to gradually construct instructional frameworks with a more solid empirical foundation from the heuristics that currently exist, such as the meta-reflexive practice described by Brownlee et al. (2016/this volume) and the epistemic climate features related to pedagogy, authority, curriculum, evaluation, and support suggested by Muis et al. (2016/this volume). Hopefully, the preliminary frameworks discussed in this Handbook section will, eventually, form the basis of specific testable hypotheses that can drive theory development as well as increase the field's educational importance. Closely related to this fourth goal are the goals of trying to specify the type of epistemic change that may follow from the implementation of a particular instructional framework and the way this type of change may be sensitively measured.

Thus, a fifth goal is to try to specify the effects of particular epistemic cognition interventions in terms of breadth, length, and productivity. Presumably, epistemic changes may vary in breadth from specific attunements of epistemic resources to particular task contexts to broad changes in epistemic stances or worldviews, and in length from short-lived, transient changes to enduring ones. Further, epistemic changes may be more or less productive in terms of academic performance, with further demonstrations of productivity needed to justify the incorporation of epistemic cognition interventions in regular classroom activities. Preferably, the value of interventions to change epistemic cognition for individuals' life outside school should also be demonstrated.

Finally, measures tailored to different types of epistemic change are highly needed in the area of epistemic cognition intervention. In particular, more use of behavioral measures that are sensitive to context-specific, short-term changes in epistemic cognition seems warranted. Hopefully, new measures of this kind will be developed that are also brief and easy to use so that practitioners can use them repeatedly in the classroom. In the meantime, observations of individuals' participation in specific practices of knowledge construction and evaluation (e.g. including discussions with peers, think-alouds, and software-tracked traces of task processing), the artifacts they produce during those practices (e.g. summaries, explanations, and arguments), and their reflection on those practices and the artifacts they produce (e.g. during cued, retrospective interviews; cf. Sandoval, 2012), may provide windows on epistemic cognition through which even context-specific, short-term changes can be registered. However, rather than banning self-report epistemic cognition measures from all intervention work, as some criticism towards such measures might suggest (see Mason, 2016/this volume), this methodology can still be regarded as a valuable way to capture more global, enduring changes that can be expected to follow from some interventions, for example, interventions targeting students' epistemic beliefs.

In conclusion, the issues discussed in this response chapter indicate that lingering questions concerning the educational implications of epistemic cognition research cannot be answered without carefully considering issues dicussed in the other sections of the current Handbook. After all, epistemic cognition interventions do not constitute an island in a sea of epistemic cognition research but, rather, raise issues inextricably interwoven with issues concerning different perspectives on epistemic cognition, contextuality, measurement, and modeling that are throroughly discussed by the authors of the four remaining sections.

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# Section V

## Measuring and Modeling Epistemic Cognition

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# 23

# PSYCHOLOGICAL PERSPECTIVES ON MEASURING EPISTEMIC COGNITION

*Lucia Mason*



## INTRODUCTION

The purpose of this chapter is to critically review theory and research on relevant aspects of the measurement of epistemic cognition, and to highlight the changes that have occurred in this area of investigation in the last decades. To deal with measurement implies addressing theoretical issues, as measurement is strictly related to theory. The chapter first introduces the classic approaches to the study of epistemic cognition. Each approach is characterized in terms of construct definition and related measurement. It will be evident that the construct has been conceived in different ways, and consequently has also been measured through different methods. These are critically reviewed to highlight potentials and limitations. The chapter then introduces more recent approaches that have led to articulating and expanding the construct, as well as to outlining how new approaches to measurement may overcome the limitations of the instruments most commonly used. The issues of the specific level at which to measure epistemic cognition, and the cultural aspects that need to be considered are also presented because of their implications for measurement. Finally, current trends are presented and the features of proposed measures are outlined. The chapter ends with overall implications for theory, research, and practice.

In the literature, both the terms *epistemological* and *epistemic* are still used to refer to beliefs about the nature of knowledge and the process of knowing, although recently, the latter has been used to a greater extent. For the purpose of conceptual and lexical clarity, some scholars in the field of educational psychology (Murphy, Alexander, Greene, & Edwards, 2007; Alexander & Sinatra, 2007) proposed to distinguish beliefs about knowledge and knowing (*epistemic*) from beliefs about the study of knowledge (*epistemological*). Some years earlier, from a philosophical perspective on psychology, R. F. Kitchener (2002) argued in favor of the distinction of two different levels: the epistemic level and the theory of the epistemic level. It is most likely that students have *epistemic* beliefs. I therefore consistently use the adjective *epistemic* to refer to beliefs as personal, implicit or explicit, assumptions about the nature, source, and justification of knowledge. Throughout the chapter, the adjective *epistemic* is used when reviewing theories and studies that use the adjective *epistemological* to refer to these beliefs.

Research is not only focused on beliefs but also on the processes that form these beliefs and their influences on learning outcomes. The term *epistemic cognition* has been proposed as a more adequate general term as it "emphasizes knowledge and the processes involved in its definition, acquisition and use" (Greene, Azevedo, & Torney-Purta, 2008, p. 143). Consistently, I use the overarching term *epistemic cognition* to refer to both representations and processes.

## CLASSIC APPROACHES TO CONCEPTUALIZATION AND MEASUREMENT OF EPISTEMIC COGNITION

Research on cognition about the nature and source of knowledge, its truth value, and the justification criteria of assertions, has flourished after Perry's (1970) pioneering work. Different lines of investigation since then are characterized by different conceptual frameworks and methodological perspectives (Hofer, 2004b). These lines are reviewed here to make clear the diversity of theoretical points of view and their implications for measuring epistemic cognition. It is not an exhaustive review of studies that have been conducted in accordance within these frameworks.

### *Epistemic Cognition as Developmental Progression of Cognitive Structures*

**Construct definition.** Developmental psychologists have defined epistemic cognition in terms of domain-general cognitive structures comprising coherent and integrated representations that characterize a level or stage of cognitive development (Baxter Magolda, 1992; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994; Kuhn, 2000). Kuhn labeled a developmental progression that is shared across these models in terms of relations between objective and subjective positions toward knowledge. This progression is a move from an absolutist to a multiplist to an evaluativist point of view.

According to the *absolutist* view, knowledge is absolute, certain, non-problematic, right or wrong, and does not need to be justified because it is based on observations from reality or authority (i.e. prevalence of the objective dimension). From the *multiplist* position, knowledge is conceived as ambiguous and idiosyncratic, thus each individual has his or her own views and truths (i.e. prevalence of the subjective dimension). At the *evaluativist* level an individual believes there are shared norms of inquiry and knowing, and some positions may be reasonably more supported and sustainable than others. Only at this level are the objective and subjective dimensions balanced, as they are integrated and coordinated, and one does not dominate the other (Kuhn, 2000).

Researchers working within developmental frameworks have argued they follow a particular progression, and evidence of this three-stage sequence of epistemic cognition has been found within later childhood, adolescence, college years, and adulthood. To account for developmental patterns across the lifespan, scholars have posited the three-stage sequence occurs in two iterations, first during childhood and then again in adolescence and beyond (Chandler, Hallett, & Sokol, 2002).

Developmental theorists have considered thinking skills and representations about knowledge to be closely linked. One can find evidence of the development of so-called ways of thinking (Belenky et al., 1986), epistemic reflection (Baxter Magolda, 1992), reflective judgment (King & Kitchener, 1994), and epistemic understanding

(Kuhn, Cheney, & Weinstock, 2000). To exemplify, both King and Kitchener (1994) and Kuhn (2000) examined personal views of knowledge in relation to reasoning about ill-structured problems that present conflicting positions (e.g. who built the pyramids in Egypt or the causes that lead criminals to return to crime after they are released from prison). When individuals reflect and reason on these issues, their underlying assumptions about knowledge and its limits, certainty, and criteria for knowing can be identified.

**Measurement.** Developmental researchers primarily use interviews to assign respondents to a general epistemic level. More or less structured interviews solicit reasoned reflections on issues from which to derive underlying assumptions about knowledge. For example, King and Kitchener (1994) conducted longitudinal and cross-sectional studies, based on the use of the Reflective Judgment Interview, on ill-structured problems that cannot have a clear-cut right answer. The purpose was to assign each respondent to a level of development (e.g. pre-reflective thinking, quasi-reflective thinking, and reflective thinking).

The interview method is appropriate for this theoretical approach as it allows a more exhaustive and potentially more authentic description of how individuals reason on ill-structured problems. Reponses are assumed to rely upon participants' existing repertoire of cognitive skills (King & Kitchener, 1994). Interviews usually provide rich data about an individual's representations and assumptions about knowledge and knowing. They are also very demanding because they are time-consuming and expensive, because trained interviewers must conduct them. Another criticism of interviews is that the global assignment of an individual to a particular level can be problematic when considering the various aspects of epistemic reasoning being examined. In this respect, across ill-structured problems, very often individuals are not assigned to the same level. King and Kitchener (2002) argued their interview may underestimate respondents' cognitive abilities as it poses questions of great difficulty to students who are asked to produce responses "'de novo' and without practice or even much time to collect their thoughts" (p. 57).

Developmental theorists have also used paper-and-pencil instruments involving ill-structured scenarios. Wood et al. (2002) created a paper-and-pencil measure of reflective judgment that asked participants to read short summary statements reflecting different levels of epistemic sophistication. Participants wrote their own short response and then rated on a Likert scale the extent to which given responses were similar to their own.

To make it more feasible than long interviews, Kuhn et al. (2000) also developed a simplified paper-and-pencil instrument to assess levels of epistemic cognition (i.e. absolutist, multiplist, and evaluativist) across judgment domains, as well as in individuals younger than the university students and young adults typically studied. They investigated the transitions from absolutism to multiplism, then to evaluativism, across five judgment domains: personal tastes, aesthetic judgments, value judgments, truth judgments about the social world, and truth judgments about the physical world.

Concerns about this instrument include the non-epistemic nature of the personal taste and values domains, the use of only one question to assess epistemic cognition (e.g. "Can only one of their views be right, or could both have some rightness?"; Kuhn et al., 2000, p. 16), and the lack of specific content on which to take a particular stance. Typically only two generic claims are presented, for example, "Robin thinks the first piece of music they listen to is better. Chris thinks the second piece of music they listen to is better" (Kuhn et al., 2000, p. 317), with no content justifications to support them.

Vignettes, with text and pictures, supplemented by interviews, have also been used by developmental theorists to assess levels of epistemic cognition. In a longitudinal study on the integration of objectivity and subjectivity in epistemic development from ages 10 to 16, vignettes were designed to capture different points along an objective to subjective continuum, from objective "facts" to mixed objective and subjective facts to subjective "values" (Mansfield & Clinchy, 2002).

Although responses to such vignettes also require time-consuming coding, they may be more adequate than fixed-choice formats (Kuhn et al., 2000), especially with children, as they present concrete situations, preventing the risk that they refer to different mental representations of what is described verbally. It is crucial that children rely on the same visualization of the issue under examination when researchers seek to identify the criteria they use in deciding what to accept as true, or what to reject as untrue, and whether they believe that everyone must inevitably agree on the same truth. The closeness and meaningfulness of the vignette to children's everyday experience may be crucial for an accurate picture of their level of epistemic cognition.

### *Epistemic Cognition as Multidimensional Sets or Systems of Beliefs*

**Construct definition.** Epistemic cognition has also been defined in terms of multiple sets of more or less independent beliefs about the nature and acquisition of knowledge, which are not assumed to develop in synchrony (Schommer, 1990; Schommer-Aikins, 2002). Many studies have been conducted on the basis of Schommer's seminal conceptualization and measurement of dimensions of epistemic beliefs. Schommer's (1990) domain-general conceptualization has included dimensions called simple knowledge, certain knowledge, omniscient authority, fixed ability, and quick learning. The first two dimensions of epistemic belief have been described as regarding the nature of knowledge, and the dimension of omniscient authority as regarding the nature of knowing. The last two dimensions regard the nature of learning (Hofer & Pintrich, 1997). In several empirical studies, the dimension of omniscient authority, however, has not emerged as a separate factor (e.g. Schommer, Mau, Brookhart, & Hutter, 2000).

A different approach that shares the multidimensionality of epistemic beliefs, but conceives them as theories, has been advanced by Hofer (2000; Hofer & Pintrich, 1997). In this approach, individuals' views are not a collection of independent ideas, but rather a coherent integration of compatible perspectives. In addition, Hofer proposed different epistemic dimensions than Schommer (1990). In their well-known review, Hofer and Pintrich (1997) posited that beliefs about learning are related to beliefs about knowledge, but should not be considered as epistemic for the sake of conceptual clarity. Therefore, Hofer (2000) considered only dimensions about knowledge and knowing when defining four essential epistemic dimensions:

- *Certainty of knowledge*: the degree to which knowledge is conceived as stable or changing, ranging from absolute to tentative and evolving knowledge
- *Simplicity of knowledge*: the degree to which knowledge is conceived as compartmentalized or interrelated, ranging from knowledge as simple discrete facts to knowledge as complex interrelated concepts
- *Source of knowledge*: the relationship between knower and known, ranging from the belief that knowledge resides outside the self and is transmitted, to the belief that it is constructed by the self

– *Justification of knowledge*: what makes a sufficient knowledge claim, ranging from belief in observation or authority as sources, to belief in use of rules of inquiry and evaluation of expertise

Hofer (2000; Hofer & Pintrich, 1997) not only omitted the two dimensions regarding learning proposed by Schommer (1990), but also added the dimension regarding the justification of knowledge.

**Measurement.** Scholars who have endorsed a multidimensional perspective on epistemic beliefs have adopted self-reports using Likert-type scales to assess degree of agreement with certain statements about knowledge and knowing. Schommer's (1990) questionnaire propelled investigation in the field as it easily allowed survey studies. Several scholars have used Schommer's questionnaire or a modified version, including both beliefs about knowledge and beliefs about learning (Buehl, Alexander, & Murphy, 2002; Kardask & Howell, 2000; Qian & Alvermann, 1995; Schraw, Dunkle, & Bendixen, 1995; Sinatra, Southerland, McConaughy, & Demastes, 2003). Hofer's (2000) questionnaire comprises items regarding the dimensions within the nature of knowledge (i.e. certainty and simplicity) and the nature of knowing (i.e. source and justification), but has no items regarding learning, in accordance with her theoretical position.

As self-report instruments, Schommer's (1990), Hofer's (2000), and similar questionnaires have the great advantage of being easily applied at large scales. They can be administered simultaneously to a large number of students and answers can be readily scored. They can be easily used in studies aimed at examining relationships between epistemic beliefs and facets of academic achievement, such as reading comprehension (Schommer, 1990), problem solving (Schraw et al., 1995), text processing (Kardash & Howell, 2000), and conceptual change (Mason, 2003; Sinatra et al., 2003).

Self-report epistemic questionnaires have been criticized for a number of reasons. First, they have problems from the psychometric point of view of validity and reliability. Validity is problematic as these instruments do not seem to adequately capture all the dimensions included in the construct definition. Hofer (2004a) suggested self-reports seem more useful for capturing the two dimensions about the nature of knowledge (i.e. simplicity and certainty) than the other two dimensions about the nature of knowing (i.e. source of knowledge and justification for knowing) although in some studies the former emerged as only one factor (Qian & Alvermann, 1995; Schommer et al., 2000). Replicability of theorized factor structures underlying self-report questionnaires has been hard to achieve (Clarebout, Elen, Luyten, & Bamps, 2001; DeBacker, Crowson, Beesely, Thoma, Hestevold, 2008). Hofer (2004a) hypothesized the dimensions about knowing are too complex and multifaceted to be assessed using simple Likert-scale measures, but may be more manifest in interviews.

Another issue limiting the validity of epistemic self-reports is related to the complexity of the developmental trajectory. For example, it is difficult to establish what corresponds on a Likert-type scale to the midpoint between the belief in external authorities as true knowledge transmitters and the belief in oneself as an active constructor of knowledge (Muis, Bendixen, & Haerle, 2006). A related concern is that when an individual disagrees with a given item in a questionnaire this does not mean she or he holds a contrary belief (Greene & Yu, 2014).

The low reliability of factors resulting from factor analysis, as well as the use of rather homogeneous samples of college students, are other problems that threaten the reliability of self-report measures of epistemic beliefs. Finally, inaccuracy and inconsistency may undermine the suitability of self-report questionnaires. Students may report their thinking inaccurately because the items of a scale refer to issues that are too difficult, given the deep level of metacognitive engagement required to answer them in a valid and reliable way (Greene et al., 2008). Inconsistency may also threaten psychometric properties. Hogan (2000) indicated that divergences in students' answers to epistemic questionnaires about the nature of scientific knowledge were due to whether they referred to their own science knowledge, or the knowledge of professional scientists.

Scholars who share a multidimensional view of epistemic cognition have also used semantic differential measures. A semantic differential scale aims to capture connotative meanings of epistemic beliefs about a topic, that is, the evaluative judgments a person associates with them. Stahl and Bromme's (2007) Connotative Aspects of Epistemic Beliefs (CAEB) scale is made up of pairs of items expressed through opposing adjectives such as exact–vague, absolute–relative, confirmable–not confirmable, open–closed, dynamic–static, temporary–everlasting. A factor analysis of the 17-item version of the CAEB resulted in two reliable factors that were stable over three data sets regarding the domains of botany, genetics, and physics. The first factor was labeled "texture" and included items regarding the structure and accuracy of knowledge. This "texture" dimension ranged from the belief that knowledge is exact and structured to the belief that it is unstructured and vague. The second factor was labeled "variability" and included items about the stability and dynamics of knowledge. This "variability" dimension ranged from the belief that knowledge is inflexible and static to the belief that it is flexible and changing. The CAEB detected differences between students' connotative epistemic beliefs in the three different domains. Botany was perceived as the most imprecise and inflexible domain, genetics as the most unstable and changing, and physics as the most precise (Stahl & Bromme, 2007). Stahl and Bromme replicated the two-factor structure using confirmatory factor analysis. In a study of implicit evaluations of website reliability, epistemic beliefs about the examined topic were reliably assessed by the CAEB (Mason, Pluchino, & Ariasi, 2014).

Semantic differential scales may be easier and quicker for students to complete accurately, compared to other scales. They may also provide more information than the usual self-reports that focus only on explicit denotative aspects of epistemic beliefs. These scales can be used to gain an impression of epistemic beliefs in large samples of students. Furthermore, detailed comparisons of individual profiles are allowed at item and underlying dimensions levels (Stahl & Bromme, 2007). A limitation of the CAEB is that it is not able to distinguish between denotative and connotative aspects of epistemic beliefs, and measures only the latter through evaluative-associative assumptions.

### *Epistemic Cognition as Situated Resources*

**Construct definition.** Scholars from a situative perspective on learning processes have proposed a finer-grained and context-sensitive definition of the construct. Epistemic resources, as they are called (Hammer & Elby, 2002), are fine-grained representations used in a multiplicity of situations, but are situated in context. They are theorized as cognitive structures activated in a given context but not necessarily in another, as different contexts trigger different resources. Students may have more epistemic resources available regarding the source of knowledge. It depends on the contextual variables of the situation in which the learning takes place, and whether they activate the resource that knowledge is "transmitted stuff" instead of the resource that it is "fabricated stuff" (Louca, Elby, Hammer, & Kagey, 2004). For example, Elby and Hammer (2010) asked

Louis, a college student, how he prepared for his physics test. He said he "studied every word of those homework solutions . . . I was memorizing the book, too" (Elby & Hammer, 2010, p. 411). When asked about his strategy for tutoring other students, he responded: "what I would like to do is to build on what they already know instead of introducing a totally new concept" (Elby & Hammer, 2010, p. 411). In the context of test preparation, Louis's response reflected a view of knowledge based on absorption from authoritative sources. In the context of peer tutoring, his response reflected a view of knowledge as something that is built on what is already known. This meant that both epistemic resources were available to Louis and were triggered in different contexts.

The epistemic resources model rejects two essential conceptions that underlie the developmental and systems models (Hammer & Elby, 2002). The first rejected conception is that epistemic beliefs are components of the declarative knowledge of students, accessed consciously and articulately by asking them appropriate questions. In contrast, Hammer and Elby have argued students do not usually reflect in explicit and direct ways on the nature of science and scientific knowledge in their science classes. The second rejected conception is that individuals have "trait-like beliefs." Therefore, even if students cannot access their representations about knowledge directly and explicitly, they can access other aspects of their habits and preferences from which the epistemic aspects can be derived.

According to the epistemic resources model, epistemic cognition is sensitive not only to domain, as currently accepted by scholars adopting other perspectives, but also to specific contexts within domains. Even when the theorists observe consistency within a given context, it is not due to a global unitary set or theory of epistemic beliefs, but rather to a local coherence, which may not emerge in a different context (Elby & Hammer, 2010). Here context does not correspond to a domain, or subject matter, as several contexts can be salient within a domain, as in the example of Louis. Moreover, Hammer and Elby have also included learning "beliefs" when considering epistemic resources, arguing students' views about learning are inseparably linked to views about knowledge and knowing (e.g. Elby & Hammer, 2010).

**Measurement.** According to these scholars, working mainly in science education, students' epistemic beliefs cannot be measured by traditional quantitative methods because those assume theories or traits that are consistent across contexts. Observations of teaching and learning processes, supplemented by interviews (audio and/or videotaped), have been used to examine epistemic beliefs in naturalistic case studies (diSessa, Elby, & Hammer, 2003). Such instruments are not conceived as means to reveal global or even domain-specific epistemic beliefs. Rather, only when students are probed in different contexts while carrying out different activities, both within and across domains, can the generality of their epistemic beliefs be determined (Elby & Hammer, 2010). For example, changing the location of an interview from the physics to the education building, when the interviewer is introduced as a physicist, could show context stabilities and instabilities, although the interview protocol is exactly the same. Changing the order of the questions, which may elicit some coherence, could also contribute to revealing deliberate stabilities and instabilities (Elby & Hammer, 2010).

## RECENT APPROACHES: CRUCIAL ISSUES AND IMPLICATIONS FOR MEASURING EPISTEMIC COGNITION

More recent accounts in the field of epistemic cognition have tried to overcome the limitations of the classic approaches and provide a more articulated, accurate, and complete definition of the construct and, consequently, a theoretical basis for its measurement. This section reviews four crucial issues with important methodological implications: the types of epistemic cognition to consider, the exhaustiveness of the current construct definition, the level of specificity at which it should be examined, and the cultural aspects of epistemic cognition.

### *Differentiating between Types of Epistemic Cognition*

Based on a comparison of research on students' expressed epistemic beliefs and their inquiry practices in school science, Sandoval (2005) pointed out a paradox: the latter appeared in line with scientific practice, but the former appeared to be naïve. Drawing from Hogan's (2000) contrast between students' *proximal* and *distal* epistemology and Louca et al.'s (2004) contrast between professed and enacted epistemology, Sandoval proposed distinguishing between *practical epistemology* and *scientific* or *formal epistemology*. Practical epistemology is intended as the set of ideas that students have about their own knowledge production in school science, while formal epistemology is the set of ideas about scientific knowledge, and its production, that students seem to have about professional science.

Educational researchers should focus on the practical epistemic ideas that students bring to bear on their own scientific sense making, both in practice and as expressed beliefs. Sandoval (2005) offered his position as an argument for "a middle ground" between two camps. In one are the developmental and dimensional scholars who think that epistemic beliefs can be directly assessed and developed. In the other camp there are situativists who argue epistemic beliefs are only revealed through practice. It is an open question whether practical epistemology can develop into formal epistemology through appropriate practices of inquiry for school science, such as asking questions; identifying and pursuing strategies to answer those questions; generating, examining, and interpreting data; and drawing and communicating conclusions.

In terms of measurement of practical epistemology, Sandoval (2005) suggested interrogating students' perceptions of their own inquiry experiences. Two aspects of inquiry activities are particularly worth examining: the *artifacts* students produce during their activities and the *discourse* they generate as they construct and evaluate the artifacts. Sandoval recommended a close analysis of students' thinking to overcome the limitations of self-reports and decontextualized interviews. In any case, it is essential to focus on conceptions in practice, not presumptions regarding what students believe about a science that they do not know.

### *Expanding the Construct Definition*

**Distinguishing ontological and epistemic cognition.** In the debate regarding the definition of epistemic cognition, Greene et al. (2008) posited that current psychological approaches ignore important issues in philosophical epistemology. In philosophical epistemology, the nature and limits of knowledge do not regard whether knowledge itself is simple or certain, but rather what types of claims can be justified as knowledge. In other words, the focus is not on the qualities of knowledge but on the justification of knowledge. In philosophical epistemology, a claim is knowledge only if it meets three conditions: the belief condition, the truth condition, and the justification condition (Murphy et al., 2007). The qualities of knowledge, the two dimensions of simplicity and certainty in classic research on epistemic beliefs, as reported previously, are not the focus of philosophical epistemology, but pertain to the *ontology* used by an individual to understand knowledge claims in a domain.

Based on this philosophical frame of reference and adopting the multidimensional framework, Greene at al. (2008) posited that only one of the four dimensions described by Hofer and Pintrich (1997), that is, justification for knowing, should be considered epistemic. In addition, they proposed expanding the current conceptualization of the justification dimension to differentiate it into more than one dimension, in accordance with philosophical epistemology that distinguishes between internal and external sources of knowledge. Specifically, Greene et al. (2008) called for separating the dimensions of personal justification (e.g. experience and reasoning) and justification by authority (e.g. teachers and experts). In their model, ontological cognition is captured in a single dimension merging Schommer's (1990) and Hofer and Pintrich's (1997) dimensions of simple and certain knowledge. Epistemic cognition is captured through two justification dimensions, that is, justification by authority and personal justification.

The expansion of the justification dimension has been adopted by other scholars in the field who share a multidimensional framework. Ferguson and Bråten (2013) recently examined a third type of justification, justification by multiple sources, which emerged in a previous think-aloud study on reading multiple documents (Ferguson, Bråten, & Strømsø, 2012). Justification by multiple sources occurs when students evaluate which claims to take into account on the basis of cross-checking, comparing, and judging across a variety of sources of information.

Regarding the measurement of epistemic cognition, according to Greene et al. (2008), Likert-type scales can be considered appropriate instruments when used in large-scale administrations with heterogeneous samples, because homogeneous samples may represent a threat to the reliability issue, as mentioned above. Greene et al. (2008) acknowledged Hofer (2004b) and Muis et al.'s (2006) concern that a single item rated on a Likert-type scale may be unable to capture more than the two perspectives represented at the edges of the Likert continuum (e.g. the belief that knowledge is simple and the belief that it is complex). Nevertheless, patterns of responses to various items may be informative indicators of two or more perspectives. Greene et al. (2008) have also indicated that qualitative research is useful for revealing new ways in which students justify knowledge or other aspects of epistemic cognition.

**Beyond the classic epistemic dimensions.** Integrating arguments from philosophy and psychology, Chinn et al. (2011) proposed expanding classic dimensions of epistemic cognition to include other important components. Specifically, their framework includes five components: (1) epistemic aims and values, (2) the structure of knowledge and other epistemic achievements, such as an explanation, (3) the sources and justification of knowledge and other epistemic achievements, (4) epistemic virtues and vices, and (5) reliable processes for achieving epistemic aims. For space constraints, I briefly introduce only components 1, 4, and 5, as they have never been included in any previous models.

Chinn et al. (2011) defined epistemic aims as "goals related to finding things out, understanding them, and forming beliefs" (p. 146). Examples of different aims include acquiring true beliefs or beliefs that approach the truth when only justified true beliefs are considered as acceptable; acquiring minimally justified beliefs when simply having a justification is conceived as sufficient for belief; or acquiring understanding when explanatory relations between pieces of information are sought. Epistemic values refer to what has significance for individuals, for example knowing how to do things, or acquiring knowledge of theories or knowledge about societal problems. People may seek to acquire knowledge only if they perceive its value is greater than the cost of acquisition, in terms of effort and time (Chinn, Buckland, & Samarapungavan, 2011).

An epistemic virtue is "a learned, stable disposition that is (a) directed at epistemic aims such as true belief, knowledge, and understanding, and (b) relatively efficacious in achieving these aims" (Chinn et al., 2011, p. 156). Examples of epistemic virtues are intellectual honesty, courage, and carefulness, as well as open-mindedness. In contrast, an epistemic vice is a disposition that impedes the acquisition of truth. Examples of epistemic vices are intellectual cowardice and closed-mindedness. According to Chinn et al., the range of epistemic virtues can be expanded to include perseverance, vigor, flexibility, thoroughness, and others to better predict and account for learning processes and outcomes. The fifth component of epistemic cognition regards reliable and unreliable processes of achieving epistemic aims. An example of the former is to seek out a broad range of evidence to support a theory. An example of an unreliable process is confirmation bias.

Chinn et al. (2011) have also proposed renaming the justification dimension regarding authority as testimony. This means abandoning the negative connotation that the term authority has in most research on epistemic cognition, because testimony plays a fundamental role in all human knowledge. Learning from others is not less desirable than learning from one's experience and reasoning (see also the concept of the division of cognitive labor, Bromme, Kienhues, & Porsch, 2010). Belief in authority (i.e. testimony) as a source of knowledge is associated with better reasoning when evaluating multiple documents (Bråten, Strømsø, & Samuelstuen, 2008).

Regarding measurement, Chinn at al. (2011) called for a consideration of the situated nature of the five components of their model. They recommended a finer-grained examination of epistemic cognition to account for variance in performances. They argued contextualized cognition cannot be adequately captured using questionnaires. They suggested interviews and mixed methods to examine different aspects of epistemic cognition. They also recommended taking into account tacit epistemic commitments that can be derived when analyzing students' performance in epistemic tasks, such as the kinds of artifacts and discourse analyzed by Sandoval and associates (2005; Ryu & Sandoval, 2012; Sandoval & Millwood, 2005). Chinn et al. (2011) admitted it is impossible to devise a single interview protocol or measure able to capture all aspects of epistemic cognition simultaneously, because of its complex and multifaceted nature.

### *Degree of Specificity*

The degree of specificity at which epistemic beliefs are examined is another issue for measurement, because different pictures of students' representation about knowledge and knowing may emerge if they respond to questions in general, versus considering a specific domain or topic. The studies carried out according to developmental and multidimensional theoretical frameworks for epistemic cognition have mainly addressed only domain-general beliefs about knowledge and knowing. Perry (1970), Baxter Magolda (1992), King and Kitchener (1994), and Kuhn (2000) examined the development of epistemic cognitive structures taking a domain-general perspective. Scholars who adopted a multidimensional approach also generally measured domain-general epistemic beliefs (e.g. Schraw et al., 1995).

Many studies that examine domain-specific personal epistemology adapt only the surface details of other domain-general epistemology instruments. In addition, some studies of students' epistemic beliefs across domains used the same self-report questionnaire in a single administration, asking students to respond to the same set of items while keeping another domain in mind (Hofer, 2000). Muis et al. (2006) criticized this approach in terms of validity. It is difficult to know whether students really keep a particular domain in mind, especially in the case of very generic items, such as "Most words have one clear meaning."

In response to Muis et al. (2006), Hofer (2006) posited that individuals' beliefs about knowledge and knowing can be identified as *general epistemic beliefs*, as *disciplinary perspective on beliefs*, and as *discipline-specific beliefs*, like mathematics or science (e.g. De Corte, Op 't Eynde, & Verschaffel, 2002). More recently, epistemic beliefs have been measured at the topic-specific level, either through self-reports (e.g. Bråten & Strømsø, 2010a, 2010b) or semantic differential scales (e.g. Mason et al., 2014). Scholars from the situative perspective (e.g. Hammer & Elby, 2010) have focused on a finer-grained level of analysis of context. As mentioned above, these scholars do not adopt a quantitative approach, limiting comparisons with scholars with theoretically different frameworks.

To sum up the implications for measurement, even when adopting a developmental or multidimensional framework, it is now broadly accepted that epistemic cognition includes levels of both domain-generality and domain-specificity (Muis et al., 2006). Focusing on a topic-specific level implies a further contextualization of domain-specific beliefs, in accordance with a more general attention to "contextual" factors in research on learning processes and outcomes. Some scholars who take a topic-specific approach still think students may hold more or less sophisticated representations about knowledge and knowing on a particular topic, and use self-report or semantic differential scales (Bråten & Strømsø, 2010a, 2010b; Mason et al., 2014). This approach is therefore in contrast with the situated resource view, according to which students' use of epistemic resources cannot be captured through instruments that assume the stability of views about knowledge and knowing (e.g. Hammer & Elby, 2002).

### *Cultural Aspects*

Perry's (1970) pioneering work on epistemic development was criticized because his research was based solely on white males at an elite university. Even as scholars tried to overcome this limitation, measurement of epistemic beliefs has historically been devised and validated in the United States. These instruments have been translated and applied in other cultures by assuming similar underlying factor structures (Briell, Elen, Verschaffel, & Clarebout, 2011; Elen & Clarebout, 2001; Mason, 2003). Research on epistemic beliefs in multiple cultures has challenged this way of carrying out research in different cultures and the guiding conceptual models.

In particular, the developmental trajectory of Western cultures has been questioned. Karabenick and Moosa (2005) found that Omani college students were more likely than American students to believe that knowledge is simple and certain, and authorities are the source of knowledge. Tabak and Weinstock (2008) indicated that adolescent Bedouins were more absolutist than Jewish students at the same grade level, in all five domains of the Kuhn et al. (2000) instrument. Inconsistent age-related epistemic development may be explained by cultural differences.

Hofer (2008) listed important issues that should be taken into account when designing cross-cultural research, most of which are pertinent to measurement. The construct of epistemic cognition itself may be problematic, as some aspects may be universal but others culturally specific. For example, what is considered as a source that provides "true knowledge" may vary from culture to culture. The directionality of the development of epistemic cognition may be questioned, as what is considered sophisticated in one culture may not be in another. The relationships between epistemic cognition and other constructs (e.g. learning strategies) that are relevant in learning may not be universally conceivable. A critical methodological issue concerns the preservation of original word meanings through translation. Another problem arises when different factor structures emerge from the use of an instrument. Issues of validity should be faced and interpreted to decide whether the construct can survive, and its variations can be reasonably accounted for (Hofer, 2008).



## CURRENT MEASURES OF EPISTEMIC COGNITION

Recently, researchers have been exploring new measures, or revisiting old measures to assess epistemic cognition in ways that try to overcome the limitations associated with the mainstream tradition based on self-report questionnaires. This section briefly presents characteristics of recent approaches to measurement.

### *Think-Aloud Protocols of Epistemic Cognition in Action*

Taking into account the need for a more contextualized method of measurement, scholars have examined beliefs about knowledge and knowing in the concrete learning scenarios in which beliefs may be manifested. The line of investigation about the search, evaluation, and comprehension of information from multiple sources has examined epistemic beliefs in action, theoretically moving from the widely shared multidimensional approach and taking into account the crucial issue of the specificity of the measurement level. Using think-aloud methodology, Mason and associates (Mason, Boldrin, & Ariasi, 2010; Mason, Ariasi, & Boldrin, 2011) investigated university and high school students' spontaneous reflections about the four classic epistemic dimensions during Web search, and the evaluation of sources and information on a controversial topic. Protocol analysis revealed activation of beliefs about the knowledge accessed, especially about the credibility of the electronic sources, and the process of knowing from online information. Similarly, Barzilai and Zohar (2012) examined the role of absolutist and evaluativist epistemic perspectives in online evaluation of website trustworthiness about controversial topics, and critical integration of multiple sources in sixth graders.

Think-aloud studies may reveal epistemic beliefs activated in a concrete learning activity or task, and test whether they are aligned with supposed dimensions in accordance with theoretical frameworks. Moreover, data derived from think-aloud protocols may be used in both qualitative and quantitative analyses. However, think-aloud methodology is also limited. It can disrupt or distort the process of thinking itself, as cognitive resources are diverted from the execution of the primary task (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Thinking aloud, therefore, is not guaranteed to accurately reflect thinking in the moment.

### *Knowledge Artifacts and Discourse*

Students' artifacts and the discourse around their production can be used to reveal the epistemic cognition that underlies them (Sandoval, 2005). What kind of artifacts can be used to assess epistemic cognition? To exemplify, written artifacts in the form of arguments offer opportunities to examine students' practices of making claims and linking them to evidence (Sandoval & Millwood, 2005). Arguments illuminate students' epistemic practices related to justification for knowing while they try to learn science through inquiry. An instructional focus on argumentation may improve children's understanding and application of epistemic criteria for scientific arguments (Ryu & Sandoval, 2012).

Yet, students' artifacts cannot directly uncover the epistemic goals that drive their practices. In this regard, Sandoval (2005) proposed the use of interview protocols to elicit the reasoning behind decisions that seem salient from an epistemic point of view. Verbal exchanges during collaborative inquiry, for example, may offer rich material to assess practical epistemology. Nevertheless, discourse analysis is also limited, as it requires a lot of inferential activity to understand the reasons behind what students say. Interviews or video-prompted recalls may be useful complements of artifacts and discourse, but they are time consuming or expensive, thus not suitable for large-scale studies.

### *Cognitive Interviews*

Interviews were recently re-proposed within a qualitative design to investigate the degree of alignment between current models of epistemic cognition and actual epistemic cognition in different domains, and in individuals at different ages and levels of expertise (Greene & Yu, 2014). Semi-structured interview protocols have been used to minimize interviewer effects, but researchers are often encouraged to deviate from the protocol as needed, and probe responses for relevant information. Given the small sample sizes that can be involved, the aim of interviews is not a generalization of findings to larger populations, but a deep examination of whether the data fit an underlying model of epistemic cognition. For example, interviews with middle school students and faculty members about the domains of history and biology recently raised concerns that current models of epistemic cognition require modification with respect to the kinds of knowledge considered, similarities and differences within and across domains, and possible justifications for knowledge claims (Greene & Yu, 2014).

The cognitive interview has recently been proposed to evaluate the cognitive validity of the most common self-report measures of epistemic cognition (Greene, Torney-Purta, & Azevedo, 2010; Muis, Duffy, Trevors, Ranellucci, & Foy, 2014). Cognitive validity indicates the degree to which respondents interpret items according to the meaning intended by researchers. A study with primary and secondary school students tested the suitability of a pilot instrument, the Epistemic and Ontological Cognition Questionnaire. It revealed, for example, various interpretations of words like "believe" and "true," as they indicated opinions when used in reference to students themselves, but knowledge or fact in reference to authorities (Greene et al., 2010). Greene et al. suggested eliminating the neutral response in a scale with an even number of options to avoid its use as an "I don't know" response rather than the intended midpoint between poles. Similar findings emerged from a study with students of four educational levels that examined the cognitive validity of Hofer's (2000) questionnaire across the domains of psychology and mathematics (Muis et al., 2014). In this study, however, the neutral position was used as intended by respondents as opposed to a conflicting response.

Cognitive interviews differ from the previously mentioned interviews as they examine the extent to which respondents' interpretation of items aligns with researchers' intended meaning. They seem particularly useful in piloting measures with the aim to develop unambiguous items interpreted exactly as researchers intend them.

### *Scenario-Based Instruments*

Barzilai and Weinstock (2015) created a scenario-based instrument to assess students' epistemic cognition through a measure that reflects its multidimensional nature and accounts for its context-sensitive nature. It is intended to tap learners' epistemic cognition about the nature, sources, certainty, justification, and reliability of knowledge. The instrument first presents a scenario describing a specific topic or dilemma. The scenario introduces two conflicting expert accounts. After reading, participants are asked to rate their agreement with responses to various questions about the scenario. For example the question, "What should knowledge about [the scenario] be based on?" is followed by three responses: "Mainly theories that explain the topic; Mainly people's opinions about the topic; Only detailed data about the topic." After cognitive interviews and pilot studies, the final version of the instrument was made up of 48 items. Results from both exploratory and confirmatory factor analyses showed the instrument was a reasonably reliable measure of Kuhn's three epistemic positions. Better construct validity emerged for the science context, indicating that disciplinary differences play an important role in item interpretation (Barzilai & Weinstock, 2015).

This scenario-based instrument was used in an experimental study about the role of epistemic cognition in the comprehension of multiple author perspectives in blog posts regarding a socio-scientific controversy (Barzilai & Eshet-Alkalai, 2015). The study revealed the instrument was able to reliably assess the three epistemic positions examined according to Kuhn et al.'s framework, and that the effects of these positions on multiple text integration was mediated by the comprehension of author perspective. As in other cases, the instrument was effective in measuring subjects' alignment with a conceptual scheme that was presumed to exist. In this regard, a scholar who adopts a situativist perspective would argue that achieving such an alignment is taken as evidence that the scheme accurately captures the phenomenon of interest, but it is an open question whether such an approach can discriminate individual views in this way.

This scenario-based instrument seems promising with respect to the other paper-and-pencil instrument designed to assess absolutist, multiplist, and evaluativist positions, developed by Kuhn et al. (2000). As mentioned above, the latter includes only one question for each item and lacks specific content. The new instrument developed by Barzilai and Weinstock (2015) has potential to overcome these limitations in assessing epistemic cognition in multiple contexts. However, two issues may limit its potential. First, the questions may be too difficult for students to respond reliably. Second, prior knowledge of the topic may influence how a person responds. If students know a lot about genetics, for example, it is probably easier for them to answer epistemic questions about deformed frogs.

## IMPLICATIONS FOR THEORY, RESEARCH, AND PRACTICE

The measurement of epistemic cognition is complex, because of the nature of the construct itself, its definition, and the different levels at which it can be measured. The classic definition of cognition about knowledge and knowing has been articulated and expanded on the basis of an integration of psychological and philosophical issues (Chinn et al., 2011; Greene et al., 2008). The construct might be modified further in the light of new theoretical analyses and empirical evidence. The cognitive interviewing technique may provide critical information about the validity of questionnaires and survey development. It is also generally agreed that epistemic cognition should be measured at a finer grain size than in the past, as it may vary according to the context in which it is embedded, although context is seen at different levels of specificity by scholars in the field. Undoubtedly, there is still a need for research on measurement. Scholars need valid and reliable instruments that capture the multifaceted construct of epistemic cognition in relation to different disciplinary domains and contexts. The ultimate aim is to make available suitable instruments that tap intra- and inter-individual variation. In this regard, widening the age range, cultural and social background, and academic skills of the samples will be beneficial for both theory and research (Greene & Yu, 2014).

Better measurement is essential for educational implications to be actualized. Given the importance of epistemic cognition within and beyond the classroom, there is a particular need for interventions to promote its development, as this volume documents. In order to test the effectiveness of these interventions at different academic levels, valid and reliable instruments are necessary to measure beliefs about knowledge and knowing before and after interventions. Scholars have recently used the term "epistemic climate" to refer to various components that characterize a learning environment (Feucht, 2010; Muis & Duffy, 2013). Embedding the measurement of students' epistemic beliefs in different epistemic climates will enrich the field's knowledge of the contextual factors that may contribute to epistemic change in the desired direction, and foster academic achievement.

It is clear one single measure cannot tap all aspects of epistemic cognition simultaneously, given the complexity that has been highlighted (cf. Chinn et al., 2011). Such complexity emphasizes the need for theoretically grounded measurement that relies on mixed methods. The combination of quantitative and qualitative methodologies, as well as analyses at different resolutions that consider individual, contextual, and cultural aspects, is likely to offer an increasingly clear and complete picture of our fascinating, complex cognition about knowledge and knowing.

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# 24

# METHODOLOGICAL CONSIDERATIONS FOR THE STUDY OF EPISTEMIC COGNITION IN PRACTICE

*Gregory J. Kelly*



Theoretical developments in epistemic cognition have called for greater and more effective use of philosophical perspectives (Greene, Azevedo, & Torney-Purta, 2008; Murphy, 2003). Recent research has examined the multiple ways that research in philosophy can inform epistemic cognition. For example, Chinn et al. (2011) developed a five-component, philosophically grounded framework to inform research on epistemic cognition. In this chapter, I provide methodological procedures emanating from a sociocultural perspective on knowing and learning. I consider ways that philosophy and the empirical study of epistemological issues, such as studies of epistemic cultures producing knowledge (e.g. Knorr-Cetina, 1999), can help conceptualize epistemic cognition as practice and contribute to robust views about how epistemology relates to learning. I draw primarily from social epistemology with a focus on scientific knowledge (Longino, 2002) for examples of how to develop methodological implications of disciplinary and situated perspectives on epistemic cognition. This social view of knowing and learning coalesces well with sociocultural psychology. In particular, the focus of this chapter will be on how to research epistemic cognition situated in social practices. I draw from sociohistorical psychology and situated cognition to illustrate the ways that meaning is learned through participation in activity (Hutchins, 1995; Kozulin, 2003; Vygotsky, 1978). The prominent role of discourse and practice as mediators for learning is illustrated with examples from professional practice and science education settings (Kelly, 2014a). The methodology I propose offers a potential contribution to the study of epistemic cognition by considering the ways that epistemic practices are constructed through interaction (Kelly, 2008, 2011; Ostman & Wickman, 2014). Illustrative examples from engineering education are provided. I propose a reflexive turn posing questions about what counts as knowledge for the study of epistemic and ontological cognition. The chapter concludes by considering ways that different, complementary views of epistemic cognition can contribute to fruitful research directions.

By providing an alternative to the typical methodological approaches to the study of epistemic cognition, I hope to expand the conversation about how substantive issues in learning can be researched from different perspectives. A practice view of epistemic cognition examines ways that knowledge is used in activity and serves to inform ways of creating pedagogies that support the development of knowledge and justification for knowledge claims (Kelly, 2011; Kelly & Sezen, 2010; Ryu & Sandoval, 2012). Building from anthropological and sociological studies of science and education and sociocultural psychology, the perspective developed here examines ways that epistemic practices are constructed in interaction through concerted activity. A key component of the interactional accomplishment of epistemic practice is discourse (Kelly, 2011). Discourse is often defined as language-in-use that includes verbal exchanges, written texts, signs and symbols, and other semiotic resources (Jaworski & Coupland, 1999). These semiotic resources include contextualization cues, such as gesture, eye gaze, prosody, and proxemics (Bloome, Carter, Christian, Otto, & Shuart-Faris, 2005; Gumperz, 2001; Green & Castanheira, 2012; Strauss & Feiz, 2014). Language use shapes social order and is shaped by social order (Fairclough, 2010; Jaworski & Coupland, 1999), as social groups use language to create particular ways of talking, thinking, acting, and being (Gee & Green, 1998). These actions, when coordinated through concerted activity, may become patterned, thus developing cultural practices of members of a group (Kelly & Green, 1998; Smith, 1996). Thus, through language use and other actions, social groups create meaning. These meanings are supported by at least three functions of language: communication of propositional information, establishment of social relationships, and expression of identity (Cazden, 2001). Patterned uses of language, the development of cultural norms, and the building of identity change over time. As these functions of language are constructed in moment-to-moment interactions, and are influenced by cultural norms, they can be examined across time scales from the micromoments through sociohistorical timescales (Kelly, 2008; Lemke, 2000; Wortham, 2003). Under certain circumstances, these social meanings and identity are related to epistemic cognition.

## EPISTEMIC AND ONTOLOGICAL COGNITION IN PRACTICE

Greene et al. (2010) define epistemic cognition as referring to thinking about knowing, while beliefs about knowledge refer to ontological cognition. This characterization has the advantage of not labeling a set of personal beliefs a folk epistemology, as personal views about knowledge should not be confounded with disciplinary inquiry into knowledge found in philosophical studies (Kelly, 1997, 2014b). Thus, this view of epistemic cognition focuses on thinking about knowledge without assuming a coherent theory of knowledge, or epistemology, on the part of the knowing subject. Greene et al. (2010) use epistemic and ontological cognition (EOC) to refer to “both developmental and systems of beliefs models of personal epistemology” (p. 237). Rather than focusing on beliefs, I propose some research approaches to examine epistemic practices—ways of going about defining what counts as knowledge—that include interactionally accomplished understandings of knowing and uses of knowledge category systems (ontology) in learning environments. This perspective takes a view that meanings of knowing and categories of concepts “are created in the public domain in the context of collective situations and activities” (Toulmin, 1999, p. 58). Since such meanings are created in a public domain, one way to examine how thinking about knowing is accomplished is to focus on the discourse processes used in settings where issues of knowing are at stake and in play. Such a perspective views objects as acquiring properties by virtue of human activity (Bakhurst, 1997, p. 159) and through social significance where meaning is constructed and interactively acknowledged (Bloome et al., 2005). Such activity may include research settings where learners are asked about their beliefs about knowing and learning, as has often been the case for studies of epistemic cognition. An alternative to these settings would be learning contexts where meanings are defined, evoked, and socially negotiated around purposeful activity aimed at learning goals.

In a recent review of epistemology and learning, Kelly et al. (2012) identified three ways that epistemology has informed learning in science education—although these categories are specific to science in their study, the perspective is relevant to other forms of disciplinary knowledge. One group of studies considers the personal epistemology, or epistemic cognition of learners, and how learners' views of knowing influence the learning process. Another set of studies draws from philosophy, most often philosophy of science, to provide models for rational theory choice and justification of knowledge claims. A third group of studies, based in sociocultural theories of learning and the situated nature of knowing, focuses on the everyday practices of proposing, communicating, assessing, and legitimizing knowledge claims. These ways of engaging in epistemic practices occur across contexts and social groups, and draw from empirical research of professional practice (e.g. Knorr-Cetina, 1995) or the ways that teachers and students construct knowledge in educational settings (e.g. Kelly & Crawford, 1997).

To date, much of the work on epistemic cognition has focused on researching the individual's view of knowing and the influence of such views on learning. This focus has the advantage of identifying and diagnosing learners' perceptions of knowing and potentially designing learning experiences derived from such understandings. From this perspective, methodological approaches have examined students' beliefs and incorporated students' ontological cognition. Over time, such focused study has increased the rigor of such assessments. A common feature of these studies is a centering of the locus of cognition on the individual learner, even when set in a social context. I develop some alternatives to this individualistic view by thinking about ways students engage in disciplinary practices and considering how issues of knowing emerge through discourse processes. Through this process, I hope to propose complementary methods based on different ways of conceptualizing the phenomena (Kelly, 2006).

A sociocultural view of learning includes the importance of social practices and participation. Learning disciplinary knowledge includes developing abilities to engage in epistemic practices of relevant groups (Toulmin, 1972; Kelly, 2014b). Epistemic practices are the socially organized and interactionally accomplished ways that members of a group propose, communicate, assess, and legitimize knowledge claims (Kelly, 2008; Manz, 2012). These groups most often include more-knowing others in educational or professional settings. Such participation raises questions about the types of knowledge at stake in such interactions. Scheffler (1965) makes the distinction between propositional (knowledge that) versus procedural knowledge (knowledge how). Epistemic cognition often concerns complex knowledge, such as that in play for learning disciplinary knowledge. Under such conditions students need to engage in social practices where issues of knowledge are being proposed, discussed, evaluated, and assessed. Thus, in this case, epistemic cognition refers to both propositional and procedural knowledge: procedural knowledge of how to engage in conversation around substantive topics that are part of the learning process of propositional knowledge. Furthermore, learning disciplinary knowledge entails learning the processes for knowing about topics and the justification underlying such knowledge (Sandoval & Çam, 2011). Learning disciplinary knowledge requires understanding the procedures used to define and create relevant concepts. For this to occur, learners need to use language, argumentation, and embodied procedural techniques (such as that of experimentation to make sense of the scientific knowledge, or that of field testing to evaluate properties of an engineering design). Before turning to some specific methodological approaches, I propose the following premises that inform the perspective.

*Disciplinary knowledge is social knowledge.* This is particularly true in well-developed, compact fields such as science and engineering, where knowledge is the product of multiple social situations and institutions, and succeeds through building on previous knowledge and peer review (Fleck, 1935/79; Longino, 1990; Toulmin, 1972, Zuckerman, 1988). Individuals may have personal knowledge of specific aspects of their social or material worlds, but such knowledge does not count as science until interactionally legitimized by a relevant community of knowers (Kelly & Chen, 1999; Kelly & Green, 1998).

*Cognition is distributed across people, technologies, texts, and signs and symbols* (Cole & Engestrom, 1993; Hutchins, 1995; Pea, 1993). Learning about knowing involves engaging in discourse and other social practices—this includes using knowledge and talk about knowledge (Kelly, 2011; Kelly & Sezen, 2010).

*Learning occurs through participating in common ways of being and forms of life* (Goodwin, 2013; Green & Dixon, 1993; Wittgenstein, 1958). Learners appropriate ways of speaking, interacting, communicating, and engaging in social groups (Kelly, 2014a), and to the extent that knowledge is involved, epistemic and ontological cognition is situated in such forms of life and distributed. Learning involves acculturation of learners into ways of being (Goodwin, 2013; Kelly & Crawford, 1997).

*Epistemic cognition includes a set of practices—patterned actions involved in knowing* (Kelly, 2011; Ostman & Wickman, 2014). Thus, reasoning is a social endeavor that includes using evidence and engaging in genre-specific forms of argumentation (Ford & Wargo, 2012; Kelly & Bazerman, 2003; Ryu & Sandoval, 2012). This perspective considers epistemic cognition as learned ways of reasoning about knowledge.

*Ontologies are constructed through appropriation of common meanings* (Lewis, 1929). There are social origins of ontological categories that are formed and reformed through acculturation, language socialization, and learning through participation (Strike, 1982). Such categories may be challenged and reconstructed through critique, reassessment, and revision (Kelly, Crawford, & Green, 2001).

## METHODOLOGICAL CONSIDERATIONS FOR RESEARCHING EPISTEMIC PRACTICES

The methodological approaches I propose offer an alternative to both the developmental stage and systems of beliefs models described by Greene et al. (2010). These models have advanced methodologically and offer unique and valuable insights into individual's EOC. An alternative is to consider the interactionally accomplished nature of knowledge and student thinking about this *in situ*. The view suggested here is based on the value and need for consideration of epistemic practices used to construct knowledge in social settings. Indeed, as Toulmin (1979) has argued, aspects of mental life (such as views about knowing) are acquired features of our experience and cultural history. Based on the sociocultural view of learning, knowing, and social practices, a number of methodological approaches can be employed to consider ways of investigating epistemic and ontological cognition (EOC) *in situ*. Such approaches draw from multiple research methods, each offering unique insights into how social practices define knowledge for participants (e.g. Manz, 2012; Ryu & Sandoval, 2012; Wickman, 2004).

In this section, I provide a view of how epistemic practices and socially derived ontological categories imply certain methodological orientations and ways of investigating. Epistemic practices, and EOC more generally, are interactional, contextual, intertextual, and consequential. Each of these characteristics suggests methodological commitments.

*Epistemic practices are interactional.* Actions taken by members of a group become patterned ways of being through social interaction. Engaging in social practices defines what counts as knowing and knowledge, such as proposing ideas, testing hypotheses, representing concepts, evaluating merits of candidate solutions, recognizing alternatives, justifying knowledge claims, and legitimizing conclusions. Such epistemic practices are interactionally accomplished, among people, texts, and technologies, and constructed in the moment. These events are situated and contextualized, draw from common knowledge, and make reference to previous knowledge and ways of participating. A central component of these practices is the use of language, including signs and symbols, characteristic of epistemic cultures (Kelly, 2014a, b). Such discourse requires communicative knowledge about how to participate in a cultural group and includes not only the functional aspects of relevant semantics but also extensive knowledge required to fill in background assumptions that make conversation possible. Thus, there is an interactional accomplishment of social cognition around knowing.

*Epistemic practices are contextual.* These practices are situated in time, space, social practices, and cultural norms. Knowledge is constructed through specific processes with variations across disciplines and ways of knowing (Knorr-Cetina, 1999; Longino, 1990). Knowledge construction occurs over time through a series of interactions from interactions around data collection, to conversations about interpretation, to forms of representation, and to processes of communication, evaluation, and legitimation (Bazerman, 1988; Lynch, 1992). Engaging in epistemic practices thus occurs in various venues and settings and these practices need to be examined as they occur in the making (Kelly, Chen, & Crawford, 1998). Thus, the study of epistemic practices needs to be situated in specific contexts. This suggests methodologies that examine knowledge construction over time and levels of analysis (Lemke, 2000; Wortham, 2003)—for example, at the interactional micro, meso, ontogenetic, and sociohistorial time frames. This emphasis on situating discourse events in a broader context of use shows how discourse processes both shape social practices and are embedded in such practices (Gee, 1999; Gee & Green, 1998). Time scales are interrelated, as specific events are situated in ongoing activity influenced by cultural practices. For example, interactional events are constructed through discourse processes and actions, creating and being shaped by sequences of mesolevel social practices (e.g. Kelly et al., 2001). The mesolevel time scales refer to weeks and months of collective activity (Wortham, 2003). These events draw from contexts, practices, texts, and artifacts created at longer time scales (Goodwin, 2000). For example, the genre of an experimental article in science (Bazerman, 1988) becomes a cultural model that can be taken up and used to create new texts within this patterned use of language (Kelly & Bazerman, 2003; Takao & Kelly, 2003). Through moment-to-moment interactions, meanings are negotiated while drawing from the patterned activities of a relevant social group (Goodwin, 2000) and those cultural artifacts relevant to the task at hand.

*Epistemic practices are intertextual.* Discourse processes make use of and reference to previous discourse, both spoken and written texts, including the various signs and symbols characteristic of disciplinary knowledge, and are thus intertextual

(Bazerman, 2004; Green & Castanheira, 2012). Reference to previous texts codifies an ontology of a social group (e.g. members of a discipline or subdiscipline) through use and shared assumptions of meaning (Wittgenstein, 1958). The concepts in a given ontology "are not simply dictated by the findings of the laboratory, or by any sort of sense-experience. Their origin is social and historical and represents some enduring human interest" (Lewis, 1929, p. 6). The ontology is populated by a set of concepts, emerging from human interests, and constructed by social groups with histories and common cultural experiences (Vygotsky, 1978). Examining ways that texts (verbal and spoken discourse, signs and symbols) are referenced, taken up, appropriated, and reinterpreted identifies how concepts populate an ontology. Thus, intertextuality serves a method to identify socially salient concepts comprising such an ontology.

*Epistemic practices are consequential.* Ways of creating, representing, evaluating, and legitimizing knowledge have consequences for what and whose knowledge counts. Members entering into a knowledge generating culture bring ways of knowing with them that may or may not count or be recognized (e.g. Traweek, 1988). Therefore, as different epistemic cultures engage in sets of different practices (Watson-Verran & Turnbull, 1995) an understanding of EOC can be examined through the empirical study of knowing *in situ*. The empirical study of ways that knowledge is legitimized offers paths for understanding how power, culture, and social processes are tied to what gets taken for knowledge in certain contexts.

## ILLUSTRATIVE EXAMPLE: EPISTEMIC PRACTICES IN ENGINEERING DESIGN

The illustrative example of epistemic practices occurs in a fourth grade elementary classroom learning aerospace engineering (Cunningham & Kelly, 2015). The curriculum is a unit in the *Engineering is Elementary* curriculum (*Engineering is Elementary*, 2011). Engineering represents a unique form of disciplinary knowledge. Engineering education is rarely studied, particularly in elementary schools, and almost never examined as interactionally accomplished in educational contexts (Cunningham & Carlsen, 2014). While engineering education may share some common epistemic practices with other fields, such as science, literacy, and mathematics, it also includes practices unique to engineering. Such unique practices include addressing and designing solutions to real-world problems, comparing multiple alternative solutions, using investigations to test parameters across a range of conditions, optimizing designs given specific constraints, and communicating results to a client (Cunningham & Carlsen, 2014). In addition to these unique features of engineering practice, two other related topics warrant mention. First, engineering involves ethics, as designs and analyses of systems are not value neutral—designs influence values and human relationships (Johnson & Wetmore, 2008). Second, in addition to propositional and procedural knowledge, engineering draws from knowledge that is concretized in instrumentation (cf. science and instrumentation, Latour, 1987) or through templates and embodied knowledge from previous experiences (cf. gothic cathedral designs, Watson-Verran & Turnbull, 1995). Thus, engineering education represents an area of interest for the study of epistemic practices.

The following examples are a sample of the kind of interactions that identify how what counts as knowledge can be investigated by studying sociocultural practices. In this particular unit, the students experience four lessons designed to engage them in engineering design related to aerospace engineering and a set of associated science concepts. The first lesson introduces the children to aerospace engineering through a storybook. The story is set in Brazil where two young boys face a challenge that prompts them to develop a parachute that can bring an object to the ground safely. The storybook introduces an engineering design process (ask, imagine, plan, create, improve) that the students later will use in the design of their own group projects. In Lesson Two the students work as aerospace engineers to design spacecraft destined for a planet in our solar system (*Engineering is Elementary*, 2011). As they work, students must consider the characteristics of their planet (e.g. distance from Earth, temperature, composition of the surface, and atmosphere), as well as the mission their craft must accomplish. The third lesson invites the students to begin to think about the variables that influence parachute design—children conduct investigations to understand how properties of parachutes (such as size and material composition) affect their drop speed. Both of these goals are accomplished through student group investigations. Lesson Four entails students using the engineering design process to design a parachute. They imagine individual designs, based on the results of the variables studied in Lesson Three, and then come to a consensus within their group of four students to create a design. These designs are tested, and the class shares and compares their results and characteristic features across the eight student groups. These data then are used by each group to redesign their parachute before continued testing and evaluation.

For illustrative purposes I present three short episodes from Lesson Four—the building and testing of the student teams' initial designs, redesigning based on results of initial testing, and testing and interpretation of the "improved" designs. Identifying relevant epistemic practices was accomplished through a series of analytic steps.

First, the sociolinguistic analysis begins with an ethnographic description of the educational context (Green & Castanheira, 2012; Gumperz, 2001; Kelly & Crawford, 1997). In this case, the classroom events were video recorded with two cameras. The four lessons occurred across six days totaling over six hours of classroom instruction and videotape data. Initial analysis entailed reviewing the curricular materials, teacher guidebooks, videotapes of the classroom activities, and class and student artifacts.

Second, after this initial stage of ethnographic description, more detailed analyses focus on the ways the classroom practices were constructed by the participants. For this study of engineering education, transcripts of talk and action were created totaling over 2400 turns of talk. Each turn was coded for the type of discourse move. The events were segmented by the participants through sociolinguistic cues, including shifts in ideas often redundantly marked with variations in proxemics (spatial separation and body movement) and prosody (rhythmic and intonational organization; Green & Castanheira, 2012; Gumperz, 2001). These formed the basis for the creation of larger units of analysis (phase and sequence units). A set of cohesive turns of thematically tied interactions were identified as sequences of activity (Kelly & Chen, 1999). These sequences build phase units representing concerted and coordinated action among participants reflecting a common content focus of the group. This form of analysis allows for developing an understanding of the unfolding of the talk-in-interaction, as it occurs over time in a particular sequence of activity (Goodwin, 2000).

Third, these turns of talk are contextualized in the sequences of ongoing activity. Examining the instructional conversation at different levels of analysis (turn, sequence, phase) situates a given instance of interaction in an overall sequence of actions taken, allowing for over time analysis of practices (this would be at the interactional and mesolevel analysis). During this phase of the analysis, emergent themes start to be developed, including ways that knowledge is constructed, evoked, and evaluated. Instructional conversations provide a basis to examine how epistemic practices are enacted through concerted activity. Based on the theoretical assumptions described previously, this analysis can take the form of looking across units of analysis. For example, event maps provide a timeline of major actions and serve to situate particular instances of knowledge use in the ongoing activity of the classroom. The use of event maps, tied to more specific representations of the video data (Erickson, 1992), allow for different ways of representing social practices by "zooming in" to understand instances of action, and "zooming out" to view patterns of activity (Kelly et al., 2001). Any one instance of talk and action does not constitute a social practice; rather chains of coordinated activity can be identified by analysts as patterns, suggesting practices in use by the members of the classroom. For this study, event maps were created and examined to look across units of analysis. Table 24.1 represents a sample of phase units and the sequence units for one selected phase—the location in the conversation where students made observations and interpretations of the teams' data (shown at phase beginning labeled "Presentation and comparison of data from first design across groups" at 0:11:35.9). The transcripts for episode 1 (shown in Table 24.1 as the sequence unit beginning at 0:13:41.7) and episode 2 (shown in Table 24.1 embedded in the sequence labeled "observing and comparing data set" beginning at 0:15:29.6) were part of this phase of activity and presented below. Episode 1 centered on the identification of an apparent anomaly and episode 2 considered the functionality of components of the student teams' parachute designs.

**Table 24.1** Sample of event map showing only phase units and sequence units for only one selected phase ("Presentation and comparison of data from first design across groups") occurring at 0:11:35.9 on day 2 of lesson 4

| Time stamp | Phase unit | | Sequences for selected phase |
|---|---|---|---|
| (0:00:32.3) | Review of average drop speed concept | | |
| (0:05:49.0) | Frame for comparing data across groups | | |
| (0:08:00.5) | Recording group data: drop speed, suspension line length, canopy diameter | | |
| **(0:11:35.9)** | **Presentation and comparison of data from first design across groups** | (0:11:35.9) | looking for patterns in data |
| | | (0:13:41.7) | noticing anomaly in data set |
| | | (0:14:54.6) | observing and comparing across data set |
| | | (0:16:22.6) | discussing value and limits to suspension line length |
| (0:17:41.3) | Work on improved design in student groups | | |
| (0:42:01.1) | Transition to drop and test phase of improved design | | |
| (0:47:28.8) | Data recording of improved design | | |
| (0:10:03.0) | Transition back to classroom | | |

Fourth, once conversations are contextualized by the researchers (they are already contextualized by participants through their actions and understandings), specific codes for types of epistemic practices can be identified in the transcripts by examining the talk and action in detail. Looking closely at the level of turn, and sequences of interactions, specific practices can be identified in the talk and actions of participants. This allows the researchers to examine whether and in what ways instances of actions are tied together as patterns. In the examples provided below, a number of codes were used to identify epistemic practices such as "communicating features of designed objects," "representing data," "recognizing patterns in data," and "pointing out anomalies."

### *Episode 1: Observing and Finding Patterns in Data*

In this episode the student teams have each communicated the canopy size, suspension line lengths, and average drop speeds of their parachutes to the class after performing tests of their respective parachute designs. The teacher recorded the results on a flip chart table in the front of the class for all to see (reproduced in Table 24.2). She began this sequence ("looking for patterns in data," at 11:35.9) by asking the students if there was "anything you noticed?" (line 774).

**Table 24.2** Data across eight student teams for first parachute design presented to class on flip chart

| Team | Average drop speed | Canopy diameters | Suspension line length |
|---|---|---|---|
| 1 | 2.7 | 14" | 21" |
| 2 | 3.3 | 12" | 16" |
| 3 | 3.9 | 12" | 24" |
| 4 | 3.7 | 14" | 21" |
| 5 | 2.6 | 16" | 18" |
| 6 | 3.1 | 14" | 14" |
| 7 | 2.6 | 18" | 13" |
| 8 | 5 | 12" | 23" |

| Line # | Speaker | Talk and action |
|---|---|---|
| 774 | Teacher: | Alright, teams, anything you noticed? Anything you noticed at all? Valerie, what about you guys? |
| 775 | Valerie: | I noticed [groups] 8 and 3 were exactly the same suspension line length. |
| 776 | Teacher: | 8 and 3. Tyson noticed the same thing. Tyson, can you just say what you just said to me? |
| 777 | Tyson: | I don't get why if we got the same canopy size and they only had one inch more than us for the suspension lines and it's such a difference for the average drop speed. |
| 778 | Teacher: | Let's talk about this. Do you remember when you built your canopy? |

Valerie[1] (775), and previously Tyson, noticed that two of the groups (group 3 and group 8) had very close suspension line lengths (24" vs. 23"). The teacher prompted Tyson (776) to repeat something he had mentioned to her earlier. Tyson poses his confusion (777) about why a seemingly small difference in two parachute designs (that is, same canopy material and size, and only a one inch difference in suspension line length) led to a big difference in average drop speed (3.9 ft/sec vs. 5 ft/sec). Tyson participated in one of the groups in question, and thus his own identity as a student and emergent engineer may play into his keen interest in this pattern in the data. This interchange led the teacher to have the students reflect on the nature of the construction of the parachutes and their canopies. This short episode shows the beginnings of some epistemic practices. As Tyson tries to make sense of the data, he is comparing designs, evaluating results, and questioning how small differences in parachute specifications led to significant variations in performance.

### *Episode 2: Using Observations and Interpreting Functionality of Components of Design*

This sequence began with a student's observation about a pattern she noticed in the data collected and shared by the class: designs with "shorter suspension lines and bigger canopies had lower average drop speed" (791). Much like the first episode, after getting the class' attention, the teacher asked one student to share out a potentially insightful observation (792).

| Line # | Speaker | Talk and action |
|---|---|---|
| 791 | Naomi: | This isn't really a comparison but I noticed that the people who had shorter suspension lines and bigger canopies had lower average drop speed. |
| 792 | Teacher: | Naomi just said I noticed that . . . can I have you, Kiara, stand up? I don't know who this team is. Can you hold this? Turn this way. Naomi said, I noticed that . . . Naomi, can you say that one more time and we'll try to kinda point to it as you're talking? You have to speak loud because I can't hear you over here. |
| 793 | Naomi: | I noticed that the parachutes with shorter suspension lines and bigger canopies went slower and had lower average drop speed. |
| 794 | Teacher: | Than something with a long suspension line. Why do you think a long . . . We know that long suspension lines do help you, we know that, compared to the really, really short ones. But how long do you think it has to be? Do you think that long is really going to help you? |
| 795 | Student: | No |
| 796 | Teacher: | What's the purpose of the suspension line? What do you think the purpose is, Navarro? |
| 797 | Navarro: | To hold out the . . . to make it so it goes like this instead of just going like that. [*student manipulates a model parachute to show two different arrangements*] |

| Line # | Speaker | Talk and action |
|---|---|---|
| 798 | Teacher: | So it kinda keeps it like in a bowl kind of shape? |
| 799 | Navarro: | Yeah. |

Naomi repeated her observation, which led the teacher to use the observation to examine the functionality of the suspension lines (794). Given the nature of the question, a student recognized the limiting value of suspension line length (each unit of length adds weight, and may have diminishing returns for their function). When prompted by the teacher about the role of the suspension lines, Navarro demonstrated the functionality of this component of the design through embodied knowledge—he physically demonstrated how the suspension lines serve to expand the canopy and maintain its shape throughout the flight (797). In this episode, the emerging epistemic practices are making observations, noticing patterns in data, examining the functionality of components of designed objects, and demonstrating the functionality of components of designed objects.

### *Episode 3: Recognizing a (Seeming) Anomaly*

Episode 3 occurred later in the lesson (1:19:14.6) when the students were again comparing data across groups on a common table presented on a flip chart. This time the discussion centered on the second, improved design, which took into account the previous designs, the data collected and compared across the groups, and the discussions about the related variables. The teacher again collected the results from the student team groups, noting in a different color on the same data table the results of the "improved" student teams' designs. In this case, a student began the exchange with a question about how two teams had similar characteristics, but different results.

| Line # | Speaker | Talk and action |
|---|---|---|
| 1218 | Navarro: | How does number 4 and number 8 have the same thing, but they have different drops [speeds]? |
| 1219 | Teacher: | 4 and 8 have the same what? Same this? OK and different drops, but look at how close they are. |
| 1220 | Navarro: | Yeah but still. |
| 1221 | Teacher: | Aren't they pretty close? How far away are they? Four tenths? That's really close, that's really close. Well it should be . . . |
| 1222 | Teacher: | Navarro makes a good point. You would think it would be the same. How would we get data to be really, really close? Close to what we think? |
| 1223 | Navarro: | Do it over and over. |
| 1224 | Teacher: | Over and over and over and over. Test and test and test and test. |

During the discussion, Navarro pointed out an anomaly in the data table (1218): groups 4 and 8 had the same measures for relevant variables (canopy size [18"], suspension line lengths [14"]), but differed in the dependent variable of drop speed

(2.3 vs. 2.7 feet per second). The teacher noted that the drop speeds are close, but then recognized that Navarro had a point about the variation in the data (1219, 1221). She used this anomaly to address a broader issue about data collection by posing the problem for the student about "how to get the data to be really, really close?" (1222). Navarro responded by noting the value of multiple data trials (1223). By looking closely at these interactions, a number of epistemic practices can be identified including: improving engineering design through a process; taking into account previous designs, data, and collective thought; pointing out anomalies; and noting the value of multiple data trials.

In these three episodes some hypotheses about the emerging epistemic practices can be identified. As a class, teacher and students working together with the help of the engineered objects, data representation, and common ways of speaking and writing, were able to take actions that can be argued are burgeoning practices of engineering. For example, they communicated features of designed objects, represented data, compared designs, evaluated results, recognized patterns in data, improved engineering design through a process, pointed out anomalies, and noted the value of multiple data trials.

These illustrative examples show ways that the study of interaction can be used to examine epistemic practices, and through the study of practices, an examination of epistemic cognition. In these cases, *what counts* as knowledge is intersubjective and often in play as participants converse. The students and teacher referred to previous events, aspects of the student team designs, and commonly shared data. Thus, the questions about knowledge (e.g. relationship of limited utility of suspension line length after threshold for canopy envelopment) are distributed across the participants and relevant texts. The discussion relied on multiple participants, as each built on previous comments/observations, took the conversation in a particular direction, and evoked the texts presenting the data from the trials. These events are illustrative of how a distributed epistemic cognition can be developed through experience in knowledge building practices of proposing, communicating, constructing, analyzing, and justifying. To fully examine epistemic cognition in these cases, or others derived from events of classroom life, research methods need to be extended to examine ways of identifying patterns over time and across practices through systematic inquiry (Kelly, 2014b). Furthermore, these events suggest the need to examine how individual students take up and learn from the social processes of making these decisions about engineering design and analysis. Consistent with the ethnographic orientation of the perspective presented here, a logical next step would be to examine the artifacts, such as the students' engineering notebooks, for evidence of how they learned to engage in the epistemic practices constructed in the public spaces. Additional analysis may be provided by complementary research methods that consider in detail how students reason about knowing and knowledge.

## REFLEXIVITY: BUILDING COMPLEMENTARY METHODS FOR INVESTIGATING EOC

Research in epistemic and ontological cognition has advanced into new and interesting areas. The field is developing new methods and seeking ways to bring philosophical and other epistemological perspectives to the study of students' thinking about knowing and knowledge. In this chapter I proposed an alternative view of epistemic and ontological cognition to complement the current work in the field. By considering the ways that students use knowledge in social practices to learn disciplinary knowledge (in this case engineering), I proposed a methodological approach to complement the current paradigms in this field.

As a field we can turn questions about what counts as knowledge and how knowledge claims are legitimized on ourselves. Such reflexivity has the potential to advance complementary methods for research in EOC. In previous work, I proposed three types of dialectic epistemic conversations about research methods (Kelly, 2006). As analysts, we commit to certain vocabularies and ways of conceptualizing phenomena. Our research is communicated in textual, aural, and visual forms that provide a context of presentation. Each approach creates affordances and constraints to understanding social phenomena, and thus each needs to recognize the contingency of the respective research language (Rorty, 1989). By considering the contingencies of the research approaches, the field can become more reflexive and sensitive about these choices and more able to recognize the limitations of any one given framework for observation, description, and analysis (Kelly, 2014c). In considering ways that alternative research methodologies can be complementary around substantive issues of interest, Kelly (2006), building on Habermas (1990), Longino (2002) and Strike (1995), proposed three types of critical discourse to promote learning across differences.

The first is *critical discourse within-group*. These conversations center on the developmental and definitional work regarding the creation, specification, and extension of a research group's central theories, assumptions, and ontological commitments. Included in the developmental work would be the socialization of new members. In the case of EOC, a number of outstanding issues could be treated from within the various traditions of research, including, but not limited to, the developmental stage and systems of beliefs models described by Greene et al. (2010) and the sociocultural approach suggested in this chapter. Topics such as the nature of beliefs, stages, and systems of categories forming the basis of research instruments are debated and developed within the various points of view. Affordances and constraints of interactional analysis of the study of epistemic practices similarly could be examined.

A second conversation is *critical discourse regarding public reason*. These conversations focus on the development of epistemological commitments to assess value of educational research across traditions. Typically, considerations of methodological approaches and the potential contribution of any given approach rest on a set of substantive assumptions about knowledge in the field. Looking across the different approaches, and based in the understandings of what counts as social science research, criteria for effective methods can be discussed and debated. Likely issues to emerge are criteria such as internal consistency, empirical adequacy, usefulness for practitioners, potential for further research development, and so forth.

The final type of conversation concerns *hermeneutical conversations across groups*. These conversations center on what can be learned from differences across traditions and reevaluate both "critical discourse within-group" and "critical discourse regarding public reason." These sorts of conversations would consider ways that different methodological approaches address similar substantive issues and can be potentially mutually informative.

This book represents an advance in research in epistemic and ontological cognition by engaging in studies of the application, theoretical development, critique, and methodological approaches of epistemic and ontological cognition. What counts as knowledge about others' EOC depends on the sets of categories of analysis (ontology of the field) and of ways of proposing, justifying, evaluating, and legitimizing knowledge claims about EOC. This chapter examines the assumptions of the social practices of EOC for learners and researchers of learners.

## ACKNOWLEDGMENT

I would like to thank Christine Cunningham, Beth Hufnagel, and Peter Licona for their helpful comments on an earlier draft of this chapter.

## NOTE

1 All student names used in this chapter are pseudonyms.

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# 25

## EPISTEMIC (META)COGNITION

### Ways of Thinking about Knowledge and Knowing

*Sarit Barzilai and Anat Zohar*

One of the primary concerns of epistemic thinking research is understanding how people think about matters such as knowledge, truth, and justification. Understanding how people think about epistemic matters is highly important in current knowledge societies in which information has become more abundant and accessible, yet also increasingly diverse. This chapter focuses on the processes and resources that people employ in order to deal with epistemic challenges and explores how epistemic thinking is situated with regards to the distinction between cognition and metacognition.

Our interest in these issues emerged from our work with think aloud and interview protocols of learners who were reading conflicting online information sources (Barzilai & Zohar, 2012). Prior research has conceptualized epistemic thinking as a metacognitive construct (e.g. Hofer, 2004; Kitchener, 1983; Kuhn, 1999). However, the participants in our study made numerous epistemic evaluations and judgments that did not involve metacognition in its traditional definition as cognition about cognition (Flavell, 1979). This led us to reconsider our assumptions about the nature of epistemic thinking and to seek a more complex model that could better account for its diversity (Barzilai & Zohar, 2014). The aims of this chapter are to present our approach to analyzing epistemic thinking, to illustrate how it can apply to the analysis of verbal protocols, and to explore some of the developmental and instructional implications of this approach.

To begin, we explain the terminology employed in this chapter and, by doing so, present some of the theoretical underpinnings of our work. We employ "epistemic thinking" as an overarching term because we consider epistemic thinking as a particular aspect of the way people think. Thinking is a highly complex and diverse phenomenon (Resnick, 1987). However, over decades of research, many advances have been made in understanding how learners think and in developing approaches for teaching and assessing skillful thinking (e.g. Kuhn, 2009; Schraw & Robinson, 2011; Swartz, Costa, Beyer, Reagan, & Kallick, 2008). We view the educational aim of fostering epistemic thinking as an extension of this research tradition and of the call for education for thinking.

Within the education for thinking literature, thinking is widely considered as involving both cognition and metacognition (e.g. Schraw & Robinson, 2011; Swartz et al., 2008). Likewise, we view epistemic thinking as including both epistemic cognition and epistemic metacognition (see also Hofer, 2005; Richter & Schmid, 2010). However, it is important to note that the term "epistemic cognition" has multiple uses in current literature. Kitchener (1983) originally intended this term to denote a particular type of metacognition. Yet, more recently, this term is often used to refer to any sort of cognition that relates to epistemic matters. Hence, it is frequently unclear whether "epistemic cognition" refers to cognition, metacognition, or both. This ambiguity makes it particularly difficult to discuss the distinction between cognition and metacognition. Thus in order to increase clarity, and to be more consistent with the uses of the terms "cognition" and "metacognition" in the metacognitive literature, we use the term "epistemic cognition" to denote the cognitive or strategic level of epistemic thinking and the term "epistemic metacognition" to denote the meta level. These distinctions will be elaborated in what follows.

## THEORETICAL BACKGROUND

In order to set the stage for our analysis, we first briefly outline the construct of metacognition and then review some of the approaches for juxtaposing epistemic thinking, cognition, and metacognition.

### *What Is Metacognition and Why Is It Important?*

The field of metacognition lacks a unified theoretical framework that encompasses the numerous terms associated with this concept (Veenman, Van Hout-Wolters, & Afflerbach, 2006). In lieu of such a framework, we shall describe several of the broad ideas that are largely shared by metacognition researchers.

**Metacognition is a meta-level cognition.** Metacognition is cognition about cognition (Flavell, 1979). Hence, a key feature of metacognition is that it has a "meta" nature (Veenman et al., 2006). In a central model of metacognition, Nelson and Narens proposed that cognitive processes can occur on two or more levels: an object-level and a meta-level which includes a model that represents object-level cognitions (Nelson, 1996; Nelson & Narens, 1994). The meta-level monitors and controls cognitions on the object-level. However, this distinction is relative rather than absolute because a meta-level may also serve as the object-level of a yet higher meta-level (Nelson & Narens, 1994). Thus, cognition and metacognition are intertwined: Metacognition both draws on cognition and informs it (Veenman et al., 2006).

**Metacognition includes multiple components.** The Nelson and Narens model entails two major metacognitive components: representation of cognition, that is, knowledge about cognition, and skills of monitoring and control of cognition (Veenman et al., 2006). Indeed, since the work of Brown (1978) and Flavell (1979), a great deal of metacognition research has focused on the two major branches of metacognitive knowledge and metacognitive skills. Briefly defined, metacognitive knowledge (MK) refers to what people know about cognition and can include knowledge or beliefs about one's own and other people's cognition and about cognitive tasks and strategies (Flavell, 1979). Metacognitive skills (MS) are actions and processes used to regulate cognition and can include skills such as planning, monitoring, and evaluation of cognition (Schraw & Moshman, 1995). A third major component of metacognition is metacognitive experiences (ME). ME are conscious or nonconscious experiences that specifically accompany and pertain to cognitive activities (Flavell, 1979), such as metacognitive feelings and judgments (Efklides, 2006, 2008). According to Efklides, ME have a dual cognitive and affective nature and can inform a person about his or her cognitive processes in experiential ways. Importantly, MK, MS, and ME interact during cognitive activities (Efklides, 2008; Veenman, 2011).

**Metacognition has both general and context-specific aspects.** The generality of MK is attested to by studies that have demonstrated that learners who gain particular MK, for instance, meta-strategic knowledge about a specific strategy, are then able to transfer this knowledge to new problems in a different domain (e.g. Kuhn, Garcia-Mila, Zohar, & Andersen, 1995). Yet, MK also has domain and even topic-specific aspects. MS have also been found to have both domain-general and domain-specific aspects (e.g. Meijer, Veenman, & van Hout-Wolters, 2006). However, current evidence suggests that MS become increasingly general with age and that learners increasingly resort to domain-general MS (Veenman, 2011).

**Metacognition develops gradually.** Metacognition emerges at an early age and develops substantially in the early years (Bryce & Whitebread, 2012). Metacognition increases in both quantity and quality throughout the school years (Schneider, 2008; Veenman, 2011). Yet, various components of metacognition may develop in different times, making this a gradually evolving, multidimensional competence (Kuhn, 1999; Schneider, 2008). Additionally, not all learners achieve a high level of metacognitive competence (Kuhn, 1999; Veenman, Kok, & Blöte, 2005).

**Metacognitive instruction has a high impact on academic performance.** Metacognitive instruction has positive effects on performance in diverse areas (e.g. Dignath & Büttner, 2008). Development of MK can increase students' ability to accurately choose and apply appropriate strategies (Kuhn, 1999). Instructing and prompting students to activate MS can help them manage their thinking and learning in more effective ways (Schraw, 1998; Veenman, 2011).

### *Is Epistemic Thinking Metacognitive?*

Since the early days of research into epistemic development, epistemic thinking has been described as a meta-level thinking and has been associated with metacognitive development. Perry (1970/1999) saw the most critical point in the intellectual development of the students in his study as the point in which they discover "how to think further, how to think relatively and contingently, and how to think about thinking" (p. 41). Elsewhere, he succinctly described the transition from dualist to relativist thinking as a transition "from thinking to meta-thinking, from man the knower to man as critic of his own thought" (p. 79). "Meta-thinking," according to Perry, is essential for epistemic development because relativist thinking, as described in his scheme, entails being aware of the way one thinks, contrasting it with other lines of reasoning, and weighing multiple approaches.

In multiple lines of research growing from Perry's seminal work, epistemic thinking has been repeatedly addressed as a metacognitive construct (e.g. Bromme, Pieschl, & Stahl, 2010; Hofer, 2004; Kitchener, 1983; Kuhn, 1999; Mason, Boldrin, & Ariasi, 2010a; Moshman, 2015; Richter & Schmid, 2010). One approach to clarifying the metacognitive nature of epistemic thinking has been to conceptualize epistemic thinking as MK about the general nature of knowledge and knowing, such as knowledge about the role of knowers in the construction of knowledge and about the nature of truth and justification (Kuhn, 1999; Moshman, 2015). Another approach has been to view epistemic thinking as involving both MK about the nature of knowledge and knowing and MS such as monitoring and controlling knowledge construction and evaluation (Hofer, 2004; Kitchener, 1983). The latter approach suggests that epistemic thinking is not a specific metacognitive component but rather can be conceptualized by expanding existing metacognitive categories to include epistemic aspects (Hofer, 2004).

### *Is Epistemic Thinking Also Cognitive?*

In recent decades, epistemic thinking research has increasingly examined not only meta-level knowledge or beliefs about the nature of knowledge and knowing but also how people deal with a variety of epistemic challenges as they occur in particular academic and everyday contexts. This turn has been driven by criticism that epistemic thinking cannot be understood without attending to the ways in which it is activated in particular problem areas and situated in disciplinary, social, and cultural contexts (Chinn, Buckland, & Samarapungavan, 2011; Hammer & Elby, 2002). Thus epistemic thinking research has begun to pay more attention to epistemic processes or practices, to what people do, and not just to their knowledge and beliefs, to what they say they do or should do. Examination of epistemic thinking in action has shed light on diverse cognitive processes that result in epistemic assessments and judgments. Indeed, several researchers have explicitly described epistemic thinking as operating on both the cognitive and metacognitive levels (Barzilai & Zohar, 2012; Hofer, 2005; Richter & Schmid, 2010).

We argue that it is necessary to address the cognitive aspects of epistemic thinking because, similarly to other areas of MK, learners' meta-level epistemic understandings are formed through repeated engagement with cognitive-level epistemic processes and strategies. Furthermore, meta-level epistemic goals and standards can only be fulfilled by effectively employing epistemic processes and strategies. Lastly, distinguishing between the cognitive and metacognitive levels of epistemic thinking is necessary for explaining the important capacity for reflecting on epistemic processes and strategies, judging their reliability, and thus improving epistemic competence (see Sosa, 2010).

## ANALYZING THE FACETS OF EPISTEMIC THINKING

Our approach to addressing the complexity of epistemic thinking has been to realign this construct with current conceptualizations of metacognition and its relation to cognition (Barzilai & Zohar, 2014). We argue that epistemic thinking and metacognition are partially overlapping constructs: epistemic thinking involves both cognition and metacognition, but not all metacognition is epistemic. This approach rests on two assumptions. The first assumption is that epistemic thinking is thinking that is particularly concerned with epistemic matters. The second assumption is that epistemic thinking can be situated within existing cognitive and metacognitive categories. In the following paragraphs, we briefly explain these assumptions.

### *Identifying Epistemic Thinking*

Demarcating between epistemic and non-epistemic thinking is not a simple task and, to our knowledge, there is currently no consensual definition of the boundaries of epistemic thinking. One prevalent approach to this problem is to map the issues or dimensions that epistemic thinking is concerned with (e.g. Hofer & Pintrich, 1997). A more recent approach has been suggested by Chinn et al. (2011), who defined epistemic cognition as a complex of cognitions that are related to the achievement of epistemic ends such as true beliefs, justified beliefs, understanding, and knowledge and its representations. The important point, in the context of the current discussion, is that epistemic thinking can be identified by the issues or ends it is concerned with rather than by its form. This makes it possible to explore the manifold ways in which people think about epistemic matters. It also makes it possible to distinguish between epistemic and non-epistemic cognition and metacognition.

### *Positioning Epistemic Thinking*

Our second assumption is based on the observation that in order to deal with epistemic challenges people recruit diverse mental resources. Hence, we postulate, following Hofer (2004, 2005), that epistemic thinking involves multiple cognitive and metacognitive resources and can be analyzed by expanding existing cognitive and metacognitive categories to encompass epistemic issues. This approach has the benefit of aligning epistemic thinking research with current research on metacognition and self-regulated learning and of drawing on the distinctions made in those fields in order to clarify the nature of epistemic thinking and to advance its study and instruction. It is theoretically reasonable to assume that the distinctions made concerning the facets of metacognition also apply to the analysis of epistemic metacognition. Moreover, this assumption best explains the range of available evidence. In the next sections, we briefly present how several key distinctions that have been made with regards to cognition and metacognition can apply to the analysis of epistemic thinking and provide some example of empirical studies that have explored various facets of epistemic thinking (a more detailed discussion is available in Barzilai & Zohar, 2014).

### *Epistemic Cognition (EC)*

**Description.** When people consider the epistemic status of a specific knowledge claim (e.g. "seawater desalination plants do not harm the marine environment") or the reliability of a specific information source (e.g. a scientific report commissioned by a desalination company) they are considering knowledge representations of how things are in the world rather than representations of cognition. We argue that such thinking is more aptly described as cognitive than as metacognitive. The cognitive level of epistemic thinking, or epistemic cognition, can be defined as involving consideration of the epistemic status and properties of specific information, knowledge claims, and their sources, as well as engagement in epistemic strategies and processes for reasoning about specific information, knowledge claims, and sources. Status and properties are epistemic when they are related to the achievement of epistemic ends, such as truth, avoidance of error, justification, and understanding.[1] For instance, examination of the reliability of a source or the support of its claims can advance the achievement of the epistemic aim of acquiring true and justified beliefs.

**Examples.** Multiple epistemic strategies and processes have been identified in the literature such as validating the truth and plausibility of knowledge claims based on their consistency with prior knowledge and with other information available (Richter, 2015); using evidence to support or refute causal claims (Sandoval & Millwood, 2005); constructing and revising models based on evidence (Chinn & Buckland, 2012); judging the credibility of conflicting scientific claims based on scientific discourse features (Bromme, Scharrer, Stadtler, Hömberg, & Torspecken, 2014); or attending to authors' viewpoints in order to reconcile discrepant accounts (Barzilai & Eshet-Alkalai, 2015).

### *Epistemic Metacognitive Skills (EMS)*

**Description.** In order to competently engage in cognitive-level epistemic strategies and processes people need to select appropriate strategies or processes, to track whether they are progressing successfully, and assess if they have resulted in achievement of desired epistemic aims. EMS involve skills such as planning, monitoring, and evaluation of strategies and processes of knowledge construction and justification and of the nature of the individual's knowledge. Thus EMS are MS that are specifically geared toward attainment of epistemic aims. It is important to note that MS can serve both self and social regulation (Efklides, 2008). Likewise, EMS might be used to regulate other people's epistemic thinking or to jointly regulate collective activity (cf. Grau & Whitebread, 2012). EMS can be informed by epistemic metacognitive knowledge (EMK, see below), for example by reliability standards, but they may also contribute to the formation and development of EMK.

**Examples.** Hofer (2004) and Mason and her colleagues (Mason, Ariasi, & Boldrin, 2011; Mason et al., 2010a; Mason, Boldrin, & Ariasi, 2010b) have studied epistemic monitoring through think-aloud protocols and retrospective interviews. In their studies, students' epistemic monitoring was found to entail reflections regarding the certainty, simplicity, and source of knowledge, and justification for knowing. For instance, students have been found to plan which types of sources to seek and to monitor if the information they are reading is consistent with their prior knowledge (Mason et al., 2010b).

### *Epistemic Metacognitive Knowledge (EMK)*

**Description.** People's knowledge, beliefs, ideas, and theories about the nature of knowledge and knowing are a meta-level epistemic knowledge, or EMK. According to Flavell (1979), MK includes knowledge about persons, tasks, and strategies and their interactions. Likewise, EMK can entail knowledge about **p**ersons (EMPK) that includes knowledge about the individual as knower, about other people as knowers, and about human knowledge and knowing in general, and knowledge about **s**trategies and tasks (EMSK) that includes knowledge about strategies of construction and justification of knowledge and knowledge about the epistemic nature of tasks. EMSK is knowledge about how to carry out an activity that will result in knowing and consists of knowledge about when, why, and how to use epistemic strategies and about the reliability of these strategies. EMSK can also include meta-task knowledge about the epistemic requirements of tasks and about task conditions, such as the nature and limits of available information. It is important to note that the various facets of EMK interact with each other. Furthermore, EMK informs both EC and EMS: EMK about epistemic standards and epistemic strategies can guide the execution of cognitive-level epistemic strategies as well as their selection, monitoring, and evaluation (cf. Bromme, Pieschl et al., 2010). However, EC and EMS also serve as inputs for the construction of EMK (cf. Muis, 2007).

**Examples.** Epistemic beliefs assessments usually target meta-level knowledge or understandings about knowledge and knowing (e.g. Hofer, 2000; Schraw, Bendixen, & Dunkle, 2002). These assessments have mostly addressed the person aspects of EMK, such as personal epistemic preferences or the characteristics of human knowledge, and have paid less attention to the strategy and task aspects of EMK, for example, to knowledge about knowledge construction and justification. We have found that both EMPK and EMSK are positively related to better epistemic strategies (Barzilai & Zohar, 2012).

### *Epistemic Metacognitive Experiences (EME)*

**Description.** Several calls have been made to expand the study of epistemic thinking to encompass affect and experience (Barzilai & Zohar, 2014; Bendixen & Rule, 2004; Hofer & Pintrich, 1997; Muis et al., 2015). According to Efklides (2006, 2008), ME are what a person is aware of or feels during a cognitive task. We define EME as ME that are evoked by knowledge construction and justification processes and that are related to the nature of knowledge and knowing, for example to issues of correctness, certainty, or consistency. These experiences can serve as important inputs to EMS and may influence epistemic judgments and knowledge construction in conscious and non-conscious ways (Efklides, 2006, 2008).

**Examples.** Cognitive ease in processing information can induce feelings of truth or correctness (Kahneman, 2011). Estimates of solution correctness are related to pleasant feelings of satisfaction (Efklides, 2002). In contrast, inconsistent or conflicting information disrupts cognitive processing and can trigger unpleasant feelings of difficulty (Efklides, 2006). Recently, Muis and her colleagues (2015) examined the complex impact of epistemic emotions, which they define as emotions that are caused by the cognitive qualities of task information and the processing of that information. They found that epistemic beliefs predict epistemic emotions and that these in turn predict self-reported cognitive and metacognitive learning strategies.

## EPISTEMIC THINKING WHILE READING CONFLICTING INFORMATION SOURCES: AN ILLUSTRATION

We next illustrate how this multifaceted framework can apply to the analysis of verbal data and how such an analysis may inform the study of epistemic thinking. Investigations of epistemic thinking usually focus on specific cognitive or metacognitive aspects. Hence we conducted a study whose aims were to examine if learners spontaneously verbalize multiple facets of epistemic thinking while reading conflicting information sources, to better characterize these facets, and to understand some of their interactions.

In this study, we analyzed think-aloud protocols of 61 university students who read four partially conflicting information sources about the environmental and economic impacts of seawater desalination. The participants' task was to form and justify an argument about whether extensive seawater desalination is advisable or not. Participants' protocols were parsed into idea units, defined as the smallest units of speech that contain a single but whole idea. Drawing on a metacognitive coding scheme by Whitebread et al. (2009) and on our own analysis framework, we developed and validated a coding scheme for identifying verbalizations of epistemic and non-epistemic cognition and metacognition.

In this particular task, we found that about half of learners' verbalizations while reading entailed epistemic issues (991 out of 1858 idea units, $M = 16.25$, $SD = 7.35$). All of the proposed facets of epistemic thinking could be identified in students' protocols, in varying frequencies. 49.8 percent of the epistemic units were identified as EC, i.e. as cognitive-level epistemic processes. These processes related to the epistemic properties and status of both content and sources. 41.9 percent of the units entailed epistemic monitoring, indicating that this is by far the most prevalent metacognitive facet in participants' verbalizations in this task. Epistemic planning and epistemic evaluation were relatively infrequent, 3.7 percent and 0.6 percent accordingly. 5.1 percent of the units included EME and 3.3 percent included EMK. However, although spontaneous references to explicit EMK were relatively infrequent they were related to increased EC, $r = .27$, $p < .05$, indicating that participants with a greater tendency to evoke EMK were also more likely to verbalize cognitive-level epistemic processes.

Untangling the different facets of epistemic thinking enabled us to characterize in greater detail some of the specific cognitive and metacognitive epistemic resources that learners draw on when dealing with conflicting accounts. This has revealed a rich array of processes, skills, knowledge, and experiences. Some examples are provided in Table 25.1.

**Table 25.1** Examples of spontaneous epistemic thinking while reading conflicting information sources

| Facet | Examples | Sample Quotes |
|---|---|---|
| Epistemic Cognition (EC) | Assessing validity of claims | "Right, consumption increases"; "This is not correct"; "Maybe there isn't really a shortage." |
| | Considering justification of claims | "This hasn't been proven yet"; "This is reasonable"; "Ah, this explains that." |
| | Noting consistency and coherence of claims and data | "This looks like the same data"; "This is in contrast to the previous articles." |
| | Examining source properties | "She has an ecological approach"; "He may have a financial interest"; "This doesn't look so up-to-date." |
| Epistemic Metacognitive Skills (EMS) | Planning information gathering | "I need to get more information"; "Maybe I should follow prices more." |
| | Monitoring validity assessments | "Right, I agree with this sentence"; "This information doesn't look right to me." |
| | Monitoring consistency with prior knowledge | "This is something I already know"; "This pretty much contradicts what I thought." |
| | Monitoring personal certainty | "I'm certain that . . ."; "I'm not so sure about this." |
| | Evaluating changes to knowledge and understanding | "OK, I didn't understand this before"; "I was wrong." |
| Epistemic Metacognitive Knowledge (EMK) | About self: Knowledge about epistemic dispositions | "I am very critical." |
| | About others: Knowledge about source reliability | "Everybody presents their own position in a more extreme manner." |

| Facet | Examples | Sample Quotes |
|---|---|---|
| | About human knowledge: Knowledge about the certainty of knowledge | "I don't think it's possible to know in 100%. There's no 100% in life." |
| | About strategies: Knowledge about knowledge construction strategies | "Maybe it is possible to build a solution based on several blogs"; "How do they predict this?" |
| | About tasks: Knowledge about adequacy of available information | "It is impossible to make an unequivocal decision based on these data." |
| Epistemic Metacognitive Experiences (EME) | Epistemic curiosity | "I am curious if this is right"; "It interests me to know what the implications of desalination are." |
| | Epistemic surprise | "Surprising information"; "5%, surprising data" |
| | Emotions about sources (e.g., affinity or aversion) | "I can connect to her"; "She feels truthful"; "I am always put off by people who predict the worst." |



**Table 25.2** Excerpt from Daniel's think-aloud protocol

| Line | Comment | Facet |
|---|---|---|
| 1. | I can't evaluate this data. | EMS |
| 2. | I don't think that the average reader can evaluate the impact [of desalination] on the Mediterranean, if it's a local change or something drastic. | EMK |
| 3. | It's interesting if any more studies were conducted on this topic, | EME |
| 4. | and what are the opinions of those studies. | EC |
| 5. | Is everyone in support? | EC |
| 6. | The situation is bad now. | Non-epistemic |
| 7. | But there are many more things to do before [desalination]. | Non-epistemic |
| 8. | This is a blog against desalination that calls for examining other alternatives. | EC |

In order to demonstrate the interactive nature of the facets of epistemic thinking, we next discuss a short excerpt from the think-aloud protocol of Daniel (pseudonym), one of the participants in the study. In this episode, Daniel is reading a blog post that claims that seawater desalination has a negative effect on the marine environment. He begins to examine the data presented in the blog post but soon encounters an impasse (see Table 25.2). As he reads, Daniel monitors his understanding of the data and realizes that he is unable to evaluate it on his own (line 1). This instance of epistemic monitoring leads him to consider whether evaluating such data is something a typical reader can do (line 2). In this line, Daniel explicitly evokes EMK about other people as knowers and uses it to determine whether evaluation of the data is a feasible strategy that is worth engaging in. His answer to that question is negative and consequently he changes his epistemic strategy and considers seeking corroborating accounts: Daniel voices an epistemic interest in checking out additional information sources (line 3) and comparing their positions regarding desalination (lines 4 and 5). He concludes his reading of the blog post by noting the position of the current source (line 8) and thus links the claims he just read to a particular viewpoint regarding the dilemma.

Bromme and his colleagues have argued that due to the division of cognitive labor in modern knowledge societies laypersons often encounter information which they are unable to evaluate on their own (Bromme & Goldman, 2014; Bromme, Kienhues, & Porsch, 2010). They proposed that under such conditions it is often more adaptive to switch from direct evaluation of the veracity of claims, that is, "firsthand evaluation" of what is true, to evaluation of source trustworthiness, that is, "secondhand evaluation" of whom to believe. Furthermore, they suggested such decisions require metacognitive assessments and ideas about the nature of knowledge (Bromme & Goldman, 2014). The analysis of Daniel's example sheds light on how people deal with the boundaries of lay understanding: Epistemic monitoring of firsthand evaluation strategies can alert readers to difficulties or failure to independently evaluate information. This awareness may evoke EMK about one's ability to evaluate similar kinds of data, about the conditions and limits of lay evaluation, and about relevant evaluation criteria and strategies (cf. Chinn, Rinehart, & Buckland, 2014). Readers' EMK may impact subsequent metacognitive control decisions to engage in epistemic strategies of corroboration and sourcing as alternate routes for establishing reliability.

More generally, this example illustrates the important function of EMS in regulating epistemic strategies, suggests how EMK might inform EMS, and hints at the possible role of EME in guiding epistemic thinking. Thus, we argue that by closely attending to the roles of the various facets of epistemic thinking it is possible to gain greater insight into how people deal with epistemic challenges.

## METACOGNITIVE AND EPISTEMIC DEVELOPMENT

The examples discussed in this chapter illuminate the importance of the metacognitive aspects of epistemic thinking. Indeed, the development of epistemic thinking has been tied to the development of metacognitive abilities (Hofer & Sinatra, 2010). One source of empirical evidence regarding the interrelatedness of metacognitive and epistemic development can be found in studies that have examined the development of children's theory of mind. Early development of a theory of mind, that is, an appreciation that the mind exists and that people may have different mental states such as different knowledge and beliefs, has been identified as an important milestone in epistemic development (e.g. Wildenger, Hofer, & Burr, 2010). The development of a constructivist theory of mind in later childhood, that is, the development of an understanding that the same information can be legitimately interpreted in different ways, has been suggested as a second important milestone in epistemic development (e.g. Lalonde & Chandler, 2002). Another indication of the interdependence of metacognitive and epistemic development may be found in studies that have documented that understanding of metacognitive vocabulary, including epistemic vocabulary such as "know," "guess," and "deny," develops gradually in early and middle childhood (e.g. Lockl & Schneider, 2006).

However, more cross-sectional and longitudinal studies are needed in order to better understand the links between epistemic and metacognitive development. Furthermore, because of the overlap between the two constructs, there is a need for studies that will attempt to tease apart the epistemic and non-epistemic aspects of metacognition in order to examine if they develop in tandem. Lastly, there is a need for more studies that will examine how the development of epistemic metacognition is related to the development of epistemic cognition. For example, the development of cognitive-level epistemic reasoning may predate the development of articulate EMK. Yet, limited EMK, for example, limited understanding of how to construct and evaluate knowledge despite its complex and uncertain nature, might constrain further development of epistemic cognition (Weinstock & Cronin, 2003).

## THE ROLE OF EPISTEMIC METACOGNITION IN FOSTERING EPISTEMIC THINKING

Several researchers have proposed that metacognitive awareness can promote understanding of epistemic thinking and thereby support its development. For example, Bendixen and Rule (2004) argued that learners who are more metacognitively engaged will be more aware of the need for strategies for resolving epistemic doubt and may monitor the effectiveness of those strategies more closely. Brownlee and her colleagues found that writing journals in which learners reflected on their epistemological beliefs promoted growth of these beliefs (Brownlee, Purdie, & Boulton-Lewis, 2001). Abd-El-Khalick and his colleagues demonstrated that metacognitive activities, such as reflective discussions following science inquiry activities, help promote greater understanding of the nature of science (Khishfe & Abd-El-Khalick, 2002).

However, metacognition research has shown that not all learners naturally develop high levels of MK and MS. Hence, low metacognitive competence, for example, limited metacognitive vocabulary or monitoring difficulties, might hamper learners' ability to reflect on their epistemic thinking. Furthermore, as Veenman (2011) noted, cueing and prompting metacognition may remind learners to activate metacognition but cannot compensate for low MK or MS. Therefore, some learners can benefit from explicit instruction of MK and MS (Swartz et al., 2008; Veenman, 2011; Zohar & Barzilai, 2015). Likewise, in some cases, explicitly addressing learners' epistemic metacognitive knowledge and skills might be necessary in order to promote epistemic thinking.

Elsewhere, we have discussed several key principles of effective metacognitive instruction that characterize successful metacognitive interventions (Zohar & Barzilai, 2015). In what follows we briefly suggest how these principles may apply to fostering epistemic metacognition.

(a) *Paying deliberate attention to underlying thinking structures and skills.* Teachers need to be able to identify relevant epistemic thinking components (e.g. epistemic criteria or epistemic strategies) in content-rich and often "messy" contexts and deliberately include epistemic metacognitive goals in teaching and assessment. For example, Ryu and Sandoval (2012) described how Ms. Green, an elementary school science teacher, helped students construct understandings of norms of scientific argumentation by persistently asking them questions such as "How do you know?" and "How do you convince each other?" as they engaged in inquiry activities.

(b) *Fostering explicit awareness of metacognition.* Learners' explicit awareness of the relevant epistemic thinking component should be fostered. Explicit awareness can be advanced, for example, by naming the component, by introducing relevant epistemic vocabulary, by considering relevant generalizations and rules, and by modeling and discussing the when, why, and how of epistemic strategies. It is important to note that in calling for explicit instruction we do not intend to suggest that teachers should simply tell their students what to do. Effective metacognitive instruction would involve helping learners construct and refine their epistemic metacognition by providing opportunities for representing, reflecting on, and applying epistemic meta-level knowledge and skills. For example, Braasch and his colleagues (2013) asked students to compare and contrast alternative strategies for evaluating multiple scientific documents in order to foster their understanding of reliable evaluation strategies. Paying attention to students' EMS might also be necessary in order to facilitate regulation and control of epistemic thinking. For instance, Stadtler and Bromme (2008) provided metacognitive prompts that supported monitoring of knowledge and understanding while studying with multiple information sources.

(c) *Teaching in a meaningful way.* As with any other subject matter, effective metacognitive instruction should trigger and facilitate active thinking and meaningful experiences that foster knowledge construction and robust understanding. This can benefit from collaborative learning and requires sustained and varied practice. For example, Kuhn and her colleagues (2013) facilitated the development of argumentative competence and meta-level awareness of argumentation by engaging students in a series of scaffolded games in which teams of students debated with each other. The games provided multiple opportunities for meaningful meta-talk about norms of argumentation.

(d) *Thinking across and beyond specific contexts.* Because metacognition has both specific and general aspects, teachers need to pay attention to domain-, topic-, and even task-specific aspects of epistemic metacognition, but also need to assist learners in forming generalizations that will enable them to extend their epistemic metacognition to future contexts. For instance, in the PRACCIS project, students are repeatedly encouraged to discuss and apply epistemic criteria across multiple model-based inquiry units (Chinn & Buckland, 2012).

## CHALLENGES AND FUTURE DIRECTIONS

In this chapter, we have argued that epistemic thinking encompasses multiple cognitive and metacognitive facets and that the study of epistemic thinking and the educational objective of fostering epistemic thinking could benefit from paying attention to these facets and their interactions. However, much more theoretical and empirical work will be needed in order to better characterize the various facets of epistemic thinking, to identify finer distinctions within these facets, to examine them in additional content and task contexts, and to clarify how they might change and develop.

One of the challenges facing future research is examining the implications of this approach for models of self-regulated learning (SRL). These models have so far focused mainly on the impact of epistemic beliefs on SRL (e.g. Greene, Muis, & Pieschl, 2010; Muis, 2007). More recently, Muis et al. (2015) suggested expanding Muis' model to include epistemic emotions. Based on our analysis, we would suggest that SRL models could be further expanded to include epistemic strategies and EMS. This raises two possible directions for future research. One direction could be to continue examining epistemic thinking as one of the aspects of SRL and to study how additional epistemic components contribute to SRL. However, it might also be possible to apply SRL frameworks in order to specifically model epistemic thinking. For example, it might be fruitful to produce more detailed models of how learners self-regulate and co-regulate the achievement of epistemic aims.

Another major challenge ahead is to identify more clearly when, why, and how different epistemic facets may contribute to promoting epistemic thinking. Currently, attempts to foster epistemic thinking focus on various aspects of this construct such as scaffolding learners' epistemic strategies, engaging learners in epistemic monitoring or reflection, introducing meta-knowledge about epistemic issues, such as epistemic criteria or strategies, or a combination of these approaches. The outcome measures of these interventions are also diverse and can include assessment of epistemic strategies, of EMK, or of additional learning outcomes. In order to better understand how epistemic thinking can be successfully fostered it would be helpful to clarify and map which facets of epistemic thinking are being addressed in intervention studies, by which instructional means they are being addressed, and which outcomes are impacted. Additionally, future studies might compare the efficacy of addressing specific cognitive and metacognitive facets of epistemic thinking in order to elucidate their contribution to epistemic development. When doing so, it would be important to consider the characteristics of the learners and of the instructional context, since the effectiveness of interventions is likely to depend on learners' prior epistemic and metacognitive tendencies and on task resources and demands. Thus we hope that future research might deepen the understanding of the intersecting roles of epistemic thinking and metacognition in learning and instruction.

## ACKNOWLEDGEMENTS

We are grateful to Arnon Keren and Ernest Sosa for their helpful comments on earlier drafts of this manuscript. Preparation of this chapter was partially supported by a grant to Sarit Barzilai from the I-CORE Program of the Israel Council of Higher Education and the Israel Science Foundation (grant, 1716/12).

## NOTE

1 We thank Arnon Keren for pointing this out.

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# 26

## EPISTEMIC COGNITION AND MOTIVATION

*Jason A. Chen and Michael M. Barger*



Why do you want to teach? What are the reasons you decided to major in philosophy in college? Why did you consult three different physicians *and* comb through hundreds of medical journals just to find out whether you should have your daughter vaccinated—isn't asking your own doctor sufficient? Motivation is at the root of all of these types of questions. Motivation researchers are primarily concerned with the cognitive processes by which people initiate and sustain behaviors. For example, if a group of teachers indicate they decided to teach because they believe ensuring the next generation of young people enters their adult lives prepared to face the challenges of the twenty-first century, then these teachers are likely describing a belief in the *utility* of what they do. On the other hand, if a student said she decided to major in philosophy because she took introductory courses in logic and in ethics and earned superior marks in these classes, then her *competence beliefs* are likely the most salient aspect of her motivation.

Although motivation historically has been presented in many different ways (e.g. need satisfaction, innate drives), in this chapter we frame the most commonly studied constructs of motivation as important cognitive structures and processes that guide our behaviors. We conceive of behaviors in a broad sense of the word to also include cognitive behaviors such as asking oneself whether a certain strategy is the best approach to solve a problem. This focus is in line with the purpose of this chapter and Handbook—to focus on cognitive structures and processes that guide behaviors related specifically to building and evaluating knowledge. Given this focus on the cognitive basis of motivation, we then explore how motivational aspects of cognition relate to aspects of cognition that concern the nature of knowledge and knowing. Although the literature about the intersection of motivation and epistemic cognition is relatively small, scholars are becoming increasingly interested in questions such as, "Why might some students refer to a politician about whether vaccines are effective and safe rather than refer to their family doctor?" At the heart of these types of questions is the assumption that cognitive behavior (including epistemic cognition) is motivated. That is, might some students refer to their teachers as the definitive source for an answer because they believe that it is not worth the time and effort to find more nuanced answers from multiple sources of information? Or might other students seek out alternative answers that are different from their textbook because they want to show off to their peers and teachers about how smart they are?

To understand the linkages between motivation and epistemic cognition, however, we must first understand the theoretical frameworks that guide research in motivation as well as the empirical findings that have supported them. Motivation is a very broad construct that can include competence beliefs (i.e. "Am I able to do this task?"), value beliefs (i.e. "Do I find this task compelling?"), and goal orientations (i.e. "What is the reason I am engaging in this task?"). Given the large number of constructs included under the umbrella term of motivation, clarification is necessary regarding which constructs are typically included when researchers describe motivation. From there, we explore the studies that have examined the links between epistemic cognition and motivation, we consider ways that theory on epistemic cognition has implicitly enveloped motivational constructs, and we delineate how clear motivational constructs might inform such research. We conclude by exploring areas where future research is needed, and offer comments about the types of studies that may be productive for the field.

## FRAMEWORKS FOR UNDERSTANDING MOTIVATION

### *Understanding What People Value*

One family of constructs that has received a considerable amount of attention in the motivation literature is individuals' *beliefs about the value* of a task or subject area. People's motivation to do any task is tied to the value they see in doing it. Eccles and Wigfield (2002) suggest there are four major components to this value component: *attainment value*, which is the importance of doing well on a given task; *intrinsic value*, which is the enjoyment one gains doing a task; *utility value*, which is defined as how a task fits into an individual's future plans or personal agenda; and *cost*, which refers to what the individual has to give up in order to do a task and how much effort must be exerted. Research has shown that students' task values predict whether or not they actually pursue a task (Battle & Wigfield, 2003; Durik, Vida, & Eccles, 2006; Simpkins, Davis-Kean, & Eccles, 2006). This is especially true regarding career choices (Brophy, 2009). Research has shown that when students perceive a task to be useful for their future endeavors, they are more likely to initiate an activity and remain engaged in it (Greene, Miller, Crowson, Duke, & Akey, 2004; Johnson & Sinatra, 2013; Miller & DeBacker, 1999), and do better on measures of achievement (Cole, Bergin, & Whittaker, 2008; Greene, et al., 2004).

A closely related way to examine whether students find a task compelling is research on *interest*, the positive cognitive and emotional reaction a person has to a specific object (Hidi & Renninger, 2006; Schiefele, 1991). The object in an academic setting might be a particular task, topic, or subject area. Researchers further divide interest into individual interest, which a student holds toward the object in general, and situational interest, which is brought about by a particular context (Mitchell, 1993; Schiefele, 2009). As an example, a student might not be very interested in science, but could become highly engaged in an experiment that involves colorful chemical reactions or appreciate science when a particular teacher describes how science makes the world a better place. Situational interest can develop into individual interest under the right circumstances (Hidi & Renninger, 2006).

### *Understanding People's Competence Beliefs*

Researchers concerned with people's competence beliefs often focus on two constructs that have received the lion's share of research in motivation. The first construct is self-efficacy, which Bandura (1997) defined as individuals' beliefs about their own capabilities to learn or perform tasks at designated levels. A wealth of research has shown that students' self-efficacy plays an important role in their academic success and in the academic choices they make (Schunk & Pajares, 2005). Students' academic self-efficacy has been shown to relate to (a) their performance in many different academic subjects, (b) their level of interest in those subjects, (c) the amount of effort they put forth in accomplishing those academic tasks, and (d) their subsequent career choices (see Pajares & Urdan, 2006).

A second major construct discussed in reference to students' competence beliefs is their *implicit theories of ability*, which Dweck and Leggett (1988) described as the view that individuals hold of their ability as either a fixed entity or as a quality that can change with effort and appropriate strategies. Those who adopt a fixed theory of ability tend to view their ability as a relatively static trait that cannot be changed, whereas those who adopt an incremental theory of ability are more likely to believe their ability can change. Decades of research have shown that implicit theories of ability predict academic achievement (Aronson, Fried, & Good, 2002; Blackwell, Trzesniewski, & Dweck, 2007; Hong, Chiu, Dweck, Lin, & Wan, 1999; Robins & Pals, 2002; Stipek & Gralinski, 1996). The literature in this field has shown that implicit theories do not influence achievement directly, however. Their influence is mediated by students' goal orientations.

### *Understanding the Orientation of People's Goals*

Goal orientations have had an extensive history in the motivation literature (see Maehr and Zusho, 2009). They deal with individuals' *reasons* for initiating a task and continuing to engage in it. In the academic domain, there are two broad orientations from which students might approach a task (Ames & Archer, 1988; Elliott & Dweck, 1988; Nicholls, 1984). They could adopt a performance goal, seeking to demonstrate competence to others. Alternatively, they could endorse a mastery or learning goal, pursuing a task for the sake of improving skills and understanding. Goals might also be divided further by whether students are approaching or avoiding the possible outcome (Elliot & Church, 1997; Elliot & McGregor, 2001). For instance, students might have a performance approach goal, in which they want to demonstrate how smart they are, or a performance avoidance goal, in which their main objective is not to appear incompetent at the task.

Scholars have noted that individuals often orient themselves toward different personal goal orientations because of the "messages in the learning environment (e.g., the classroom or school) that make certain goals salient" (Urdan & Schoenfelder, 2006: 334). In classrooms that emphasize social comparison, the goal structures could be described as performance oriented, whereas in classrooms in which deep learning and understanding are valued rather than surface-level memorization the goal structures could be considered mastery oriented. Decades of research have demonstrated that mastery goal structures are associated with adaptive learning patterns (for a review see Meece, Anderman, & Anderman, 2006), suggesting that environmental factors created within classrooms could be contributing to the ways in which students orient themselves to academic tasks.

In sum, motivation is a broad field composed of many different constructs and theoretical frameworks. It is a field of study concerned with addressing the question, "Why do people behave the way they do?" Answers could pertain to, among others, beliefs about competence, beliefs about the value that people place on a task, or the goals to which people orient themselves. Traditionally, these beliefs have been studied in relation to observable behaviors such as solving mathematics problems or pursuing careers in various fields. Yet, how might motivation play out in the context of epistemic cognition in which the behaviors might be more invisible?

## HOW SCHOLARS IN EPISTEMIC COGNITION HAVE APPROACHED MOTIVATION

If students believe, for example, that one historian's account of how World War II began is indisputably true, might there be motivational consequences to this belief? Would the motivational consequences for these students be different from their peers who believe that the "true" cause of WWII can never be fully known, and that this historian's account is merely one point of view about an event? Scholars who have explored these types of questions are concerned with the relationships between students' epistemic cognition regarding a field of study and their motivation to engage in that field of study. We examine this line of inquiry next.

### *Epistemic Cognition and Relations to Motivation*

Drawing from research in mathematics education (Schoenfeld, 1983, 1989), Schommer (1990) set out to investigate what she called epistemological beliefs and their relationship to learning. Here we will use the more common "epistemic" belief. Her underlying assumption was that epistemic beliefs influenced how students learned academic material, which was in line with Schoenfeld's assumptions regarding mathematics learning. Schommer posited that epistemic beliefs included beliefs about the *structure* of, *certainty* of, and *source* of knowledge, as well as the *speed* and the *control* of knowledge acquisition. The construction of the latter two dimensions was influenced by Schoenfeld's findings regarding students' beliefs about mathematical knowledge being ascertained very quickly (speed of knowledge acquisition), and by Dweck and Leggett's (1988) work regarding people's beliefs about the malleability of their intelligence.

The empirical literature supporting Schommer's (1990) framework of epistemic beliefs has shown that beliefs about knowledge and knowing have important relationships to motivation. Early scholarship suggested that epistemic beliefs give rise to students' motivation. This likely emanated from Hofer and Pintrich's (1997, 2002) hypothesis that epistemic beliefs might function as a type of implicit theory that gives rise to students' motivational orientations. The studies that follow point to this possibility, in which epistemic beliefs orient students toward certain types of goals, which then have implications for the ways in which students regulate their motivation.

In one example, Bråten and Strømsø (2004) revealed one aspect of how epistemic beliefs function like a type of implicit theory by showing that students who believed in stable and unchanging knowledge (considered less constructivist) were less likely than their peers with more constructivist orientations to adopt mastery goal orientations. Similarly, Chen and Pajares (2010) showed through a path analysis that an incremental view of ability in science was directly related to students' beliefs that scientific knowledge is dynamic and evolving, and that experimental results are a good way to generate new questions about science (rather than serve as simple demonstrations about things we already know to be true). They also found that fixed views of ability in science were directly related to students' beliefs that scientific knowledge is best described as coming from an external authority rather than from one's own personal reasoning and thoughts, and that scientific knowledge consists mostly of truths that are knowable with certainty. These findings suggested that views about malleable intellectual capacity were related to views about a dynamic nature of knowledge, which were in turn related to higher end-of-year grades. On the other hand, those who viewed attributes such as intelligence or scientific knowledge as static were more likely to characterize those attributes as simplistic, all-or-nothing, entities. Similar to Bråten and Strømsø's (2004) work, Chen and Pajares's study suggested these beliefs about the dynamic nature of ability and knowledge were indirectly related to self-efficacy, self-regulatory beliefs, and ultimately students' grades through their effects on goal orientations.

A similar study by Mason et al. (2012) showed through a path analysis that, for students in Grades, 5, 8, and 11, the more students believed in scientific experimentation as a tool used to provide evidence for questions and to generate new questions to ask, the more likely these students were to pursue learning activities to understand the material. They also found, although students' belief in an uncertain and constantly evolving scientific knowledge base was not significantly related to goal orientations, this belief was directly related to science knowledge. These findings extend those from Chen and Pajares (2010).

Beghetto and Baxter (2012) used structural equation models to explore the relationships between self-efficacy, epistemic beliefs, intellectual risk-taking (the willingness to share tentative ideas, ask questions, and try new tasks), and teachers' rating of students' understanding of science or mathematics. Although their findings in science mirrored the findings of the aforementioned studies, Beghetto and Baxter found that students who held their own *mathematics* competence in high regard were more likely to believe that mathematical knowledge was external to them. This may reflect a belief that mathematical competence has to do with understanding knowledge from competent experts, and less to do with developing the conceptual understanding to solve problems creatively in a variety of ways.

Finally, although the vast majority of studies concerning the relationships between epistemic cognition and motivation are cross-sectional, we point to one experimental study that specifically isolated epistemic cognition and explored the effects of such a manipulation on outcomes that included motivation. In a quasi-experimental study, Muis and Duffy (2012) manipulated the epistemic climate of classrooms such that students in the intervention condition experienced a classroom environment that demonstrated statistics knowledge as contestable and constantly evolving. Students in the control condition experienced statistics instruction in a traditional format that did not challenge the epistemic climate. They found that students in the intervention classroom evinced changes toward more constructivist stances, which coincided with increased statistics self-efficacy. The authors posited that, because of the intervention, students changed the ways in which they thought about statistics knowledge, and in turn, used different strategies to understand the material, which forced students to more deeply process the material. Ultimately, this resulted in greater self-efficacy for mastering the content.

Students' self-reported epistemic beliefs and motivation in the control condition, however, remained constant.

Taken together, the aforementioned studies suggest that, when a field of study (e.g. science or statistics) is presented as a dynamic body of knowledge that requires individuals to inquire deeply to understand the subject, then students are more likely to orient their goals toward understanding the subject rather than demonstrate their competence to others or avoid appearing incompetent. In turn, when classroom structures encourage mastery goals people are more likely to embark on a trajectory that involves expending additional effort to self-regulate their learning and develop strategies to better understand the material.

### *The Motivation behind Epistemic Cognition*

The line of inquiry we just outlined explores relationships between the different dimensions of epistemic cognition on the one hand and motivation toward a particular academic subject on the other hand. Another way in which scholars in epistemic cognition have studied issues related to motivation is by exploring the reasons why individuals would *want to* engage in thinking about knowledge and knowing in the first place. Chinn and colleagues (Chinn, Buckland, & Samarapungavan, 2011; Chinn, Rinehart, & Buckland, 2014) have pioneered this line of inquiry under what is often referred to as epistemic cognition (Greene, Azevedo, & Torney-Purta, 2008), which is a far more expansive construct than the epistemological beliefs mentioned earlier. This expanded perspective seems to fold motivation constructs into epistemic cognition. It acknowledges that thinking about knowledge is not merely a "cold" cognitive process (Pintrich, Marx, & Boyle, 1993), but a "hot" process involving affective and motivational components.

This expansion of epistemic cognition includes the traditional epistemic beliefs, but also includes components such as epistemic aims, epistemic values, and the reliability of processes used to obtain knowledge (Chinn et al., 2011). Epistemic aims are the goals that people adopt toward knowledge. Epistemic aims are directed toward end-states of knowledge pursuit, called epistemic achievements, which might vary from obtaining true facts or understanding the relations between these facts. In differentiating epistemic aims from non-epistemic aims, Chinn and colleagues (2014) argued that the latter are aims that are not specifically directed toward knowledge. For example, the epistemic aim of understanding differs from the non-epistemic aims of experiencing pleasure or maintaining self-image, even though such aims might interact.

There are similarities in Chinn and colleagues' framework to work done by scholars studying goal orientations. For example, a mastery goal orientation involves a primary focus on the actual act of learning and understanding *for learning's sake*. Two common mastery goal measures (Achievement Goal Questionnaire, Elliot & McGregor, 2001; Patterns of Adaptive Learning Survey, Midgley et al., 2000) include items that get at the act of seeking to understand: "One of my goals in my classes is to learn as much as I can," and "It is important to me to understand the content of this course as thoroughly as possible." Performance goal orientations, on the other hand, particularly those with a normative standard (Elliot, Murayama, & Pekrun, 2011), involve a primary focus on demonstrating competence to others. Although students can certainly demonstrate competence to others while also trying to understand something deeply, the emphasis is on which goal is the primary focus. However, in the case of a multiple goal pursuit (e.g. Barron & Harackiewicz, 2001; Daniels et al., 2008; Pintrich, 2000) students might be oriented toward juggling both types of goals. This issue of a multiple goal pursuit could inform scholarship on epistemic and non-epistemic aims (Chinn et al., 2014). For example, just as it is quite reasonable to read a book both for the sake of learning about the history behind modern models of the atom, as well as to read the book to ace a test (i.e. orientation toward both a mastery and a performance goal), the same is true for epistemic cognition. That is, students could be oriented toward understanding the biases behind a particular author's version of history so as to understand the complexity of the issue (an epistemic aim). However, these same students could also be oriented toward understanding the authors' biases in order to be esteemed by their peers for finding an interesting insight (a non-epistemic aim).

Whereas the discussion about epistemic aims reveals similarities to goal orientations, Chinn et al. (2011) also included features in their model that relate to issues of understanding what people value. For example, Chinn et al. noted that epistemic aims can be informed by what they call epistemic values—epistemic achievements that individuals find interesting, useful, or otherwise compelling. If an individual sees, for example, video footage of archaeologists discovering the remains of a human skeleton in the early Jamestown settlement that suggested cannibalism during the "starving time" of 1609 to 1610, this startling discovery might trigger excitement and interest in understanding the circumstances surrounding the situation. This interest trigger might then recruit a series of behaviors directed toward whichever goal or combination of goals this student is oriented toward.

To play out the complex interactions between epistemic aims, epistemic values, and motivation, we present two hypothetical scenarios. First, going to the earlier example of Jamestown, if classroom conditions are such that students have to sift through evidence from primary sources and forensics results to seek a better understanding of what life was like in the "starving time," students' motivation could certainly be recruited toward treating knowledge in history as tentative (i.e. we do not know for sure what life was like in Jamestown to have led to cannibalism) and highly complex (i.e. understanding the situation requires historians, archaeologists, and scientists). On the other hand, if classroom conditions are such that students are presented with a news story about how forensic scientists discovered that a person was cannibalized during the "starving time," and that the colonists were incompetent farmers and so could not produce enough food for themselves, motivation could certainly be recruited toward treating historical knowledge as certain (i.e. we know for certain that the colonists were inept and therefore could not produce enough food, which led to cannibalism) and somewhat simple (i.e. finding the answer to the question was a forensic science issue that does not require historical knowledge to figure out). Notice that in both scenarios if the classroom centered on a highly engaging activity in which students worked collaboratively about a real-life problem that actual professionals deal with, students could see the value of wrestling with issues related to knowledge and knowing, and they could develop the competence beliefs to do so. Researchers and practitioners could consider these activities to be quite motivationally sound. However, in the first case, presenting a more comprehensive case of the types of inquiry happening in Jamestown recruits students' cognitive resources (both epistemic and motivational) toward a more nuanced and adequate picture of knowledge and knowing. Whereas in the second case, although a compelling and interesting presentation of the material could be motivating, that motivation may be directed toward a more simplistic view of knowledge and knowing. We bring this up because in scholarship that explores the relationship between epistemic beliefs and motivation, such as in Chen and Pajares's (2010) or Bråten and Strømsø's (2004) work, their results suggest that more nuanced and complex views of knowledge and knowing are related to more adaptive forms of motivation. However, in the epistemic cognition framework outlined by Chinn et al. (2011), beliefs about value, competence, and goal orientations can be directed toward any variety of outcomes that can vary widely in how nuanced they are, and may or may not be epistemic. Such a line of inquiry requires a conception of and measures of motivation and epistemic cognition that are highly specific, both to the domain and likely even to the task in which students are engaged.

As the field has expanded from conceptualizing a set of personally held beliefs about knowledge to a broad spectrum of cognitive processes related to knowledge seeking, motivation has implicitly been folded into the framework of epistemic cognition. Researchers in both fields have begun to bridge the gap between these two critical components of learners' thinking and behavior. This expanded conceptualization of epistemic cognition has generated an exciting array of questions and lines of inquiry that researchers can pursue. In the final section of this chapter, we pose some of these lines of inquiry, with a specific focus on the intersection of epistemic cognition and motivation.

## FUTURE DIRECTIONS FOR RESEARCH

Epistemic achievements are a worthy educational outcome in their own right. However, schooling has long been considered a means to an end. For example, students are told to get good grades and do well on tests so that they can get into a good college and/or get a good job (Kuhn, 2003). Over a decade ago, Kuhn (2003) argued that, "once an activity becomes identified as merely a means to an end, it becomes easy to devalue it as without significance in its own right. One undertakes it because it produces some totally different dividend that is valued" (p. 18). Later, she argued that intellectual pursuits should be valued because the activities that produce intellectual achievements are valuable in and of themselves, and that students can and do experience these activities and achievements as enjoyable in their own right. The question Kuhn posed was, "What makes it happen?" What allows for students to derive intrinsic enjoyment and value in engaging in intellectual pursuits? One answer that she posed was that, "students' developing understanding of what it means to learn and to know is a key component of the process. . . . Their school experiences are for most students the primary basis for the understandings they construct of what it means to learn and know and, not incidentally, whether investing one's time and effort in such pursuits is worthwhile" (p. 18). At the heart of this issue is finding ways for students' motivation toward wrestling with knowledge and knowing in progressively more adequate ways to flourish. Current classroom and school conditions, for the most part, make it difficult to see the value of engaging in activities that do this. However, we believe that research at the intersection of epistemic cognition and motivation can draw on these two frameworks to investigate the ways in which educators, policymakers, and instructional designers can create environments and activities that make engaging in intellectual activities that focus on forming progressively more adequate ways of dealing with knowledge and knowing an integral and valued part of students' experiences in a large variety of fields.

### *Integrating Frameworks for Epistemic Cognition and Motivation*

Central to the problem of creating environments in which students find it worthwhile to engage in intellectual pursuits is what motivation researchers would call value beliefs. The vast literature about the development of interest and intrinsic motivation could be of great help to those exploring how students' interests in engaging in activities that lead to progressively more adequate epistemic achievements are triggered in the first place. Furthermore, how are students' interests in these activities not just triggered for a moment, but also *sustained* so that students are likely to reengage in activities that lead to progressively more adequate epistemic achievements throughout their lifetime unprompted from external requirements? When we say "progressively more adequate epistemic achievements" we are describing movements toward a more comprehensive understanding of issues, knowledge, and/or skills in which students see evidence and rationales for a variety of positions, but ultimately commit to one stance based on reason and evidence.

Of course, all of this cognitive activity directed toward epistemic achievements requires the enlistment of motivation to exert the effort to engage in these types of activities in the first place. Current theories of interest development (see Hidi & Renninger, 2006) may help us in this regard. *Triggered situational interest* refers to a psychological state that results from momentary changes in affect. These triggers are usually externally supported (Hidi & Renninger, 2006). Future research could investigate the types of activities and cues that trigger an interest specifically to think critically about knowledge and knowing.

In particular, because students are engaging in activities and are consuming and using information in an increasingly mediated world—accessing stories, entertainment, messages, and other information from portable and connected devices—researchers and educators need to understand the variety of conditions that trigger students' interests within these virtual learning environments to think specifically about progressively more adequate conceptions of knowledge and knowing. For example, it is easy to read a news story from one's social media feeds without thinking critically about the adequacy of the claims made in the article. What are some ways in which educators, instructional designers, and researchers can trigger students' interests in enlisting their cognitive resources toward things such as exploring who wrote the news piece and why that matters, or thinking about whether or not the claims are well justified? Some research has shown that interest can be triggered by using novelty (Palmer, 2009), promoting student autonomy (Palmer, 2009; Skinner, Furrer, Marchand, & Kindermann, 2008), using group work (Minnaert, Boekaerts, & deBrabander, 2007), and making the utility of an activity salient (Hulleman, Godes, Hendricks, & Harackiewicz, 2010). Yet, we know little about the *specific* activities that trigger students' interests toward reasoning about knowledge and knowing in progressively more adequate ways. For example, Sandoval and Harven (2011) found that autonomy, although an important general principle for promoting motivation in students, was especially beneficial in triggering students' interests in science inquiry when the activities had to do with collecting and analyzing data. However, in order to trigger students' interests in focusing on the epistemic components of data collection and analysis, what specific things do educators and instructional designers need to make salient? In addition, Sandoval and Harven found that tasks related to investigation, rather than tasks related to argumentation, appeared to have the greatest effect on triggering students' interests because students noted the high value of having evidence to back up one's own ideas.

The intriguing findings from Sandoval and Harven (2011) above lead to another issue. Triggering an interest in thinking about knowledge and knowing is one thing, but sustaining that interest is quite another endeavor. Yet, this is a critical component in developing students' long-term and enduring *individual interests* toward an activity. Sandoval and Harven noted that the key feature that seemed promising in sustaining interest was students' desire to be able to have good evidence to support their ideas. This suggests that making the utility of tasks salient holds promise in sustaining students' interests. However, because students who perceive something to be useful but also do not believe that they can accomplish this valuable task are likely to experience quite negative academic and motivational outcomes (see Bandura, 1997), future research also needs to explore the variety of ways to support both students' beliefs about utility and their beliefs about their own competence.

In addition, research has shown that, whereas the earlier phases of interest development, such as triggering interest, are primarily affective, the later phases of interest development, such as well-developed individual interest, also require that students possess a sufficient stock of knowledge and a well-developed self-efficacy. Future research could investigate the specific types of knowledge that need to be built up so that students' individual interest to engage in activities that lead to progressively more adequate epistemic achievements can develop. For example, what outcomes could be likely if students have a large store of knowledge about the variety of sources from where knowledge can come (i.e. professional mathematicians, teachers, peers, books, and even themselves), but have little knowledge about how to adjudicate among all the sources?

As we mentioned earlier, self-efficacy is a key determinant in students' academic choices, including choices to recruit cognitive resources toward dealing with knowledge and knowing in progressively more adequate ways. Because self-efficacy is so important researchers have begun to investigate what fuels self-efficacy. Bandura (1997) posited that there are four sources of self-efficacy. Students' perceived past successes inform their beliefs about how well they can perform in future endeavors. These *mastery experiences* are thought to be the strongest source of self-efficacy (see Usher & Pajares, 2008). However, in the absence of sufficient mastery experiences, students need to draw from other sources such as *vicarious experiences* (thinking, "if they can do it, then so can I"), *social persuasions* (the spoken and unspoken messages from significant others that inform our self-efficacy), and *affective states* (anxiety, adrenaline rush, moods, and other feelings). Although researchers have explored these broad categories regarding the antecedents of self-efficacy, less well known are the specifics of these sources. For example, if mastery experiences are the strongest source, then what exactly counts as a mastery experience? Also, if the strength of vicarious experiences and social persuasions depends on how well a student identifies with or trusts the vicarious model or persuader, then what specific things encourage a strong identification or trust? As it relates to thinking about knowledge and knowing, what specific experiences could tell students that they have, for example, successfully adjudicated between several sources of knowledge? What characteristics do students look for when they identify a suitable role model who can show them how to handle knowledge and knowing in progressively more adequate ways?

Overall, the questions and lines of inquiry we have posed regarding the development of interest and self-efficacy require researchers to be able to capture data about the more fine-grained tasks students undertake so that educators and instructional designers can create learning environments that build students' self-efficacy and take full advantage of interest-triggering and interest-sustaining features that can lead to enduring individual interests in thinking about knowledge and knowing in sophisticated ways. In our final section, we discuss issues related to capturing these data.

## *Issues of Measurement*

Research in epistemic cognition has had a long history of measurement issues (see DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008). One reason for this might be because students' epistemic cognition often operates "under the radar" such that students are unaware of what their epistemic aims are, for example, or what they believe about the certainty of a knowledge claim even if they are prompted to think about them. In addition, students might be able to articulate only a limited set of their cognitions related to knowledge and knowing (i.e. they might articulate their beliefs about the source of knowledge, but not their epistemic values). Furthermore, students' cognitions (both epistemic and motivation) may only crystallize or become activated when presented with a situation in which they have to act, which means that measures need to be quite context and task specific. These cognitions are very likely to vary depending on the situation, such that in one situation students might set an epistemic aim of understanding and learning about a knowledge claim, but 10 seconds later might set a non-epistemic aim of trying to impress their peers. Therefore, we encourage researchers to explore a variety of ways to assess students' epistemic cognition and motivation, especially in ways that allow researchers to tap these cognitions and beliefs *in situ*.

One way to innovate the ways epistemic cognition and motivation are measured is to leverage the capabilities of computers. Researchers are already using computers as assessment tools to assess cognitive activities. For example, the *SAVE Science* project (Ketelhut, Nelson, Schifter, & Kim, 2013; Nelson, Kim, Foshee, & Slack, 2014) uses immersive virtual environments (IVEs) to assess students' scientific inquiry skills. Rather than assessing scientific inquiry by using multiple-choice questions, these virtual assessments allow researchers to collect large amounts of information regarding students' actions in the virtual world. Inferences can be made regarding students' thinking as they reason through complex scientific problems. Other virtual environments such as *Epistemic Games* (http://edgaps.org/gaps/) also seek to create models that assess complex problem-solving skills.

In a similar way, researchers can use these types of virtual assessments to infer students' motivation and epistemic cognition. For example, scientific inquiry skills require students to collect data from a variety of sources, use experimental data to make inferences, and use the information to come to some conclusions. These types of inquiry processes tap into issues of epistemic cognition by getting at students' beliefs about a scientific authority or how much they trust visual cues in the IVE versus the experimental results they obtained. When students have to perform an action, these actions are likely goal-directed. It could be quite feasible to assess whether the goals are directed toward knowledge or toward non-epistemic aims. These are only a few examples of the variety of beliefs and cognitions that researchers could gather from using these IVEs.

Although such assessments are not meant to replace traditional assessments such as self-report questionnaires, virtual assessments certainly can provide researchers with more fine-grained, in-the-moment information regarding the goals that students are oriented toward when pursuing epistemic achievements, the value they see in attaining these epistemic achievements, and students' beliefs about whether they can muster their resources toward successfully reaching these epistemic achievements. In that way, these virtual assessments can offer a more nuanced look into students' motivation and epistemic cognition. However, there are issues of validity and reliability that need to be addressed before researchers can make claims about students' cognitions and beliefs, and their relationships with other outcomes of interest. This is a ripe area of research, and one that will require researchers to find creative yet rigorous ways to evaluate how valid and reliable these dynamic assessments are. We are excited by these possibilities for future research, and encourage scholars to continue using innovative technologies not just as learning and teaching tools, but also as a way to assess students' cognitions.

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# 27

# INTERROGATING THE RELATION BETWEEN CONCEPTUAL CHANGE AND EPISTEMIC BELIEFS

*P. Karen Murphy and Patricia A. Alexander*

As educational psychologists whose philosophical orientations embrace the power of the individual mind, we nonetheless acknowledge the ever present and highly influential nature of social and contextual forces that shape and drive human thoughts and actions. That is, as educators committed to promoting students' academic development and their journeys toward richer and more evidenced-based understandings about themselves and the world around them, we must abandon the expectation that we can ensure the desired end of that journey is ever reached. Such control for the learning and development of another is not within our purview.

Nonetheless, as educators, we are by no means powerless or ineffectual when it comes to shaping the experiences that can serve as catalysts for positive growth and development in others (Alexander, 1997; Bruner, 2004; Graesser, Gernsbacher, & Goldman, 2003; Piaget, 1968). Within the vast literatures that deal with conceptual change and epistemic beliefs, there are lessons to be learned about more efficient and effective ways that we—as more knowledgeable others (Vygotsky, 1986)—can perhaps persuade, entice, cajole, or even compel others to do more than simply accept the superficial perceptions or shallow interpretations that form at first blush (Limón & Mason, 2002; Sinatra & Pintrich, 2003; Vosniadou, 2008). By moving through the world with only a fleeting sense of what operates there, by relying upon unfiltered or unexamined perceptions, by failing to question or interrogate ideas that arise, humans inevitably leave themselves open to forming incomplete or even misguided understandings. We regard these as initial understandings or primitive concepts (Vosniadou, 2013). For continued progress to be made within any realm of human learning and performance, these initial or primitive concepts must be reflected upon and evaluated, and potentially replaced by more evidenced-based conceptions or examined understandings (Murphy, 2007; Murphy & Alexander, 2008).

In essence, development in any field of human learning and performance rests on conceptual change (Alexander, 1998; Murphy & Alexander, 2013). Such change, in our judgment, is often subtle and uncomplicated, representing the simple assimilation of new perceptions or experiences that transpire with limited awareness or effort (Carey, 1985). At other times, however, transformation in thought and performance demands much more conscious awareness or concentrated effort on the part of the individual or more intense, persuasive, or confrontational experiences (Chinn & Brewer, 1993; She, 2002). These more demanding conditions are what have been characterized within developmental psychology as strong or radical restructuring (Carey, 1985; She, 2004).

Yet, whether the conceptual transformation being considered is a case of assimilation or restructuring, it reflects changes in individuals' knowledge *and* beliefs (Murphy, 2007; Murphy & Alexander, 2008; Murphy & Mason, 2006). Specifically, we use the term *knowledge* to refer to all that is accepted as true that can be externally verified or confirmed by another on repeated interactions with the object. This type of information is often referred to as factual information (Murphy & Mason, 2006). By contrast, we employ the term *belief* when referencing that which one accepts as true or desires to be true (Murphy & Mason, 2006). Importantly, within this conceptualization, beliefs do not require verification and often cannot be verified. Such notions are more often considered opinions, which often carry a valence of importance for the individual and are generally more emotion-laden. Given the level of importance and emotion, such beliefs are often resistant to change.

Changing knowledge without altering beliefs, or visa-versa, lessens the likelihood that an incomplete or erroneous conception will be set aside or that progress forward in any domain of human inquiry will be sustained (James, 1911/1996; Murphy, 2007; Peirce, 1958). For that reason, in this chapter we will consider the relation between conceptual change and epistemic beliefs through the lens of the CLAIM (Characteristics of the Learner and Argument Interaction Model) framework (Murphy, 2007, Murphy & Alexander, 2013). We have chosen the CLAIM as our frame for this chapter because it is a model that considers conceptual change through an epistemic lens with due consideration for the dynamic roles of one's knowledge and beliefs in the processes through which an individual gains or alters their understandings. This model (see Figure 27.1), characterizes systematic shifts in knowing and believing that begin with *recognition*, progress to a level of *explanatory power*, and ultimately lead to *examined understanding*. We will also explore how the desired end in epistemic cognition is the capacity to weigh the source and level of evidence required to address a given problem in relation to the significance or value of that problem to the individual or society (Chinn, Buckland, & Samarapungavan, 2011; Greene, Azevedo, & Torney-Purta, 2008). This conditional application of evidentiary standards to justify a given belief about knowledge is what Alexander and colleagues have termed *epistemic competence* (Alexander et al., 2011; Alexander & the Disciplined Reading and Learning Research Laboratory, 2012; Grossnickle, Alexander, & List, in press).

We begin by articulating the claims that we judge to be substantiated about conceptual change and epistemic beliefs that speak in some way to their interrelation. Next, we interrogate those claims in light of Murphy's CLAIM framework and the notion of epistemic competence. Finally, we bring the chapter to a close by weighing the implications of this exploration for educational theory, empirical inquiry, and more importantly instructional practice.

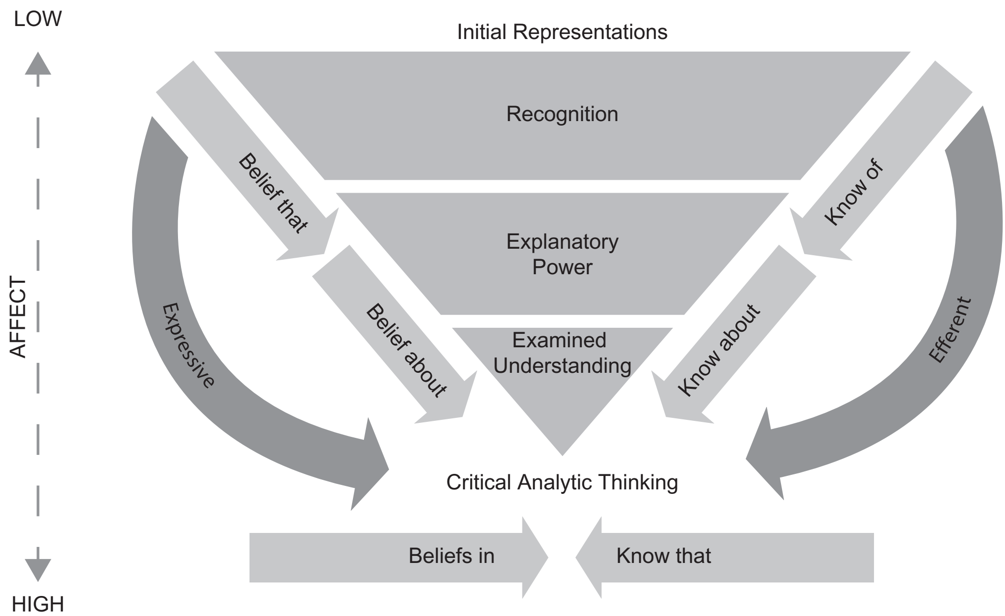


**Figure 27.1** Characteristics of the Learner and Argument Interaction Model (CLAIM) (Murphy, 2007; Murphy & Alexander, 2013).



## RECOGNITION: FORWARDING CLAIMS ABOUT CONCEPTUAL CHANGE AND EPISTEMIC BELIEFS

If we delve into the extensive literatures pertaining to conceptual change and epistemic beliefs, particularly that work that speaks to their potential associations, we are able to forward several claims about each. We regard these claims as adequately substantiated statements of some import to understanding the relation that can or should exist between transformations in conceptual understanding and beliefs about knowledge and knowing. For each of these claims, we speak briefly to the theoretical and empirical literature that grounds or provides evidence for its articulation.

### *Conceptual Change Is a Necessary and Inevitable Occurrence in Learning and Development*

The initial notions that individuals form about themselves or the world in which they live can be serious impediments to subsequent learning (e.g. Vosniadou, 2013). Whether conveyed as initial conceptions or misconceptions, these understandings portent a less empirically grounded notion about how the world operates or the particular evidence that needs to be privileged when reaching conclusions (Greene et al., 2008). There is certainly no question that the primitive determinations that individuals make can become hindrances to further conceptual growth or to performance in academic domains or disciplines (Sinatra & Chinn, 2011). Yet, we, and others (e.g. diSessa, 2002; Vosniadou, 2008, 2013), have come to appreciate that such primitives are often first steps in an individual's journey toward more sophisticated or evidenced-based judgments. We must all start the process of academic development with primitive and overly simplistic notions, after all. What is really at issue is whether individuals languish within this more impoverished realm or progress to richer vistas of the world through formal or informal means, whether they remain comfortable with or unaware of the limitations to the interpretations or judgments they have formed, or manifest dissatisfaction with or doubt about conceptions they presently hold. Given that the goal of learning implies progress away from initial or more erroneous understandings toward more enriched conceptions, we regard the aforementioned languishing or lack of awareness as undesirable.

These somewhat contrasting perspectives on naïve understandings or malformed notions as either impediments to be avoided or as unavoidable and even necessary steps in individuals' development have been well reported within the conceptual change literature (e.g. Carey, 1985; Hewson, 1981; Strike & Posner, 1992). Indeed, until fairly recently two traditions of inquiry represented these contrasting views (Murphy & Mason, 2006). The work within science education, for instance, drawing from the literatures in philosophy and history of science, repeatedly documented students' resistance to moving beyond more primitive representations of underlying scientific concepts and principles (Chi, 2008; diSessa, 2002). The models and explanations that arose from the expansive literature most often portrayed students' intuitive knowledge or less scientific judgments as undesirable understandings to be hopefully eradicated through more effective instruction (Murphy & Mason, 2006). By comparison, within the literature arising from cognitive and developmental psychology, there was more appreciation that individuals' understanding of more complex or counter-intuitive notions do not spring forward fully formed (Carey, 1985; Vosniadou, 2007). Rather, there may be a natural progression in how these more sophisticated or scientifically accepted concepts are birthed through a growing dissatisfaction with existing views that leads to more systematic exploration and, ultimately, to more enlightened states of understanding (e.g. Vosniadou & Brewer, 1992). Even those holding to alternative perspectives on the change process (e.g. diSessa, 2002; Reif, 1987) nonetheless envision growth as a consequence of more developed and less primitive perceptions of the world and domains of learning that take form in that world.

Despite the differing perspectives and research traditions captured within the literatures from science education and cognitive/developmental psychology, there is more consensus than would appear to exist on the surface. Both conceive of naïve understandings or malformed notions as inadequate or undesirable as ultimate ends of students' academic development (Vosniadou, 2013). Further, both seek ways to either replace such naïve ideas with more scientific ones or to spur the students' development forward. We see these shared elements within the work by Vosniadou and Brewer (1992) who have chronicled individuals' progression from more intuitive to more scientifically accepted understandings by means of the mental models they communicate. For instance, in representing the day/night cycle, children will typically construct quite intuitive models based largely on their everyday experiences. Their progress is toward more synthetic models that infuse various culturally accepted ideas about the day/night cycle with some smattering of personal experience and scientific facts. Later, certain children may come to model the day/night cycle in more scientific ways, setting aside their earlier reliance on everyday perceptual experiences or commonly held cultural beliefs in favor of more tested notions that would be supported by the scientific community. Thus, we see in the work of Vosniadou and Brewer the conveyance that intuitive or nonscientific understandings are unavoidable steps in human learning and performance, yet such models of understanding should hopefully be left behind in the course of continued academic development.

### *Conceptual Change Transpires in All Realms of Human Learning*

One of the lingering and seemingly paradoxical aspects about the research in conceptual change pertains to the frequent acknowledgment that the transformations in understanding, which are the focus of this literature, occur in all manner of domains and disciplines regardless of orientation (e.g. social or natural science) or form (e.g. schooled or everyday) (Murphy & Alexander, 2013). Nonetheless, within the contemporary literature, one would be hard pressed to locate studies of conceptual change that extend beyond the fields of science or mathematics. Even in the latest version of the *International Handbook of Conceptual Change* (Vosniadou, 2013), for instance, the vast majority of contributions pertained to STEM areas, most notably science, mathematics, medicine, and other more well-structured domains. The modifier *well-structured* refers here to the perceptions that the domains in question are often viewed as entailing problems or tasks that can be empirically verified or for which there are more general agreement upon acceptable, if not "correct," solutions (Alexander, 1998; Frederiksen, 1984). Conversely, more *ill-structured* domains would be those (e.g. art, history, or literature) for which commonly accepted outcomes are more elusive or open to debate. A few of the chapters sought to carry the message of conceptual change to other areas, such as social science (Lundholm & Davies, 2013) and history (Carretero, Castorina, & Levinas, 2013; Leinhardt & Ravi, 2013).

When one looks deeper into the philosophical and psychological writings undergirding conceptual change the seemingly paradoxical aspects dissipate, as does strong emphasis on such change within STEM domains. More specifically, the concern for changing knowledge and beliefs has a presence as far back as recorded history. We find such interest clearly manifested in the Socratic dialogues (e.g. *Theaetetus*, Ross, 1953), with musings of the Sophists (Cooper, 1932), and prominent in Aristotle's foundational writings on rhetoric (Cooper, 1932). These historic approaches to changing knowledge and beliefs were by no means domain-specific and did not privilege any one arena of human thought and reflection over another.

Even turning to more contemporary literature, we likewise find support for our claim about the ubiquity of conceptual transformations and the processes underlying them within the writings of social psychology. For instance, the contributions of Petty and Cacioppo (1986) and their formation of the Elaboration Likelihood Model (ELM), which conveys the process and paths toward persuasion, have been incorporated into emergent models of conceptual change, elevating the merits of argumentation and refutation as mechanisms to evoke deeper reflection and reconsideration of held beliefs (e.g. Dole & Sinatra, 1998; Murphy, 2007).

### *The Intention to Build Knowledge Matters for Conceptual Change*

Recently, Alexander (2014) has drawn attention to two varied intentions or goals that individuals bring to any learning experience, whether formal or informal in character—information management versus knowledge building. As individuals move through the world and seek to manage and regulate all the sensory experiences or information they encounter, they must find ways to cull the noise from relevant messages. They must determine what the task is that is set before them, and they must garner the necessary data that would allow them to complete that task (Duschl, 2008). Once the task is fulfilled, those engaged in information management can ceremoniously rid themselves of the understandings they temporarily hold in abeyance and move on to the next situation and the next task (Chinn & Brewer, 1993). When, by contrast, individuals have embraced a goal of knowledge building, they have committed themselves to a more effortful, reflective, and at times frustrating enterprise. Individuals engaging in knowledge building employ the strategic and metastrategic tools required to not only weigh the evidence and competing explanations that will be encountered, but also to link that newly achieved understanding to the system of knowledge and beliefs that already exists in their minds (e.g. Franco, Muis, Kendeou, Ranellucci, & Sampasivam, 2012).

What is important to recognize about this distinction between information management and knowledge building is that both are manifestations of human intentionality and require some form of strategic processing and self-regulation (Graham, Harris, & Mason, 2005; Hand Hohenshell, & Prain, 2004). Yet, their differences, which may reflect more externally motivated (e.g. "I have to get this project done for history class.") versus more internally motivated intentions (e.g. "I want to understand why all the settlers disappeared at Jamestown."), might help to explain why the sought-after ends of some conceptual change instruction are rather short-lived or highly context bound (Sinatra & Chinn, 2011). In effect, students in classes may come to grasp the objectives within their current academic setting but have no personal intention to integrate such understandings into their overall system of beliefs or allow these alternative conceptions to alter their more deeply rooted knowledge system. The implications of the claim we forward is that researchers concerned with conceptual change cannot operate under the assumption that individuals populating classrooms and other learning environments share their goal of transforming knowledge and beliefs into more accepted or rich understandings. Making such a presumption is apt to set one up for disappointment—students who seemingly "get it" when the context requires it or when the task demands it may settle back to more comfortable, but more impoverished, views as soon as the situation fails to require it or the task allows it.

### *Epistemic Beliefs Are Multifaceted and Developmental in Nature*

The educational research community's fascination with epistemology and the role that education may play in the development of students' beliefs about knowledge and knowing is most often traced to William Perry's (1970) classic study of Harvard undergraduates. Yet, it was not until the 1990s that educational psychologists, along with those concerned with the philosophy of science, rediscovered epistemology as a powerful explanatory force in students' learning and development. The "psychologizing" of epistemology, to borrow Dewey's (1897) term, led to efforts to systematically measure these beliefs so that they could be more reliably and validly investigated. As might be expected, these orchestrated efforts to build measures of epistemic beliefs have opened avenues to debate within the research community as to what legitimately qualifies as epistemological (Hofer & Pintrich, 1997, 2002), and whether presumed measures of epistemic beliefs encroach on questions of ontology and axiology (Greene et al., 2008). There have also been disputes as to whether espoused or enacted epistemic beliefs are rather stable constructs or should vary appreciably in response to contextual or developmental factors (e.g. Duschl, 2008; Sandoval, 2005, 2014).

Over the last two decades, while debates continue as to the most accurate conceptualization or representation of facets encompassing individuals' beliefs about knowledge and knowing (Hofer & Pintrich, 2007)—as well as the most suitable label for that system of beliefs (e.g. epistemic beliefs, epistemological beliefs, personal epistemologies, or epistemic cognition)—there are few if any educational or psychological researchers who would argue strongly for the unidimensionality of this construct (Greene et al., 2008; Muis, Bendixen, & Haerle, 2006; Schommer, 1990). It is perhaps not surprising that evidence weighs heavily on the side of epistemic beliefs as a multifaceted construct. There is nothing simple about knowledge or knowing per se; thus, it would seem perilous to assume that their manifestation would be other than multidimensional.

Yet, this complexity of knowledge and knowing entails more than conceptualizing the underlying structure of said beliefs. It also extends to the fact that most researchers in this field contend that there should be some systematic shift in the manner in which the facets of epistemic belief are enacted over the course of the lifespan (e.g. King & Kitchener, 1994; Kuhn, Cheney, & Weinstock, 2000), particularly as a result of educational or transformative experiences (Heddy & Sinatra, 2013). However, we do not wish to argue for the simple naïve to sophisticated dichotomy that has found its way into the epistemic literature. The very complexity of beliefs about knowledge and knowing and the highly situated and contextual character of enacted beliefs, which we will discuss later, preclude the overly simplistic depiction of them as either naïve *or* sophisticated that is often found in the literature and obscures the often long-term and nonlinear process of transformation that unfolds (Duschl, 2008; Murphy & Alexander, 2013). Our earlier depiction of the journey from naïve to more accepted or justified understandings was an attempt to dispel the overly simplistic notion that beliefs are categorically one or the other.

### *Epistemic Beliefs Are Potentially Available for Reflection and Critical Analysis*

There is a recognition that individuals' beliefs about knowledge and knowing operate at varying levels of conscious awareness and entail more than the beliefs per se but the processes, aims, and uses to which those beliefs are put (Chinn et al., 2011). The rationale for the coining of the term *epistemic cognition* and the goals of this volume are testament to that position. Those using the term epistemic cognition often reference the conceptualization proffered by Karen Kitchener (1983), who employed the term to refer to the individual's reflection "on the limits of knowing, the certainty of knowing, and criteria of knowing" (p. 222). As she and others (Chinn et al., 2011; Greene et al., 2008) contend, epistemic cognition pertains to individuals' *cognition about the epistemic.*

Beliefs about knowledge and knowing, as well as cognitions about such beliefs, can operate explicitly or tacitly (Murphy & Alexander, 2013). While the nascent representations that individuals form exist below the level of consciousness in what Murphy (2007, 2013) casts as "initial representations," they can eventually progress into awareness. Once in the sphere of consciousness, there is the opportunity for individuals' understandings to be explicated or potentially critically analyzed. Within the CLAIM framework, the most sophisticated level of understanding demands such examined understanding.

Murphy (2007) is not alone in the valuing of reflection and critical analysis toward the pursuit of knowledge and knowing. One of the commonalities for many educational psychologists and science educators working in this area of inquiry is the reliance upon instantiations or adaptations of Toulmin's (1958) model of argumentation. Indeed Toulmin's model is regarded by many as the canonical form of argumentation and the components of his model—claims, grounds, warrants, backing, and rebuttal—serve as the foundational means by which individuals reflect upon and evaluate their knowledge or their ways of knowing (e.g. Nussbaum & Edwards, 2011; Reznitskaya et al., 2001). Thus, while beliefs about knowledge and knowing can operate consciously or subconsciously (Chinn et al., 2011), it remains a goal of development to reach the level of examined understanding where individuals seek to interrogate the perspectives or interpretations they hold in light of available evidence and weigh the relevance and quality of that evidence vis-à-vis the claims they forward (Murphy, 2007).

### *Standards of Evidence Vary by Domain, Task, and Context*

Although beliefs about knowledge and knowing may have once been conceptualized as quite domain-general in nature (i.e. manifesting in relatively stable ways across different contexts or situations), there is now wide acceptance of a more complex, contextual, and "nuanced" (Duschl, 2008) view of these judgments. This contextualization of epistemic beliefs was first made apparent in debates about whether these beliefs were domain-general or domain-specific (Buehl & Alexander, 2002, 2005). The crux of these debates was whether individuals' epistemic beliefs were relatively trait-like or differed significantly according to the field to which they were associated (e.g. science versus history). These early debates have been largely settled by growing empirical evidence that individuals' beliefs about knowledge and knowing have both general and specific characteristics (e.g. Muis et al., 2006).

What this duality suggests is that individuals' beliefs about knowledge and knowing do not completely reconfigure when the focus is on problems of a scientific or mathematic nature compared to those that pertain to history or political science (e.g. Kardash & Howell, 2000; Mason & Boscolo, 2004). Yet, these beliefs about knowledge and knowing do change in documentable ways, in part due to the standards of evidence associated with these domains and in part due to individuals' perceptions of the very nature of the problem at hand (Muis, 2004). In essence, there is little doubt that various domain or disciplinary communities rely upon varied sources or forms evidence in justifying understandings or interpretations (Duschl, 2008; Sandovoal, 2005). In some ways, these evidentiary differences serve to give domains their discernible character, which Duschl calls epistemic communities of practice. In science, empirical evidence may well be privileged over social authority or common perceptions, while in history there is the acknowledgment that multiple interpretations of past events can be crafted from the same body of primary and secondary sources.

Yet, the more nuanced nature of epistemic beliefs that Duschl (2008) and others (e.g. Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003) describe goes well beyond the issue of domain differences and embraces the documented effects that task, context, and even learner differences can have on individuals' justifications or their acceptance of some claim as true. Due to these contextual and situational effects, standards of evidence cannot be truly stable or constant, even within any domain or discipline. Taking this notion of variability to the extreme, there are those who would contend that there can be almost no standards of evidence at all, precisely because no two contexts or situations are ever the same (e.g. von Glasersfeld, 2002).

While no two contexts or situations are exact replicas, and relevant contextual and situational factors inevitably influence the sources and form of evidence upon which individuals or groups rely, we maintain that generalizable standards of evidence can be invoked. There is simply too much evidence that individuals seek to find a level of similarity or predictability in the world around them (e.g. Leher & Schauble, 2012). Humans seek out the commonalities and the similarities that manifest within contexts and situations that permit them to think and act without complete reinvention (James, 1996/1911). What this means for epistemic beliefs is that the contextual or situational variations that exist can be viewed as iterations of discernible and distinguishable patterns in reasoning and problem solving which, in turn, call forth certain standards of evidence that can be applied in the judgment of veracity or accuracy (e.g. Driver, Newton, & Osborne, 2000; Muis, 2007, 2008). Without the presence of these discernible and distinguishable patterns, individuals would find themselves unable to navigate the complexities and dynamism of the world and would be paralyzed in their ability to make judgments about their knowledge and knowing. In essence, individuals' epistemic judgments are not apt to be random events, but rather likely reflect somewhat predictable outcomes when critical factors such as nature of the task, level of personal value or significance, or consequences for incomplete or inaccurate determinations are explicated. Why study epistemic beliefs or epistemic cognition otherwise?

## EXPLANATORY POWER: MELDING CONCEPTUAL CHANGE WITH EPISTEMIC BELIEFS

Now that we have laid out certain claims about conceptual change and epistemic beliefs that we contend can be substantiated on the basis of the relevant literature, we forward several additional claims. What distinguishes these particular statements from the preceding ones is that they represent efforts to fuse these two areas of inquiry and afford insights into the actions that can be taken to achieve the examined understanding we regard as requisite to more enlightened and evidentiary-based learning and performance. With each claim we forward, we provide brief excerpts from a small-group discussion among fourth graders participating in *Quality Talk* (Murphy, Greene, Butler, Criswell, & Rushton, 2014; Wilkinson, Soter, & Murphy, 2010) in their language arts classroom (Murphy, Greene, & Firetto, 2014). We purposely selected excerpts that illustrate how these principles might look in a language arts classroom as students discuss a narrative text, because language arts is generally considered a less well-structured domain.

### *Reasonable Doubts as Critical Catalysts for Individuals' Pursuits of Deeper Understandings*

Whether the focus is on changing knowledge or changing beliefs, there must be some spark or trigger that initiates the process of reflection and evaluation (Chinn & Mahlotra, 2002). At times, those triggers can be external prompts or given tasks that require response or action on the part of the individual—a common occurrence within educational settings (e.g. Chin & Teou, 2009). At other times, the sparks that give rise to reflection and evaluation come from within as individuals confront new or conflicting information that cannot be readily accommodated or justified (Murphy, 2007). Irrespective of whether the spark or trigger derives externally or internally, it would seem important to create some manner of cognitive or emotional dissonance, some level of discomfort in what is presently known or believed (Lee, 2010; Murphy & Alexander, 2013). Marked changes in conceptual understanding (i.e. knowledge) and in one's ways of knowing begin when the seeds of doubt are sown within the mind or the spirit leading to some level of uncertainty in what is presently known or believed. Peirce (1877) made such a claim in his *Fixation of Beliefs:*

> The irritation of doubt causes a struggle to attain a state of belief. I shall term this struggle inquiry, though it must be admitted that this is sometimes not a very apt designation. . . . The irritation of doubt is the only immediate motive for the struggle to attain belief. (p. 10)

Because doubts can vary appreciably in terms of their intensity or the overall cognitive or emotional discord they engender, the thoughts or actions that ensue can likewise vary greatly (Sinatra, Kienhues, & Hofer, 2014). In certain instances, for example, the doubts that spring forth require only mild attention for understanding to be clarified or beliefs restored, as in the case of accommodation (Carey, 1992). Talking through the problem or reflecting anew on the situation may be all that is needed. Such instances are less likely to lead to examined understanding because there is little reason for deep cognitive reflection. Murphy (2007) classified this elaborative process as explanatory power. In other circumstances, however, the nature of the conflict demands much more reflection and argumentation with self or others before an acceptable level of understanding can be obtained and doubts abated. It is under such conditions that examined understanding can be achieved (Murphy 2007; Murphy, Greene, & Firetto, 2014).

In the excerpt below, students are discussing the story *Moonwalk* (Bova, 2013). In the story, two brothers, Vern and Gerry, and their father are stationed in a research facility on the moon. In the story, the father goes out to collect samples from the moon's surface and explicitly instructs the two boys to stay inside. Against their father's wishes, the boys decide to explore the moon's surface. During their excursion, the older brother falls into a moon rille breaking his leg and damaging his space suit. The boys work together to get back to the research facility, fearing for their lives. In the following excerpt, we observe Student 19 experiencing doubt in her understanding regarding why the two brothers would disobey their father, particularly given the potential consequences of their actions. The following are verbatim transcriptions of the students' discussion. We have italicized the question that marks the event. Individual students are noted by number. Bracketed words indicate words and phrases that were spoken very softly and interpreted by the transcriber, and double hyphens (i.e. --) are used to indicate pauses.

19: *Why do you think Vernon and Gerry were outside when their dad asked them -- that -- not to be outside?*
2: Probably because they thought it would be fun to jump in the rilles.
16: I think like --
2: [And to be] disobedient.
16: -- when you're cooped up inside, you would probably want to go out. Because --
16: -- if you know he's not going to find out, if you aren't going to do something horrible --
2: Because they're disobedient kids.

19: When, when was it -- their nei -- their neighbors could have seen them. Like, what if they had neighbors, and they were walking around? Like, they needed to go somewhere, and they were driving to where their dad was, and they passed them, so why would they take the risk of getting in trouble, just -- what if their dad's really mean, like, or mean, or [some mean] guy who -- maybe -- I don't know.
2: Maybe disobedient, or maybe, like, sneaks.
19: Yeah, possibly. I don't know. What about you, (6)? Do you have an idea?
6: I -- well, if his dad was mean, and they caught them, it would be like, "Boys, what are you doing? I'm going to send you home this minute!"
19: Oh? Or possibly they could have wanted to go -- like, if they got caught in trouble, they might have been able to go somewhere.
6: Yeah, I think -- it was like, a mean dad would probably send them right back to Earth.
2: Yeah and like, they wanted to go home.

What becomes clear in the transcript is that Student 19 is thoughtfully weighing reasons for the brothers' behaviors offered by her peers, but she remains unconvinced about their explanatory power. By comparison, Student 2 initially believes that the children were outside because they were disobedient, and appears to be unconvinced by the explanations of her peers. The conceptual position of Student 2, however, changes over time as her peers, particularly #19 and #6, offer reasoning that appears to carry explanatory weight. Over the course of the discussion, Student 2's perspective has changed. At the end of the question event, she holds that the boys in the story may have wanted to go home and were being disobedient to achieve a particular outcome. In essence, Student 2 has accommodated the explanatory power of her peers' reasoning.

### *Critical-Analytic Thinking Entails Cognitive and Affective Engagement*

Among the models of conceptual change that have populated the literature, many have placed the onus for transformations in knowledge squarely on rational thought and logical reasoning (Murphy & Mason, 2006; Sinatra & Chinn, 2012), setting aside the power of human emotions and motivations. This was the argument made by Pintrich et al. (1993) in their review of conceptual change research: a condition that they cast as *coldly cognitive* in its orientation. Likewise, the literature on epistemic beliefs, while leaving some room for non-cognitive forces (e.g. Muis et al., 2006), has often privileged what Murphy (2007) characterized as efferent- or knowledge-driven approaches to justified true beliefs. As such, the literature on epistemic beliefs has dealt largely with the quality and weight of evidence in coming to judgments about truth or accuracy, depicting more affective approaches as less scientific or viable (Hofer & Bendixen, 2012).

While more substantial justifications must surely extend beyond the purely emotional or affective, there is evidence that deep and sustained examination of issues or concepts have emotional or affective valences (e.g. Pekrun & Linnenbrink-Garcia, 2012; Sinatra, Southerland, McConaughy, & Demastes, 2003). Individuals undergoing conceptual change or those testing the veracity or credibility of information, their own or others, cannot be so engaged without an articulation of goals, an expression of intentionality, or an investment of emotions (e.g. Pekrun & Linnenbrink-Garcia, 2014). Without this intricate dance of the efferent and expressive, there is risk that examined understanding will not be reached (Murphy, 2007; Murphy & Alexander, 2013). The path to transformations in knowledge and ways of knowing that does not pass into the terrain of human emotions and motivations is far less likely to reach the level of examined understanding that we envision as necessary for deep or enduring changes in both knowledge and beliefs.

In the excerpt that follows, we see the students entertain an affective question that invites them to explore how they might respond if they traded places with the older brother from the story who broke his leg and has fallen down into a rille on the moon. The question calls on students to consider what it would require to survive in such a situation and to cast what they know about survival in light of their personal relationships with their own siblings. What can be gleaned from the discourse is that at least one student would, at least initially, "rather die" than get help from a sibling. Importantly, this student's emotive response quickly engages peers who passionately challenge such a notion.

15: *Yeah, what -- how would you, how would you feel if you were in this situation?*
19: Well, in Vern's point of view, um, I, I wouldn't be -- um, once I fall in that ditch, I would be, like, oh, I fractured my leg, since I can't get up, how am I supposed to get help?
15: Yeah.
19: And since Gerry is younger than me, how is he supposed to know how to help me?
15: Yeah.
2: I'd be really worried (overlapping dialogue; inaudible).
6: I would, I would never really want help from my younger sister. It would be embarrassing. I'd be like, "I'd rather die!"
16: Well, first of all, who's going to (inaudible)?
15: Yeah, I would just be happy that someone helped. I would be happy, like, that someone saved my life, that I didn't die out there.
16: Oh, yeah.
15: That I didn't run out of air, because that -- you could -- it doesn't matter who saved you. It matters that you lived.
6: Good point. Because I'd probably think differently when I actually did crack my space suit running out of oxygen.

What the students surmise through exploratory talk and examinations of their understandings is that survival with a broken leg on the moon would require help, even from a younger, less experienced sibling. What is interesting about this particular excerpt is that the students in the discussion draw both on their knowledge and beliefs about broken legs, as well as the emotional nature of running out of oxygen on the moon and dying. In fact, the students appear to be easily swayed by the emotion-laden reasoning offered during the question event. This excerpt shows the power of emotion in altering students' knowledge and beliefs.

### *Conceptual and Epistemic Development Requires Context-Driven Self-Regulation*

Few researchers exploring conceptual change or epistemic beliefs would question the premise that those who achieve some success in either arena must have displayed strategic and metastrategic processing (Muis, 2007). It seems unlikely that more evidenced-based understandings or justified beliefs could occur with any regularity or be sustained over time and context without strategic effort or without the monitoring or regulation of those efforts (Muis, 2008). We have witnessed such strategic and metastrategic processing in our own programs of research: as doctors working in a hospital reason through the clinical evidence before them to arrive at an appropriate diagnosis or treatment for patients (Dumas, Alexander, Baker, Jablansky, & Dunbar, 2014), as engineering students attempt to ascertain the best way to tackle a design problem (Dumas, Schmidt, & Alexander, 2014), or as high-school students explore the effects of soap on the surface tension of water molecules (Murphy, Greene, Butler et al., 2014). Whereas *strategic* refers to intentional processes to address a particular problem or need, *metastrategic* identifies those intentional acts that have a more executive or oversight function, such as metacognition, self-regulation, or relational reasoning (Dumas, Alexander et al., 2014). The power of such strategic and metastrategic elements is one reason that successful interventions aimed at supporting or promoting conceptual change and epistemic cognition expressly incorporate strategic and self-regulatory components (e.g. Li, Murphy, & Firetto, 2014; Murphy, Rowe, Ramini, & Silverman, 2014).

The excerpt that follows serves to illustrate a student regulating his attention. In this excerpt, Student 6, whose role is to participate in the discussion by posing pertinent questions and then providing follow up to the responses offered by his peers, becomes clearly flustered when he realizes that he has lost his place in the book and in the flow of discussion, displaying self-regulatory behavior as a result.

| | |
|---|---|
| *6:* | *Hey, guys. What are we talking about now, I've lost my place?* |
| 15: | (overlapping dialogue; inaudible). |
| 19: | Like, to (overlapping dialogue; inaudible). |
| Teacher: | Well, I'm not sure what we are talking about either. |
| 6: | Yeah, I'm lost -- I don't know what topic you're talking about, and I might have something to say. |
| 19: | [The suit.] |
| 6: | Oh, we're talking about the suit. OK. |
| 19: | Yeah. |

We have come to appreciate that even the efficient and effective use of strategies may not prove enough to ensure that the highest level of conceptual understanding is attained or that the best sources and forms of evidence are invoked. The actions of the individual cannot operate independently of the context or situation when it comes to either conceptual or epistemic development. The shifting nature of the context, including the nature of the disciplinary and social communities to which individuals belong, must also be carefully monitored. As Carretero et al. (2013) have discussed in relation to history, domains and disciplines also grow and change over time. No field of human inquiry lies dormant or passes time without showing the marks of age or the lines of struggle that inevitably transpire. As with individual changes, these discipline or domain changes may be more subtle or nuanced in form, or they may be dramatic or paradigmatic in character (Kuhn, 1962). In either case, however, it is important that those attempting to achieve richer understandings or to appropriate the most suitable forms of evidence for problems or tasks of a domain-specific nature remain cognizant of the shifts in these established epistemic communities.

For individuals to attune to shifts in context, whether at the macro (e.g. domains) or micro (classroom) context, they must have the ability to reason relationally and to discern relevant similarities and differences in the fabric of the situation or in the problem at hand (e.g. Dumas, Alexander et al., 2014; Franco et al., 2012). In the excerpt that follows students are exploring the similarities and differences between Antarctica and the moon. All students in the group had previously read an expository text about scientists studying Antarctica, and therefore, they likely shared some background knowledge about both locations. What is particularly interesting in this excerpt is that the students are working together to co-construct their understandings of the similarities and differences between Antarctica and the moon. As this co-construction unfolds, they display what James (1896) would call discrimination, pointing out the relevant commonalities and dissimilarities that are foundational to relational reasoning.

| | |
|---|---|
| 16: | Anyway, things that people hadn't really discovered, really [influences] me. And just like Antarctica, I would, I would like to see Antarctica. That would be a cool place to visit. |
| 2: | But Ant-- Antarctica is different. |
| 15: | . . . it's [moon] different, because there is pretty -- well, it's not like Earth, but-- |
| Teacher: | It's obviously different, but -- |
| 15: | -- but there's stuff like it, because it's always cold on [moon], like, Earth. Like, there are some similar things. |
| 19: | There's no high peaks, there's no oxygen [on the moon]. |
| Teacher: | Let her finish, let her finish, let her finish. |
| 15: | And, like, it's [Antarctica] more like the moon, because it's different -- |
| Teacher: | Very solitary. |
| 15: | -- it's very solitary. It's very different than all the rest of the earth, it's very different. All the rest of the world is not -- |
| 2: | Yeah, but there's no wind, or -- and you don't have to trudge on the moon |
| 6: | I think our moon is way different than the earth, from the fact that there's no water, wind, no atmosphere -- |
| Teacher: | So, so (15) is saying -- she didn't say it was like the earth. She is saying that the experience on the moon for a person would be similar to an experience of going to Antarctica. |

Through this process of making an analogical comparison between Antarctica, which had been studied previously, and the moon, the students were better able to identify critical features of the story setting that would support their claims or bring them into question. In effect, they were displaying the strategic abilities we see as basic to their conceptual and epistemic growth.

## EXAMINED UNDERSTANDING: WEIGHING IMPLICATIONS FOR THEORY AND PRACTICE

As we conclude this exploration of the interplay between conceptual change and epistemic beliefs in human learning and performance, we come to what we regard as certain examined understandings about these significant and associated literatures. We center these examined understandings in two spheres of influence. First, we speak directly to those scholarly communities long invested in the study of changes in knowledge and knowing, be it from the tradition of conceptual change or epistemic beliefs. Second, we turn to the heart of educational engagement—schools—by seeking to communicate with those who populate learning environments and who strive to orchestrate classrooms that are havens of reflection and critical analysis in which deeper understandings are pursued and evidenced-based judgments are routinely espoused.

### *Conceptual Change and Epistemic Beliefs Are Intricately Intertwined as Domains of Inquiry*

We are not alone in our appreciation of the fact that scholarly endeavors to investigate the paths that lead to deeper and more culturally accepted concepts within fields of study must invariably confront questions about knowledge and knowing (e.g. Lee, 2010). Similarly, those concerned with the beliefs about knowledge and knowing, whether espoused or enacted, must eventually look to the concepts that individuals form and the changes that transpire as sources of evidence are pursued and resulting evidence weighed (Greene et al., 2008). In essence, our examined understanding is that there is a natural synergy between conceptual change and epistemic beliefs that must be embraced—there cannot be the investigation of one without some consideration of the other. Thus, it may benefit theory building and research design if there was more explicit acknowledgment of the relation between conceptual change and epistemic beliefs and more intentional interdisciplinary exploration.

### *Examined Understanding Requires the Interchange and Evolution of Cognitive and Non-Cognitive Factors*

It is not solely the marriage between conceptual change and epistemic beliefs that we want to promote or the ongoing relation between knowledge and beliefs that this union signifies. What we have come to appreciate more fully in this critical analysis is that there must also be increased attention in theory and research to the motivations and emotions that drive human engagement (Pekrun & Linnenbrink-Garcia, 2014), support reasonable and reasoned doubt (Murphy, 2007), and sustain the quest for deeper understanding that may ultimately bring long-held ideas or beliefs into question (Chinn & Brewer, 1993). As there can be no conceptual change without the intrusion into epistemic beliefs, no enduring change in knowledge or beliefs comes without a significant investment of human motivations and emotions.

### *Investigating Patterns in Contextual Forces on Conceptual and Epistemic Understanding*

The recent emphasis on the importance of context and situation in research on conceptual change and epistemic beliefs is to be lauded (e.g. Sandoval, 2014). We cannot pretend that there is true stability or constancy within individuals or within the learning environments they populate; there is too much evidence to the contrary (Murphy & Mason, 2006). Yet, we would also be remiss if we did not recognize that within the seeming chaos of the human mind or in the environments in which those minds inhabit, there are in fact discernible and identifiable patterns in human thought and action (Dumas, Alexander et al., 2014). By searching out those pockets of shared variance, theorists and researchers can be better equipped to craft the models they believe capture the essence of conceptual or epistemic change. By embracing these instances of predictability, they are more justified in constructing interventions intended to promote or support the learning and development of those who populate learning environments. By appreciating the commonalities that contexts and situations afford, they can begin to forge the transformative experiences they believe will spark conceptual growth or ignite greater critical analysis (Greeno & van de Sande, 2007).

### *Spaces for the Pursuit of Examined Understanding*

For all the merits of scholarly investigation of conceptual change and epistemic beliefs, it is within everyday educational practice that students' habits of mind and action are often formed and routinized (Duschl, 2008). Thus, classrooms must become environments that place critical analysis in the forefront of student engagement and that directly involve students in the formation of standards and procedures that lead to examined understandings (Murphy & Alexander, 2013). These "havens" for conceptual and epistemic development must also encourage students' motivational and emotional investment in the understandings and judgments they form (Murphy, Greene, & Firetto, 2014). Moreover, these "epistemic communities" should be rife with meaningful, focused, and quality discussions that support the interrogation of ideas without risk of damaging students' conceptions of self and where interpretive authority no longer resides solely within the teacher but is distributed within the classroom community (Duschl, 2008; Murphy, Firetto, & Long, in press).

### *Transformative Learning Environments to Promote Conceptual and Epistemic Growth*

Simply constructing the general framework for learning environments meant to foster conceptual and epistemic development without simultaneously paying heed to the interiors of that environment (e.g. mental processes, desired habits of mind, or allowance for individual interests and choices) will likely result in a weak and unsustainable structure (Chin & Teou, 2009). Thus, while focusing on the overall construction of learning spaces that can accommodate conceptual and epistemic growth, educators must take care to devise meaningful experiences that will allow for and even instigate such development (Sinatra & Chinn, 2012). While there needs to be some recognizable "structure" to these transformative experiences, it is important that they allow for the iterations in thought and action that are inevitable, that they scaffold or model core strategic or metastrategic processes without stifling creativity or inventiveness, and that they should be sufficiently motivational and personally relevant to sustain students' engagement (Wilkinson et al., 2010). Further, these experiences should serve to bring students' underlying knowledge and beliefs to the surface in natural and nonthreatening ways so that they can be more richly interrogated or examined by the students themselves or by their peers.

### *Examined Understanding as Part of a Systematic Reorientation of Education*

William James (1907) often wrote about the "cash value" of experiences (i.e. truth), what contemporary researchers might cast as their *value added*. Our perspective is that the "value" of schooling must extend well beyond students' ability to recognize a correct response or to craft an acceptable short-answer reply on formal or informal assessments. Such superficial, although commonplace, demonstrations of knowledge and knowing cannot nourish or sustain individuals on their journey toward deep understanding or evidenced-based reasoning that is the hallmark an educated mind (Alexander, 2007). Nor is the true value of schooling achieved if students only occasionally find themselves within spaces intended to foster conceptual or epistemic development (Duschl, 2008). Rather, optimal conceptual and epistemic growth is reliant on the presences of multiple spaces and experiences that support deep and critical reflection that, in turn, lead to facilitative habits of mind and action (Murphy, Firetto, Li, Wei, & Croninger, in press). These desirable spaces and experiences should be prevalent across all years of schooling and be evident in all academic domains. If the situation is otherwise—if only *certain students* are lucky enough to find themselves in these "havens" of conceptual and epistemic development only at *certain times* or for *certain academic domains*—then the promise of schooling and its potential "cash value" can never be fully realized.

## CODA

We opened this interrogation of the relation between conceptual change and epistemic beliefs with a pronouncement of our own philosophical orientation toward the role of the mind of the individual as the repository for knowledge and knowing, as well as the importance of knowledge and beliefs in conceptual and epistemic change. In doing so, we acknowledged the powerful and mediating influences of social and contextual variables in the process of concept acquisition and change. Moreover, we have established within this chapter that through the manipulation of a vast array of social and contextual variables spaces can be created so as to foster conceptual and epistemic growth. It remains clear that for all our best intentions or for all the investment we may make in building academic spaces and learning environments that might foster examined understanding, it remains an inescapable "truth" that conceptual and epistemic development rests on the intentions and will of those who must undergo such change. Yet, while there can be no assurance that the desired habits of mind and habits of action will ever be fully achieved, there is no alternative but to try. For certainly without effort and commitment on the part of researchers and practitioners, the status quo of weak or impoverished conceptions and of unjustified or unsubstantiated claims will be maintained—a condition that we cannot and will not abide.

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# 28

# EPISTEMIC COGNITION AND PHILOSOPHY

## Developing a New Framework for Epistemic Cognition

*Clark A. Chinn and Ronald W. Rinehart*

Our purpose in this chapter is to discuss implications of philosophical scholarship for educational research on epistemic cognition. In line with ideals of interdisciplinary cross-fertilization, our premise is that educational research on epistemic cognition (EC) can be enriched through more contact with philosophical scholarship, for several reasons. First, philosophers' discussions of what is normative in epistemic cognition run counter to many assumptions in educational research and thus suggest new perspectives for EC research. Second, philosophers' analyses of critical constructs can help identify conceptual inconsistencies and prevent conceptual confusions. Third, like educators, many philosophers develop theories detailing actual processes of epistemic cognition (both individual and social) and thus provide another rich source of ideas for other researchers to draw on.

The outline of the chapter is as follows. First, we define key terms. Second, we present a bird's-eye view of several philosophical literatures that are relevant to EC research in education. Third, we discuss several critiques of educational research that can be made from philosophical perspectives. Finally, we discuss a framework for EC grounded in philosophical scholarship that we call the AIR framework (AIR stands for *A*ims and values, epistemic *I*deals, and *R*eliable epistemic processes). This framework also specifies four principles, again grounded in philosophical perspectives: (1) EC is fundamentally social, (2) practices are central to EC, (3) EC is situated, and (4) EC is connected to ethical concerns. We elaborate on this framework in the last section.

Throughout the chapter, we will focus mainly on presenting philosophical arguments for key claims so as to stay focused on providing an overview of philosophical thought. Elsewhere we have reviewed empirical psychological and educational evidence for many of these ideas (Chinn, Buckland, & Samarapungavan, 2011; Chinn, Rinehart, and Buckland, 2014).

## TERMINOLOGY

Our definition of the term *epistemic* is guided by our review of philosophical literatures, as explained in the next section. *Epistemic* cognition is cognition directed at epistemic aims; epistemic aims, in turn, are goals related to developing some sort of representation of how the world is—of developing a cognitive "take" on the world (Catherine Elgin, personal communication, February 1, 2013). Epistemic aims discussed by philosophers include knowledge, understanding, useful scientific models, theories, true beliefs about significant matters, avoidance of false beliefs, sound evidence, good arguments, and so on. When these aims are achieved, we can say that people have developed epistemic *products*. Epistemic cognition is thus human cognition directed at setting epistemic aims (e.g. deciding to find out if eating meat is bad for health), creating epistemic products (e.g. conducting studies to examine correlations between meat eating and health), and evaluating the epistemic products that oneself or others have developed (e.g. evaluating the claims of a medical study on eating meat that is reported on a health website). Throughout the chapter, *educational researchers* refers to educational and developmental psychologists, science educators, mathematics educators, history educators, and all others who investigate the epistemic cognition of children, lay adults, and experts.

## OVERVIEW OF PHILOSOPHICAL WORK RELEVANT TO EC RESEARCH IN EDUCATION

Several philosophical subfields are informative for educators interested in epistemic cognition and epistemic practices. These include epistemology, the philosophy of science, the philosophy of mathematics, the philosophy of history, and the philosophy of the social sciences. In this section, we provide a brief bird's-eye overview of these literatures. Although a detailed description of these vast literatures is impossible, we point the reader in this section to significant philosophical work that may be of interest to educational researchers. (Chinn et al. [2011] described the grounds for selecting many of these works.)

Epistemology is the sole disciplinary field that defines its field of study as the terrain encompassed by the term *epistemic*; indeed, psychologists and educators have often identified the domain of the "epistemic" as the domain studied by epistemologists (e.g. Hofer & Pintrich, 1997). Chinn et al. (2011) argued that epistemologists should be viewed as experts on defining what should be counted as epistemic. Just as it would be odd for biology educators to define biology in a way that excludes topics studied by biologists, it would be odd for educational researchers to define *epistemic* in ways that exclude much of what epistemologists study. Chinn et al. (2011) argued, however, that educators have indeed defined their field in such ways and thus argued for expanding the scope of research on epistemic cognition research.

Although epistemologists have devoted vast attention to some issues of less appeal to educators (e.g. Descartes's problem of radical skepticism; see Chinn et al., 2011), new lines of epistemological theorizing that are highly relevant to educational research have burgeoned in the past 50 years (Alston, 2005). Particularly relevant is work on reliable epistemic processes (Goldman, 1986, 2002; Bishop & Trout, 2005, 2008), virtue epistemology (Baehr, 2011; Zagzebski, 1996), contextualism (DeRose, 2009; Dretske, 2000), disagreement (Christensen & Lackey, 2013; Feldman & Warfield, 2010), testimony (Coady, 1992; Lackey, 2008, 2010), expertise (Selinger & Crease, 2006), social epistemology (Goldman, 1999; Kusch, 2002; Schmitt, 1994), and the ethics of epistemic action (M. Fricker, 2003). Given that scholarship in these areas is seldom cited in EC research, educators interested in EC may profit by exploring these literatures.

In contrast to epistemologists, philosophers of science and philosophers of other disciplines do not focus solely on epistemic matters; for instance, they also discuss ontic issues (issues regarding the nature and structure of reality) such as the nature of species or the ontic implications of quantum mechanics. However, much of the work in these fields *is* epistemic and can therefore provide insights into EC research. Among the philosophers of science whose work may be of particular interest to EC researchers are Giere (1988, 2006), Hacking (1983, 1999), Harding (1991, 1998), Kitcher (1993, 2011, 2012), Kuhn (1962), Laudan (1977, 1984), Longino (1990, 2002), Mayo and Spanos (2010), Nersessian (2008), Solomon (2001), and Toulmin (1972). Philosophy of science has become more diverse with the emergence of new subfields including the philosophy of biology (Mayr, 1988), the philosophy of chemistry (Scerri & McIntyre, 2014), and the philosophy of physics (Batterman, 2013).

Closely related to philosophy of science is work in the social studies of science, as well as work in the history of science, which we include given the extensive discussions of sociological and historical works by philosophers. The boundaries are not sharp, as philosophers of science (such as Giere [1988] and Nersessian [2008]) have also undertaken sociological and historical analyses, and vice versa (e.g. Kuhn, 1962). Researchers in these traditions have examined the actual practices of scientists to understand how scientists work. For example, they have studied gravitational waves (Collins, 2004), subatomic particles (Pickering, 1984), and the discovery of biochemical compounds (Latour & Woolgar, 1979).

Philosophers and sociologists of science have examined how scientists decide among rival theories, how scientists conduct research to address theoretical questions, how scientists justify their ideas, how scientists engage in argumentation and collaboration, how and why scientific theories change, what theories and models are, why scientists disagree about theories, and how these disagreements are resolved. Increasingly, they have explored the methodological processes (e.g. experimentation, historical research in fields such as archaeology) used by scientists to develop theories, models, and other cognitive products (e.g. Galison, 1987; Giere, 1988; Wylie, 2002).

Unlike epistemology, philosophy of science has strongly influenced educational research—specifically, the work of science education through the seminal work of Richard Duschl (Duschl, 1990; Duschl & Grandy, 2008) and many others. However, Matthews (2004) argued cogently that science education has drawn disproportionately on the work of Thomas Kuhn and has paid relatively less attention to other worthy philosophers.

Much of philosophy of science and some of epistemology has taken a *naturalized* approach to epistemology (Kornblith, 1999). Naturalized epistemology uses empirical findings to guide insights about what counts as good reasoning, effective investigative methods, and the like (Goldman, 1986). For example, naturalized epistemologists' understanding of effective reasoning methods is guided by cognitive psychology research on reasoning biases. They learn about effective scientific practices through sociological, historical, and psychological studies of scientists, scientific teams, and scientific communities. Naturalized epistemology thus has much the same goal as one of the goals of educational research—understanding effective individual and social epistemic processes.

It appears to us EC research has made even less contact with philosophical fields such as the philosophy of history (Bunzl, 1997), the philosophy of mathematics (Parsons, 2014), and the philosophy of the social sciences (Cartwright, 2007; Cartwright & Montuschi, 2014). Although these fields can also usefully inform educational research, discussion of them goes beyond what we can review within a single chapter.

## PHILOSOPHICAL PERSPECTIVES ON CURRENT EDUCATIONAL RESEARCH

In this section, we discuss some critiques of current educational research that can be offered from philosophical perspectives. We discuss (1) the scope of the epistemic, (2) stances such as relativism, and (3) assumptions about sophisticated epistemic thinking. In this section, we will not extensively survey the educational research we refer to, because many chapters in this volume already explain this research in detail. Readers can therefore appraise these critiques in their own readings of these chapters.

### *Scope of the Epistemic*

In defining what is epistemic, educational researchers have tended to focus their definitions on knowledge and its justification (following definitions sometimes provided by epistemologists themselves; see Chinn et al., 2011). For example, Muis (2007) wrote, "consistent with philosophical notions of epistemology, this model focuses on general beliefs about how knowledge is derived and how knowledge is justified." In line with this view of epistemology, Hofer and Pintrich's (1997) seminal model of epistemic beliefs identified four categories of beliefs: beliefs about the nature of knowledge (its degree of certainty and degree of simplicity versus complexity) and about the nature of knowing (the sources of knowing and the justification of knowing).

However, if one examines what epistemologists study and looks more widely at how they define their field, one finds that the scope of epistemology is much broader than educational researchers have considered. Table 28.1 displays a range of quotations from eminent epistemologists from a variety of modern epistemological traditions that express a much more expansive view of epistemology. Several conclusions are apparent from the table. First, epistemology encompasses more than just *knowledge*. Other epistemic aims and products emphasized in these definitions, in addition to knowledge, including arguments, theories, explanation, wisdom, understanding, and evidence. Recent epistemological work has explored many of these aims and products other than knowledge (e.g. Kvanvig, 2003).

Second, many of these definitions indicate that methods and processes of inquiry are central to the epistemic; Hookway (2006) even characterized epistemology "as a theory of inquiry." Yet, none of the current psychological models of EC have examined people's "theory of inquiry" as a core topic of investigation. Even in science education, analyses of students' understanding of the nature of science have usually not included detailed accounts of students' ideas and practices of inquiry (see Allchin [2011] and Sandoval [2005] for parallel arguments).

Third, intellectual virtues are an important component of several of these definitions. Intellectual virtues are habits of mind that are conducive to achieving valued epistemic aims. For example, open-mindedness is an intellectual virtue that

**Table 28.1** Epistemologists' statements about the scope of epistemology

| Epistemologist | Statement |
|---|---|
| Alston (2005) | Epistemologists investigate "the operation and condition of our cognitive faculties—perception, reasoning, belief formation, the products thereof—beliefs, arguments, theories, explanation, knowledge" (pp. 2–3). ". . . there is no doubt that the intellectual virtues are among the important objects of [epistemological reflection]" (p. 3). ". . . the study of inquiry provides a rich harvest of objects for epistemic evaluation …. it is pretty much taken up with evaluative questions as to how researches are best or most successfully pursued" (p. 4). |
| Bishop & Trout (2005) | "A healthy epistemological tradition must have 3 vigorous and interrelated components: theoretical, practical, and social. A priority for epistemology is to develop excellent reasoning strategies (i.e., reliable and tractable) that can be used on significant problems" (pp. 17). |
| Goldman (1986) | "Epistemology deals with . . . the whole range of efforts to know and understand the world, including the unrefined, workaday practices of the layman as well as the refined, specialized methods of the scientist or scholar. It includes the entire canvas of topics the mind can address: the nature of the cosmos, the mathematics of set theory or tensors, the fabric of man-made symbols and culture, and even the simple layout of objects in the immediate environment. The ways that minds do or should deal with these topics, individually or in concert, comprise the province of epistemology" (p. 13). |
| Haack (2001) | "I take for granted the essentially evaluative character of epistemological concerns, the focus on what makes evidence *better or worse*, what determines to what degree a person is *justified in* a belief, how inquiry *should be* or *is best* conducted" (p. 22). |
| Hookway (2006) | Adopts the view of "epistemology as a theory of inquiry" (p. 98). ". . . .Epistemology should study our practice of epistemic evaluation by exploring how we are able to carry out inquiries and theoretical deliberations in a well-regulated manner." This means that "the concept of *knowledge* [is] not used to formulate the fundamental problems of epistemology" (p. 105). "What lies behind our desire to be 'good inquirers'? Perhaps we seek *wisdom* or *understanding*; perhaps we seek to contribute to the growth of flawed and fallible systems of ideas; perhaps other answers will be forthcoming" (p. 101). |
| Kvanvig (2003) | "Epistemology would seem to have a large stake in inquiry regarding successful or valuable aspects of cognition, such as wisdom and understanding . . ." (p. 187). |
| Zagzebski (1996) | Argues that epistemology should be centered on the intellectual or epistemic virtues. "Knowledge is a state of belief arising out of acts of intellectual virtue" (p. 271). |

can help people overcome false beliefs and acquire new, better ideas. Although recent epistemological theories have argued for the centrality of epistemic virtues to epistemic cognition (Zagzebski, 1996), there has been very little educational research on intellectual virtues.

To date, these issues have not been the focus of extensive educational research efforts. EC research can be enriched through investigations of a broader range of epistemic aims, through more extensive research into learners' theories and practices of inquiry, and into epistemic virtues. The definitions provided in Table 28.1 suggest that educational researchers could develop broader definitions of EC.

### *Stances Such as Relativism*

A large body of research on epistemic cognition by developmental psychologists has reported a progression through different epistemic stances as humans grow older and gain more educational experiences. According to one such theory (D. Kuhn & Weinstock, 2002), young children are realists, viewing knowledge claims as "copies of an external reality." As they grow and age they advance to a new level, absolutism, in which they view reality as directly knowable and knowledge claims are objectively right or wrong. Older students may be multiplists (or relativists), who believe that human minds generate uncertain knowledge about a reality that "is not directly knowable" (p. 125), and ideas are just opinions, no idea better than another. For the multiplist "critical thinking is irrelevant" (p. 125) because there is no truth of a matter to be had (e.g. philosophical relativism). The last level is the evaluativist: people who believe that judgments are evaluable and that "knowledge is generated by human minds and is uncertain" (p. 125). Thus, epistemic development is characterized as shifts in general epistemic stances.

From a philosophical view, however, stances such as multiplism or relativism should not be treated as generalized, omnibus stances (e.g. "a certain individual is a relativist"). Instead, philosophers treat stances like relativism as two-place predicates: X is relative to Y, where X can be knowledge, truth, beliefs, justification, and so on; and Y can be culture, individual, theoretical camp, and so on (Swoyer, 2006). For example, an individual might believe that ethics is relative to culture, but scientific truths are not, or that truth in psychology is relative to the person, whereas truth in science is not relative to any groups (see also Boghossian, 2006). Thus, an implication of philosophy is that, instead of investigating whether people are relativists, educators should investigate what X people believe to be relative to which Y.

In recent work, Chinn and his colleagues (Buckland, Chinn, & Hurwitz, 2011; Chinn & Rinehart, 2014) have argued that situational conditions (Z) should be considered in addition to these X's and Y's: for example, a person might claim that the best scientific theories X are relative to theoretical camp Y under the condition Z1 that scientists are evenly split, but not under the condition Z2 that the vast majority of scientists support one position over another.

It is important to consider all three elements (X, Y, and Z) when judging when a person is or is not a relativist. Most of the research investigating stances including relativism (or multiplism) has used short vignettes such as this:

> Vignette #1. "There have been frequent reports about the relationship between chemicals that are added to foods and the safety of these foods. Some studies indicate that such chemicals can cause cancer, making these foods unsafe to eat. Other studies, however, show that chemical additives are not harmful, and actually make the foods containing them more safe to eat" (King & Kitchener, 1994).

An interviewee who believes that both sides can be equally right on this question is at most a relativist under certain values of X, Y, and Z that are particular to this vignette: The relativist believes that food additive theories X are relative to scientific camp Y under the conditions Z1 that (a) the particular food additives are unspecified, (b) there are some studies on both sides, and (c) no additional information is given. An interviewee who is relativistic in these conditions might not be a relativist under the conditions of Vignette #2:

Vignette #2. "Johann believes that mercury is a very safe food additive. However, a vast body of evidence indicates that mercury is very harmful to the human body; all scientists agree that mercury is extremely harmful to human health and should never be used as a food additive."

A true, general relativist about food additive theories would be required to say that Johann and the scientists are equally right, even under these conditions (Z2), with very strong evidence and strong scientific opinion, because a general, omnibus relativist needs to give relativist responses under all conditions. But we suspect that very few people who express relativistic views on Vignette #1 will also express relativistic views on Vignette #2. Thus, a philosophical perspective suggests that, instead of examining whether people are relativists in general, educators should investigate the range of situations (particular configurations of X's, Y's, and Z's) that elicit relativistic responses and those that do not (see Swoyer, 2006).

### *What Counts as Sophisticated Epistemic Cognition?*

In much research on epistemic cognition, researchers have assumed that certain epistemic beliefs and certain epistemic stances are normatively better than others. For example, a belief that one acquires knowledge from authority (as by listening to a teacher or reading a textbook) is typically viewed as unsophisticated (e.g. Hofer & Pintrich, 1997). However, the philosophical literature calls into question several of the core assumptions of much educational research. As illustrations, we discuss three examples of normative assumptions that are philosophically dubitable.

**Assumptions about authority as a source of knowledge.** A widespread assumption in most EC research is that it is unsophisticated to believe that knowledge comes from authorities such as textbook authors, teachers, or even experts such as scientists. For example, Conley and Pintrich (2004) wrote that "A change toward greater sophistication in beliefs would be evidenced by weaker beliefs in external authority as the source of knowledge" (p. 191). In studies using questionnaires, those questionnaire items that address beliefs about other people as a source of knowledge are conceptualized as items about authority as a source of knowledge, which is usually seen to be an unproductive belief.

Philosophers, in contrast, recognize other people as a highly productive and indispensable source of knowledge (E. Fricker, 2002; Hardwig, 1985, 1991; Lackey, 2008). Almost everything humans know is learned from others. Hardwig (1985, 1991) examined the epistemic practices of experimental and theoretical physicists and found that even the most empirical of investigations (particle accelerator experiments involving the charm quark) depend on testimony, as theoreticians and experimentalists must share information, and as scientists often know of their own data from the testimony of lab assistants (Lipton, 1998). Physicist William Bugg, a coauthor of a 99-author paper exploring the properties of the charm quark, reported that he knew only 10 or 12 of his coauthors well enough to judge the quality of their work (Hardwig, 1991). The work required to produce the charm quark paper consumed approximately 280 to 300 person-years of labor and generated data far beyond what any one individual could ever hope to analyze. Given the realities of this kind of scientific work, Hardwig concluded that "we must also say that someone can know 'vicariously'—i.e., without possessing the evidence for the truth of what he knows, perhaps without even fully understanding what he knows" (Hardwig, 1985, p. 348). In mathematics, Weber and colleagues concluded from multiple expert studies that mathematicians "frequently believe mathematical assertions are true on the testimony of others and that the perceived authority of the mathematician advancing a claim influences which testimony mathematicians choose to accept" (Weber, Inglis, & Mejia-Ramos, 2014, p. 43). Recent EC research is starting to acknowledge the role of testimony (Bråten, Strømsø, & Samuelstuen, 2008; Chinn et al., 2011; Ferguson & Bråten, 2013; Sinatra, Kienhues, & Hofer, 2014). For example, Harris and his colleagues have investigated young children's use of testimony as a source of knowledge (e.g. Harris & Koenig, 2006). Bromme and colleagues have made the case that humans frequently need to defer to experts because it is impractical if not impossible to develop the needed level of expertise to make judgments in a field of expertise (Bromme, Kienhues, & Porsch, 2010). Collins (2014) has argued that on controversial topics such as global warming and vaccinations, the technical evaluation of the relevant evidence requires specialized knowledge that goes far beyond what ordinary educated citizens have, so that the best option for citizens is necessarily to trust expert consensus.

**Assumptions about uncertainty.** EC researchers have often assumed that sophisticated thinkers treat knowledge claims as uncertain and tentative (Perry, 1970; Schommer, 1990; King & Kitchener, 1994; Hofer & Pintrich, 1997). This seems to be a mistake. Typically even a highly established scientific theory has both core elements that are held by scientists to be quite certain as well as more peripheral elements that are less certain (Lakatos, 1976). For example, the standard model of particle physics has a hard core of well-accepted theoretical constructs as well as more peripheral components. The Higgs boson, before its recent confirmation, represented a more uncertain component. In a Delphi study of what should count as normative views of the nature of science (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003), an expert panel including philosophers of science and scientists agreed that "Students should appreciate why much scientific knowledge, particularly that taught in school science, is well-established and beyond reasonable doubt, and why other scientific knowledge is more open to legitimate doubt" (p. 701). Thus, it seems inappropriate to view the belief that some knowledge claims are quite certain as unsophisticated (Elby & Hammer, 2001).

**Realism.** Developmental stage theories have typically posited that realism is a feature of earlier, less sophisticated epistemic stances. In these models, realist beliefs occur in early stages, with younger learners committed to a one-to-one correspondence theory between ideas and the world (D. Kuhn & Weinstock, 2002). Realism is abandoned as learners develop more sophisticated epistemic stances, and no stage theory holds that sophisticated thinkers take realistic stances. However, the idea that realism is only an unsophisticated stance is simply false. Many epistemologists and philosophers of science are realists (e.g. Giere, 2006; Goldman, 1986; Newton-Smith, 1981), as are many scientists (see Giere, 2006). Indeed, a recent survey of hundreds of professional philosophers (Bourget & Chalmers, 2014) found that over 75 percent of epistemologists and philosophers of science were realists about scientific matters. Over 50 percent of these philosophers accepted a correspondence theory of truth—the very lowest level of epistemic development according to developmental theories of EC. It is thus flatly wrong that realism—even a correspondence theory of realism—is incompatible with sophisticated levels of epistemic thinking. Furthermore, sophisticated thinkers might be realists about some things but not about others; for example, Cartwright (2007) is a realist about causes but an anti-realist about scientific laws.

### *Summary*

Throughout this section, we have illustrated some of the ways in which philosophical scholarship can help educational researchers sharpen their theories, including a consideration of what key terms mean (e.g. what is epistemic, what terms like relativism mean) and what is properly considered normative. These are examples of the kinds of benefits that can be provided by an interdisciplinary approach to EC research that incorporates philosophy.

## BUILDING A PHILOSOPHICALLY GROUNDED MODEL OF EPISTEMIC COGNITION

In this section, we turn to a formulation of a model of EC that is grounded in philosophical scholarship. In accord with recent philosophical perspectives, we have developed the AIR model of epistemic cognition (Chinn et al., 2014), which we elaborate below. The AIR model identifies three components of epistemic cognition (*A*ims and values, epistemic *I*deals, and *R*eliable epistemic processes). These three components of EC can be viewed as the cognitive resources that people use to create and evaluate epistemic products and to justify their evaluations.

The AIR model also specifies four core principles. First, it emphasizes that EC is fundamentally *social*, not just individual. Second, it emphasizes that EC is centered in *practices* and *practical reasoning*, rather than formal beliefs. Third, it emphasizes the *situatedness* or *contextualization* of EC. Finally, it acknowledges the *ethical* dimensions of EC. We elaborate on this framework below and discuss its connections to contemporary philosophical scholarship.

### *The AIR Components of EC: Aims and Value, Epistemic Ideals, Reliable Epistemic Processes*

**Aims and values.** Prior to Chinn et al. (2011), models of epistemic cognition seldom included aims (or goals) as an explicit component of epistemic cognition. But as we discussed earlier, philosophers have identified multiple aims that are epistemic, and these include aims other than knowledge, such as understanding and wisdom (see Table 28.1). Weber et al. (2014) showed that mathematicians pursue distinct epistemic aims, such as achieving certain knowledge, convincing oneself than a mathematical assertion is true, and understanding the mathematics behind an assertion; they may use different kinds of evidence in support of different aims. For instance, a mathematician may believe that examples are useful for understanding, and that testimony from other mathematicians can sometimes suffice to promote conviction, but that only deductive proofs can support certain knowledge.

Philosophers have noted further that different kinds of knowledge can vary in value. One community may view knowledge of biological cloning as more valuable (because of practical uses for medical advances) than knowledge of the anatomy of foxes (which seems to lack these uses). Another community may view self-knowledge as having particularly high value because it is seen as facilitating self-actualization, which is valued in this community. Understanding people's differing values is part of understanding differences in epistemic cognition.

Aims and values can be epistemic or non-epistemic; people are often motivated by a mixture of the two (Kawasaki, DeLiema, & Sandoval, 2014; Kitcher, 1993). For example, scientists might value achieving deeper understanding of the nature of the HIV virus because it increases the global stock of knowledge about the HIV virus or viruses in general (an epistemic aim), because of the potential for developing better medical treatments (a non-epistemic aim), and because of the professional prestige that accrues to those who make important discoveries (another non-epistemic aim). Kitcher (1993) argued that scientists' desire to achieve recognition (a non-epistemic aim) is conducive to scientific progress; however, some nonscientists might (mistakenly) believe that pursuing such aims are incompatible with scientific progress because they think that scientists must be completely disinterested and selfless in order to work productively. An important area for future research is to investigate the interactions among various epistemic and non-epistemic aims, as well as what people think about these interactions.

**Epistemic ideals.** Epistemic ideals are the ideals or criteria used to evaluate epistemic products. The term *ideals* comes from Toulmin's (1972) notion of explanatory ideals—the standards or criteria that good explanations in science should meet. Any object of epistemic evaluation requires criteria to evaluate them. For example, philosophers have argued that scientists evaluate theories using criteria such as fit with a broad scope of evidence, avoiding contradictions with evidence, fruitfulness in generating new research, consistency with other theories, and internal consistency (Kuhn, 1977; Newton-Smith, 1981). Criteria for evaluating methods include whether the methods have independent empirical support, whether they are consistent with accepted theories, whether they produce consistent results, whether they avoid procedures known to be subject to bias, and so on (cf. Galison, 1987).

Criteria can be used to guide the production of knowledge claims (e.g. scientists seek to develop theories that fit the best evidence) or the evaluation of knowledge claims (e.g. scientists use criteria to evaluate others' work). Pluta et al. (2011) have shown that even middle school students can, with minimal instruction, generate philosophically sound criteria for evaluating scientific models. Because these criteria (or ideals) are directed at evaluating epistemic products, they are a core component of epistemic cognition.

Individuals, age groups, social groups, and cultures may differ in the epistemic ideals they use. For example, young-earth creationists endorse epistemic ideals (e.g. fit with sacred scriptures) that differ sharply from those of evolutionary scientists (e.g. fit with multiple lines of empirical evidence) for developing knowledge claims about the origin of species (Chinn & Buckland, 2011). Part of the task of educational researchers is to investigate these differences in epistemic ideals. Yet, when determining educational objectives, there is also a need to engage in vigorous discussions about which ideals are worthy of being set as instructional goals. If one is not willing to defend scientific ideals as superior to creationist ideals for arriving at knowledge about speciation, then one has no defensible grounds for teaching evolution in science classes instead of creationism, and indeed no adequate reason for preferring evolutionary explanations at all (see Goldman, 2010).

Part of the EC research program should therefore involve exploring whether there are rational grounds for preferring some criteria over others. This does not mean simply accepting current expert criteria uncritically, such as current scientific criteria. For example, research on gender and racial biases in science has shown that the prevailing scientific standards at a given time can involve problematic biases and must therefore be challenged and changed (e.g. Harding, 1991, 1998). Similarly, research with Native American populations suggests the possibility that some indigenous epistemic standards support knowledge of forest husbandry that is superior in some respects to the theories of scientists with connections to the logging industry (cf. Medin & Bang, 2014). What is needed is a critical analysis that recognizes the success engendered by the norms of science and many other professions but also engages in serious rational critique of these norms.

**Reliable epistemic processes.** One major epistemological theory developed in the past decades is *reliabilism* (Goldman, 1986), which conceptualizes knowledge as true beliefs produced by a reliable epistemic process that is more likely to produce true beliefs than false beliefs. Roughly, beliefs can be viewed as well justified if they are produced by reliable epistemic processes. Analogously, a reliable process for producing good scientific models is one that is more likely to produce a good model than a bad one. A reliable process for producing a well-justified historical narrative is one that is more likely to produce a well-justified narrative (perhaps as judged by the community of historical scholars) than a bad one.

A core idea underlying reliabilism is that humans use multiple causal processes to produce beliefs (or models, theories, historical narratives, etc.). Some of these processes (such as visual perception under typical conditions) are highly reliable (e.g. if you see a nearby chair in ordinary light, your belief that there is a chair near you is highly likely to be true). Such processes tend to produce or—in fact—*cause* true beliefs through causal cognitive and sociocultural processes (such as the causal processes involved in human perception). As another example, when individuals investigate issues on their own, it is usually more reliable to search for information on multiple sides of a question than just to search for information that confirms prior beliefs. Other processes (such as reading tea leaves) are highly unreliable (that is, they are more likely to produce or cause false than true beliefs). Examples of unreliable causal processes include relying on first impressions when judging ideas or consulting sacred scriptures regarding the history of the planet.

However, processes that reliably tend to cause well-justified beliefs are reliable only under certain conditions. Visual perception is reliable when distances are close, lighting is good, and observed objects are familiar. But visual perception is highly unreliable under conditions of viewing an unfamiliar face under poor lighting from across a soccer field. Similarly, argumentation is a reliable means for groups to produce knowledge under conditions such as having cognitive diversity in the group, following norms of equal participation, uptake of others' ideas, and so on, but not when minority viewpoints are systematically ignored. All reliable epistemic processes are reliable only under certain conditions. Empirical evidence can help reveal the conditions under which processes are reliable versus unreliable (Goldman, 1986), as when empirical research shows that unmasked medical trials are subject to bias and placebo effects and are therefore unreliable.

Causal epistemic processes operate at a variety of scales from individual processes (observation, evaluating the credibility of experts) to group processes (argumentation, processes of sharing information) to community and institutional processes (peer review, collective development of ideas on wikis). Across these scales, there exists a myriad of causal processes that can be used to generate beliefs about the natural and social worlds (cf. Cartwright, 2007). Moreover, many processes are tightly interwoven with topic-specific knowledge. The causal epistemic processes used to learn about predator–prey interactions in field settings (e.g. knowing what to control in an experiment studying fish in a stream) differ in manifold ways from the processes used to learn about how urban students learn best in American classrooms (e.g. knowing what to control in an experiment in schools; Cartwright, 2007). In short, sophisticated epistemic cognition entails deep and extensive knowledge of the various causal processes used to produce knowledge and other epistemic products.

Awareness of reliable epistemic processes can be used in at least two different ways: to create epistemic products (a *creative, productive* use) and to evaluate others' epistemic products and justify these evaluations (an *evaluative* use). We illustrate this with two example processes in Table 28.2, showing how each can be used either creatively or evaluatively.

What are the implications of the reliable epistemic processes component of the AIR model for EC research? One important research goal will be to investigate what people perceive as reliable and unreliable processes for producing knowledge, theories, understanding, and other epistemic products. This can be examined both through investigating their beliefs about reliable and unreliable processes and through investigating the processes that they actually employ when creating or evaluating knowledge. Researchers are likely to identify many specific areas in which there is room for epistemic growth among learners of all ages.

A second important research goal is to invest significant instructional effort toward promoting mastery of a very large repertoire of these processes, so that students can use them both creatively and evaluatively. Developing epistemic cognition is less a matter of developing a few sophisticated beliefs and more a matter of mastering a large and integrative network of causal epistemic processes, and effective instructional methods are needed to promote this goal.

**Table 28.2** Creative and evaluative uses of reliable epistemic processes

| Example process, with conditions | Creative use of the process | Evaluative use of the process |
|---|---|---|
| The process of using an electron microscope, which requires that many detailed technical protocols be in place for preparing samples, calibrating the instrument, etc. | A researcher uses the electron microscope to generate an image of the surface of a bacterium, carefully following accepted protocols and documenting procedures meticulously. (The process is used to actively generate a new epistemic product—the image.) | The researcher reads a research report that makes claims about the surface features of a particular species of bacteria. She carefully notes that all normal procedures are documented and so accepts the accuracy of the findings. (Awareness of the process and its proper conditions are used to justify a positive evaluation of the report's claim.) |
| A journalistic process in which all claims made by one source must be verified by another source before publication; required conditions include that the sources are independent of each other, unbiased, in a position to know, etc. | A journalist waits to publish news about a political scandal until she can verify the first source with an independent second eyewitness source who has no reason to lie. (Knowledge of the process is used to generate an epistemic procedure leading to the news report.) | A newspaper reader reads a report of a scandal showing no indication that a second source confirms the claims of the unnamed first source who made the accusations. The reader judges that the report is untrustworthy. (Awareness of the process and its proper conditions is used to justify a negative evaluation of a newspaper report.) |

### *Four General Principles of the AIR Model*

Four principles congruent with contemporary philosophical work are also part of the AIR model. We discuss these below.

**Epistemic cognition as fundamentally social.** Although philosophy has traditionally focused on individuals, recent philosophical work has made a strong case that the epistemic life is thoroughly social. First, as we discussed earlier, most of an individual's knowledge base comes from testimony. What one can experience oneself is a fraction of what one learns from others.

Second, most processes that reliably produce significant epistemic products are social. For example, recent work has made it clear that scientific advances depend on the argumentative critiques of ideas by the community and by the uptake of these critiques by some within the community (Longino, 1990, 2002). Researchers who have carefully examined the work of scientific teams have shown that new discoveries from empirical research emerge from the interactions of multiple workers talking about what they are seeing and how to interpret their results (e.g. Hardwig, 1985, 1991).

Third, the validation of epistemic products depends on communities. Many philosophers have pointed out that there is no such thing as a purely individual knowledge claim in science. An individual discovery only becomes knowledge when it is accepted as valid by the larger scientific community (Longino, 1990). Code (1991) has argued that this is true even of mundane beliefs. For example, an individual's knowledge that there is a green chair in her kitchen requires tacit support from others; if several trusted friends insisted to her that there was no such chair, she might need to abandon her knowledge claim and might suspect that she was hallucinating. Kusch (2002) has similarly argued that all knowledge claims require ratification from others.

These social views of EC are in strong accord with sociocultural theories of learning and other theories of learning as participation in groups and communities. EC researchers may find it productive to explore connections among philosophical theories and participatory theories of learning.

**An emphasis on practices.** Much research on EC has focused on people's epistemic beliefs. Psychologists have used surveys to investigate people's beliefs about issues such as how certain knowledge is, whether knowledge is justified by experience or authority, or what the nature of science is (e.g. Schommer, 1990; Schraw, Bendixen, & Dunkle, 2002). Science educators have used surveys and interview protocols to investigate students' beliefs about the nature of science, such as what theories and laws are and what the purpose of experiments is (e.g. Tsai, 2007). There is growing evidence within education that correlations of these beliefs with actual epistemic actions (e.g. how people reason about topics) are low (Chinn et al., 2011), and many educators have argued that it is at least as important to investigate people's practical, enacted epistemologies (e.g. how they actually reason about a body of evidence to draw a conclusion) as to investigate their generalized self-reported beliefs (e.g. the extent to which they agree with statements saying that knowledge should be based on evidence; Allchin, 2011; Sandoval, 2005; Sinatra & Chinn, 2011).

This move toward practices is supported by a number of trends in philosophical scholarship, particularly in the philosophy of science, which has extensively examined the thinking of scientists engaged in scholarship. These researchers have consistently reported that the work of science lies in the practical thinking about how to develop particular experiments (or other kinds of studies) and how to interpret findings. Their interactions center on topic-specific processes, such as how to design experiments, how to develop needed equipment, and how to interpret results (see Galison, 1987; Lynch, 1985; Staley, 2004). There is no indication in any of this research that scientists philosophize formally about the general characteristics of knowledge in their field as they work. Rather, their work involves a practical, *enacted epistemology* focused on solving problems of their practice; when they discuss epistemic criteria, they do so not in general terms but in the context of evaluating the specific epistemic products that they and their colleagues are creating. These conclusions are consistent with recent educational studies of scientists' thinking (e.g. Samarapungavan, Westby, & Bodner, 2006).

In addition, much practical reasoning is tacit (e.g. Lynch, 1985). Collins (2014) has observed that physicists could only successfully design gravity wave detection devices if they went to other labs that had successfully built these machines. Studying detailed manuals was insufficient; much of the knowledge was tacit and never articulated within a manual. Thus, the work of science involves practical, enacted, partly tacit reasoning much more than formal beliefs about science (see also Sandoval, 2005).

**Situatedness or contextualization of epistemic cognition.** Recently some educational researchers have argued that EC is situated—that is, people will exhibit different EC in different situations (e.g. Hammer & Elby, 2002). For example, in group work in a health class, a student may carefully weigh scientific evidence relating to which diet is most efficacious, whereas in a doctor's office, the student simply accepts the doctor's expertise as grounds to choose the doctor's recommended diet. Then at home the student might rely on indistinct feelings of her own well being to decide whether to decrease meat intake. Different settings may elicit different epistemic cognition (for empirical evidence, see Rosenberg, Hammer, & Phelan, 2006; Elby & Hammer, 2001; and discussions in Chinn et al., 2011).

Philosophical scholarship provides additional arguments for the situatedness of EC and highlights some of the ways in which EC may be situated. As a first example, we consider the recent epistemological theory of *contextualism*, according to which even foundational constructs such as *knowledge* can vary by context. DeRose (2009), for example, has argued that whether a person claims to *know* something may depend on the stakes. A doctor may ordinarily say that she knows that a certain food additive causes cancer when talking with her family, but hesitate to say she knows the same thing when beginning to prepare a talk on the topic for a conference of doctors—a venue where the stakes (and community norms) are higher. Similarly, Dretske (2000) has argued that whether one *knows* something depends on contextual factors like relevant alternatives. Zoo visitors may know with certainty that the striped animals they see ahead of them are zebras. But if they hear a moment later that some zoos in the area have been too poor to afford zebras and so have cleverly painted stripes on donkeys to look like zebras, they may suddenly no longer know they are seeing zebras. The observational evidence does not change, but the presence of a new relevant alternative changes their epistemic judgment. Thus, contextual factors such as the stakes, community expectations, and relevant alternatives can affect basic epistemic judgments. Experimental philosophers have begun investigating such issues (Beebe, 2014); such situational factors could be much more extensively studied in educational research.

Second, philosophers of science have increasingly argued for the "disunity" of science (Galison & Stump, 1996). In other words, there is no common method or set of practices in science. Rather, different fields of study conduct inquiry in different ways (Galison & Stump, 1996); even within a single field such as biology, the inquiry methods of microbiologists differ sharply from those of field ecologists, to the point that a microbiologist cannot confidently evaluate the quality of the ecologist's work, and *vice versa*. Understanding processes of carrying out a procedure such as chromatography requires very specialized knowledge, much of which is partly tacit and involves seeing things in new ways over time (Goodwin, 1994; Lynch, 1985); producing and evaluating knowledge claims based on chromatographic methods requires this specialized knowledge and simply cannot be done by someone with merely general scientific knowledge.

Third, philosophers have pointed out that even though scientists use seemingly general criteria to evaluate products such as theories and models—criteria such as fit with a broad scope of evidence and fruitfulness—these criteria can only be used and interpreted contextually in particular situations (e.g. Kuhn, 1977; Niiniluoto, 2002). What counts as evidence (and how one determines what evidence exists) for a quark researcher will differ in manifold ways from what counts as evidence for an ecologist. Further, how scientists weigh criteria varies from situation to situation. In one theoretical dispute, scientists may judge that fruitfulness is a more important criterion than current fit with evidence, when a new theory looks promising but still needs more evidential support. In a different dispute, fit with evidence may predominate over fruitfulness (Kuhn, 1977). EC researchers have seldom studied how epistemic criteria used by learners may vary contextually.

**Ethical connections.** Although ethical issues have not figured significantly in educational research on EC, recent philosophical scholarship has emphasized ethical aspects of EC. For example, philosophers have recently explored epistemic responsibilities and epistemic injustices. Research on epistemic responsibilities asks what people are ethically obligated to do. For example, are people ethically obligated to become well informed about issues such as global warming? If so, why? If not, why not? What issues are people morally obligated to become well informed of? How much effort is morally required on particular topics to become well informed? All of these questions examine issues of epistemic responsibility that have received no attention in EC research to date. Educational research could examine individual, group, and cultural differences in ideas about epistemic responsibility.

Research on epistemic injustices examines inequalities in knowledge uptake and dissemination in communities. M. Fricker (2011) has argued that the epistemic voices of women and cultural minorities are often neglected improperly, so that these people's epistemic rights are violated by those who do not listen to them or take up their ideas. Greater uptake of epistemic perspectives of underrepresented groups could yield improvements in epistemic criteria and epistemic processes used in epistemic communities (including science) as well as improvements in the causal processes used within these communities to produce knowledge. Failure to disseminate knowledge equitably within society is another form of epistemic injustice and can be viewed as an unreliable process of social knowledge dissemination.

Another point at which EC touches on ethical issues concerns epistemic virtues and vices. Sosa (2007) wrote that there are "two parts of epistemology: (a) theory of knowledge, and (b) intellectual ethics. The latter concerns evaluation and norms pertinent to intellectual matters generally, with sensitivity to the full span of intellectual values. It is therefore a much broader discipline than a theory of knowledge focused on the nature, conditions, and extent of human knowledge" (p. 89). Virtue epistemologists, one group of philosophers who study intellectual ethics, consider virtues (e.g. benevolence, courage, justice, etc.) and vices (e.g. deceit, intellectual cowardice, etc.) to be crucial for understanding the full range of human epistemic activities (Zagzebski, 1996). These virtues can be regarded as reliable processes (in the case of virtues) and unreliable processes (in the case of vices) for producing knowledge, good scientific models, or the like. Educational research can illuminate conditions under which different virtues such as open-mindedness are conductive to developing knowledge (Sinatra & Chinn, 2011). Research could investigate how individuals, groups, and cultures differ in their ideas about epistemic virtues and vices.

## A LAST WORD

In this chapter, we have striven to provide a sampling of philosophical ideas that are relevant to EC research. We have discussed several philosophical critiques of EC research. We have also discussed a framework for EC research that we believe to be well-supported by philosophical scholarship, as well as by educational research. We have argued that philosophical scholarship warrants the study of the AIR components of EC: aims and values, epistemic ideals, and reliable epistemic processes. We have argued further that philosophical scholarship supports treating epistemic cognition as thoroughly social, situated, enacted through practical reasoning, and closely connected to ethical issues. The philosophical references cited in this chapter encompass a broad range of excellent work containing many ideas that can be fruitful for EC research. In part, this chapter can be viewed as a call to EC researchers to explore contemporary philosophical work more fully, through reading relevant literatures and engaging more with philosophers, at conferences and other scholarly venues, within the review process, and perhaps even on joint projects. We are confident that the benefits of future collaborations will flow in both directions.

## ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1008634. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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# 29

# THOUGHTS ON KNOWLEDGE ABOUT THINKING ABOUT KNOWLEDGE

*Gale M. Sinatra*

No, that title is not meant to be a tongue twister. Perhaps it is a meta-meta idea. This chapter contains my reflections on the field of *epistemic cognition.* In other words, what *I think* about what *researchers think* about what *individuals think* about knowledge. That needs a bit of unpacking. The study of epistemic cognition is indeed a bit difficult to unpack. The chapters in this section of the *Handbook of Epistemic Cognition* on measuring and modeling epistemic cognition well illustrate the challenges and the promise of efforts to think about and study what individuals think about as they think and study.

As seen in the chapters in this section, unpacking these nested ideas might very well be accomplished by expanding the research on epistemic cognition to include motivational, metacognitive, and conceptual change processes. Clark Chinn and I (Sinatra & Chinn, 2011) made this argument when we called for educational psychologists to expand their perspectives on epistemic cognition by looking to science educators who had already taken a "broader view of epistemic cognition" (p. 262). This view came from efforts to understand the nature of science (Khishfe, 2008; Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) and was grounded in work by philosophers, historians, and sociologists of science. We noted that, "rather than focusing on knowledge and justification narrowly conceived, this work focuses on a wider variety of epistemic phenomena developed by scientists (experimentation, theories, hypotheses, etc.) and inquiry practices engaged in by scientists (experimentation, theory choice processes, how ideological and personal interests affect theories, and so on)" (Sinatra & Chinn, 2011, pp. 261–262). It is clear that the field of epistemic cognition is now moving towards considering a broader range of epistemic practices. The contributors to this section have broadened their views to include constructs such as motivation, metacognition, and emotions. I have examined epistemic motivations as well (Sinatra, Kardash, Taasoobshirazi, & Lombardi, 2012), and more recently, I have studied epistemic emotions (Muis et al., 2015). While this broadening is productive, it does raise the question: *How can the field expand and also clarify the definition of epistemic cognition, particularly given the need to incorporate epistemic* *practices, which are central to this construct?* As noted by Barzilai and Zohar (2016/this volume): "demarcating between epistemic and non-epistemic thinking is not a simple task and, to our knowledge, there is currently no consensual definition of the boundaries of epistemic thinking" (p. 413). Epistemic cognition will be a less useful idea if "epistemic" is tacked on to every construct in educational psychology without focusing on clarifying, through empirical work, which processes and practices are truly epistemic in nature.

## PUTTING "COGNITION" BACK IN EPISTEMIC COGNITION

The contributors to this section are addressing methodological issues with measuring epistemic cognition. However, first, it is necessary to consider construct definition issues. That is, what exactly is it that epistemic cognition researchers are trying to measure? It is difficult enough to construct sound methods of measuring psychological constructs that are fairly well defined. But developing measures for fuzzy constructs compounds the challenges and increases the noise.

Many of my colleagues and I have raised issues regarding the challenges of both defining and measuring epistemic beliefs (see, for example, Hofer & Sinatra, 2010). So, I will not reiterate a laundry list of those concerns here. Instead, I will pivot to a current definitional challenge, which is how to distinguish epistemic beliefs from epistemic cognition. Epistemic beliefs and epistemic cognition are woefully conflated in the current educational research literature. Perhaps this is because some researchers see no difference between these constructs. In my view, beliefs and cognition are not the same construct any more than knowledge and thinking are the same construct. Beliefs and knowledge are the contents of cognition, but cognition is fundamentally a *process*. Therefore, when researchers refer to epistemic cognition, they are referring to a process. As Mason (2016/this volume) reminds the field, developmentalists consider "thinking skills and representations about knowledge to be closely linked" (p. 376). To be sure, the epistemic cognition process invokes or draws upon learners' beliefs, schemas, mental models, resources, frameworks, or other contents of their cognition but, fundamentally, it is the process of epistemic cognition that must be captured if researchers and practitioners are to realize the potential of this construct.

This distinction between epistemic beliefs and epistemic cognition is important, and it is not being addressed with rigor in the field, which I believe is a concern. Some chapters in this section do not specifically differentiate epistemic beliefs and epistemic cognition (e.g. Chen, 2016/this volume; Murphy & Alexander, 2016/this volume), while others argue "personal views about knowledge should not be confounded with disciplinary inquiry into knowledge" (see Kelly, 2016/this volume, p. 394). A key difference, as I see it, is that epistemic beliefs describe the contents of cognition, which are relatively stable over time, whereas epistemic cognition describes a process, which is inherently dynamic in the moment, and also changes over time. Of course educators hope, and some have also demonstrated, that epistemic beliefs can and do change over time and through development (Kuhn, Cheney, & Weinstock, 2000; Muis & Duffy, 2012). However, in a particular moment, individuals have a set of beliefs, resources, or conceptual knowledge that they bring to bear on the learning situation or environment. Unless that learning situation spans a significant time frame (e.g. a semester of college, as in Muis & Duffy, 2012), beliefs about knowledge are unlikely to change significantly during the learning moment. There are, of course exceptions, and I can imagine a brief intervention that might shift someone's beliefs about the nature of knowledge within a single lesson, but without a targeted and carefully crafted intervention designed to promote change, spontaneous epistemic belief change is not highly likely to happen quickly and unprompted.

In contrast, cognition, and therefore, epistemic cognition, is by definition a highly dynamic process that unfolds and changes during the learning process. Epistemic cognition is not a variable, but rather describes the process of thinking that draws on beliefs and knowledge to reason, problem solve, or make decisions (see Hofer, 2016/this volume; Iordanou, Kendeou, & Beker, 2016/this volume; Moshman & Tarricone, 2016/this volume). The components of that process, and the mechanisms that drive the process, are precisely worth the effort to unpack.

The chapter by Chinn and Rinehart (2016/this volume) meets this definitional challenge head on. They begin by providing their definition of epistemic cognition: "*Epistemic cognition* is cognition directed at epistemic aims" (p. 461). Note that they make the explicit claim that epistemic cognition is indeed "cognition" and while this may seem obvious or even redundant, it bears emphasizing because it is *the process of thinking* that is at the heart of epistemic cognition. The rest of their definition (i.e. epistemic cognition is about epistemic aims) is open for debate, but fundamentally, I believe they are on the right track to emphasize the process of cognition in their definition.

Now, consider the next part of their definition, that of epistemic aims. One aspect of the content of epistemic cognition, according to Chinn and Rinehart (2016/this volume), is epistemic aims, which they define as "goals related to developing some sort of representation of how the world is—of developing a cognitive "take" on the world"[1] (p. 461). They then ground this idea within philosophical thinking about the goals individuals have for developing and evaluating knowledge, and the products of knowledge (i.e. claims and evidence).[2]

A key contribution of Chinn and Rinehart's chapter is that they call for epistemic cognition researchers to broaden their perspectives on epistemic beliefs and epistemic cognition by turning to the philosophical roots of epistemology itself, noting, "the scope of epistemology is much broader than educational researchers have considered" (Chinn & Rinehart, 2016/this volume, p. 463). Educational researchers' definitions of epistemic beliefs and epistemic cognition have been narrow in comparison to the breadth of philosophical epistemology (e.g. epistemic aims), such that even the process aspects of cognition have gone largely underexplored, or in some cases, ignored all together (for a notable exception see Greene, Azevedo, & Torney-Purta, 2008).

Similarly, considering epistemic aims as motives broadens the perspective of epistemic cognition researchers further. Chen and Barger (2016/this volume) note that, "as the field has expanded from conceptualizing a set of personally held beliefs about knowledge to a broad spectrum of cognitive processes related to knowledge seeking, motivation has implicitly been folded into the framework of epistemic cognition" (p. 432). More specifically, they describe students' mastery goal orientations as consistent with the epistemic aims and epistemic values of seeking out knowledge, understanding events, and the desire to confirm or disconfirm hypotheses. It seems both Chinn and Rinehart and Chen and Barger are looking for more ultimate causes (e.g. aims, motives, goals) for more proximate activities (e.g. seeking and evaluating information).

If epistemic cognition is broadened as these contributors suggest, then the overly narrow descriptions of epistemic cognition as dichotomized beliefs (i.e. beliefs that knowledge is either simple or complex, either certain or uncertain, either changing or unchanging) along polarized dimensions, as reflected by self-report, Likert-type epistemic beliefs measures, will not be able to capture the breath of the construct. The practice of relating self-reported beliefs to learning outcomes has been criticized in the past (see Hammer & Elby, 2002), but of late, it has again come under serious scrutiny. For example, Graesser (2015) expressed concerns both about using self-report measures, and about studies that rely exclusively on correlating self-report measures. I am arguing that to realize the potential of epistemic cognition research for education, the field must mature, and with such maturation will come more careful construct definitions. Researchers must move towards defining and capturing the process of epistemic cognition in action in more nuanced ways than dichotomized belief dimensions. For it is in this effort that the promise of epistemic cognition may be realized. In the next sections, I discuss these and other challenges with epistemic cognition measurement that are highlighted by the contributors to this section.

### *Measurement Issues Highlighted in Section v*

The chapters in Section V bring to the fore several measurement issues that have plagued the field for some time, and a few new issues that have reached a turning point. Next I discuss several of these issues and how the contributors shine a light on these challenges and, in many cases, offer unique solutions.

### *Moving beyond Self-Report and Categorical Dichotomies*

As mentioned, self-report of psychological constructs is currently under fire. The editors of the top journals in educational psychology have come out against the exclusive reliance on self-report to measure constructs such as epistemic beliefs (see for example, Graesser, 2015). The history of challenges with the reliability and validity of self-reported Likert-scale surveys of epistemic beliefs has been extensively discussed (e.g. Greene & Yu, 2014; Hofer & Sinatra, 2010; Muis, Bendixen, & Hearle, 2006; Sinatra & Chinn, 2011). In her chapter, Mason (2016/this volume) notes that the problems with self-report surveys call into question the very conclusions drawn from research using these measures.

I am not suggesting this has been an unproductive line of research. I have employed self-report measures in my own research and do see the value of continuing to do so. I believe that self-report measures have an important role to play in psychological research. For some constructs, such as self-efficacy, researchers really do want to know individuals' views; and in cases where they have no particular motivation to misrepresent those views, these measures can be informative. And as Mason reminds us, Greene et al. (2008) point out that self-report Likert scales can have utility when researchers consider patterns of responses to many items designed to measure psychological constructs, especially when sample sizes are large.

However, it is not necessarily the concern that individuals tend to misrepresent their views about knowledge that plagues epistemic belief research, but rather, as has been frequently noted by those calling attention to this issue, it is that by asking individuals to reflect on the nature of knowledge, the survey itself may be prompting individuals to do something they do not normally do: make explicit their often tacit epistemic cognition (Sandoval, 2005). Thus the measure is not necessarily assessing explicit, long-held beliefs or prior ways of applying those beliefs to learning situations, but rather it is assessing a view that was constructed on the spot. Thus, it is easy to see how quickly constructed responses may or may not relate to individuals' actual thinking and reasoning on the current task, or to past learning situations, creating a challenge for both reliability and validity of inferences from scores on these measures. This is a problem because often tacit, enacted beliefs about knowledge that impact thinking and learning are precisely what researchers were hoping to ascertain by administering the surveys.

In addition to issues of reliability and validity, there is another vexing problem with self-report surveys of epistemic beliefs. These measures too readily lend themselves to interpretations of knowledge as dichotomized (i.e. simple vs. complex). Many researchers have criticized these interpretations (e.g. Sandoval, 2005). While it is true that Likert-type scales with opposing poles (e.g. certain vs. uncertain) only invite, and by no means necessitate, dichotomized interpretations, all too often, the findings are interpreted dichotomously. This is a concern because knowledge is not certain or uncertain but rather some knowledge is *more certain* (e.g. the spherical shape of the earth) than other knowledge (e.g. the causes of the US war with Iraq). Some knowledge is much *more complex* (e.g. the causes of climate change) than other knowledge (e.g. the current level of ocean acidification). And some knowledge is *well justified* (e.g. the earth revolves around the sun), while other knowledge is less so (e.g. vaccines are linked to autism).

It is not at all unusual that in the infancy of psychological construct exploration, the field simplifies a complex construct by dichotomizing. The nature versus nurture dichotomy in human development spanned decades and produced countless debates at psychological conferences and publications in psychology journals. However, as the field of human development matured, researchers came to understand that it had been a false dichotomy all along, and that all development is the result of an interaction between genetics and the environment.

There have also been repeated calls to move away from dichotomizing beliefs into value-laden bins such as "sophisticated" and "naïve" (cf. Sinatra, Kienhues, & Hofer, 2014). In this volume the calls persist. Murphy and Alexander note that, "the overly simplistic depiction of [epistemic beliefs] as either naïve *or* sophisticated … obscures the often long-term and nonlinear process of transformation that unfolds [in EB development]" (Murphy & Alexander, 2016/this volume, p. 445).

Given that these concerns about self-reported epistemic beliefs and dichotomized views have been raised so many times before, by so many members of the field, why raise them again here? I do this for two reasons. First, researchers in the emerging field of epistemic cognition continue to over-rely on Likert-scale epistemic belief surveys and continue to dichotomize epistemic beliefs despite these calls. It is time to stop giving researchers a pass on these practices. Reviewers and editors should push back more vigorously to nudge the field towards more nuanced conceptualizations of the construct of epistemic beliefs.

Epistemic cognition is still emerging as a field, but more creative measures and methods of analysis must be developed to move the field forward. Several examples of these can be seen in the chapters in this volume. Mason (2016/this volume) reviews traditional paper and pencil measures, but also approaches using interviews and vignettes. Barzilai and Zohar (2016/this volume) analyze students' verbalizations for their epistemic content, and Kelly (2016/this volume) uses discourse analysis to examine patterns of epistemic thinking embedded within a social learning context.

A second and perhaps much more critical reason to raise the red flag again regarding Likert scales and dichotomous classification schemes is that these do not capture epistemic cognition well. A Likert scale is unlikely to measure the dynamic process of epistemic cognition, or document the process of thinking and reasoning about knowledge, or capture the richness of such cognition. Rather, researchers should look to fields such as self-regulation (Greene, Muis, & Pieschl, 2010) and engagement (Azevedo, 2015) for methods designed to capture *processes* such as the use of log traces of students navigating on-line learning environments, data mining, and learning analytics (Gobert, Baker, & Wixon, 2015; Winne & Perry, 2000). Researchers should also look to tasks that require critical evaluation of evidence and models (Chinn & Buckland, 2012; Lombardi, Sinatra, & Nussbaum, 2013). Epistemic cognition researchers could learn from those who employ classroom observations to measure engagement, and thinking is needed on how such observations could be used to capture epistemic cognition (Renninger & Bachrach, 2015; Ryu & Lombardi, 2015). These methods and others designed to drill down into processes are more likely to prove fruitful for understanding epistemic cognition than Likert scales.

### *Moving towards Measuring Epistemic Practices*

If it is time to move away from static, dichotomized conceptualizations and self-report measures, then what should the field move toward? I suggest it is time to focus on defining and measuring *epistemic practices*, as my colleagues and I have been calling for (Chinn & Rinehart, 2016/this volume; Greene & Yu, 2014; Kelly, 2016/this volume; Sinatra & Chinn, 2011). This is a focus on how individuals use their epistemic beliefs and conceptions of knowledge in reasoning, problem solving, and decision-making. As Chinn and Rinehart (2016/this volume) argue, "developing epistemic cognition is less a matter of developing a few sophisticated beliefs and more a matter of mastering a large and integrative network of causal epistemic processes" (p. 471).

Chinn and Rinehart's chapter is a primer on how and why this move toward measuring epistemic practices may prove more fruitful than a sole focus on beliefs. They propose the AIR model of epistemic cognition and describe its three components, aims (and values), ideals, and reliable epistemic processes. With aims and ideals, Chinn and Rinehart are foregrounding the importance of goals in epistemic cognition. This is fundamental because it emphasizes not just the content of cognition, but also the active, intentional, and goal-directed nature of epistemic cognition. This model also brings in individuals' values regarding knowledge, which are often ignored in the study of epistemic cognition, but as Chinn and Rinehart note, "understanding people's differing values is part of understanding differences in epistemic cognition" (p. 468). Chen and Barger (2016/this volume) also relate epistemic thinking to goals through their analysis of the motives that drive epistemic thinking as well as the values individuals hold for engaging in activity, noting that individuals may engage because they value the activity, because of its utility, or because it is of interest to them.

Chinn and Rinehart (2016/this volume) also discuss ideals, or the criteria by which knowledge is evaluated (e.g. whether there is empirical support for a proposition). Barzilai and Zohar (2016/this volume) recognize the role of epistemic standards (i.e. ideals) as individuals reflect on epistemic aims. Again, critical evaluation is fundamentally an ongoing, dynamic, cognitive process, not a set of criteria that remains static over time for a learner. Finally, Chinn and Rinehart (2016/this volume) emphasize that knowledge produced by reliable processes is more likely to be well justified than knowledge produced by unreliable processes. Again, the active and dynamic process of knowledge justification, as an epistemic practice, is emphasized throughout the components of the AIR model.

Kelly's chapter presents a different approach to how researchers conceptualize and measure epistemic practices, but practices are at the core of this contribution. Kelly takes a sociocultural approach that examines how students acquire the epistemic practices of a discipline, such as science, through social engagement. Kelly defines epistemic practices somewhat differently than Chinn and Rinehart as, "the socially organized and interactionally accomplished ways that members of a group propose, communicate, assess, and legitimize knowledge claims" (p. 395). This shifts the focus towards knowledge as a social construction, however, like Chinn and Rinehart, it reflects the dynamic constructive nature of epistemic cognition.

Finally, the practice of knowledge justification is an epistemic practice that warrants much further study. The practice of justifying claims as knowledge, how to determine which sources of information to trust, and how to evaluate others' knowledge claims, is critically important in this current era of strong pushback from the public on scientifically grounded knowledge, as seen in the climate change denial and anti-vaccination movements (Sinatra & Chinn, 2011; Sinatra, Kienhues et al., 2014).

### *Contextualizing Measurement of Epistemic Cognition*

Another productive direction for future research on measurement is to contextualize epistemic cognition. Chinn and Rinehart (2016/this volume) caution against categorizing people as "relativists" or "multiplists" without evaluating the context or situation. Thus, they argue, epistemic cognition is contextually bound. Kelly (2016/this volume) describes epistemic practices as "situated in time, space, social practices, and cultural norms" (p. 397). Mason (2016/this volume) has examined epistemic cognition within specific scenarios about controversial topics. This call for a contextualized view of epistemic cognition goes well beyond prior work that has emphasized the domain-specificity of epistemic beliefs (cf. Muis et al., 2006). Rather, this is a call for examining epistemic practices as Kelly (2016/this volume) described "in situ" or "in settings where issues of knowing are at stake and in play" (p. 394). Examining epistemic cognition situationally sheds new light on how individuals acquire the epistemic practices of a discipline, such as science, through language, argumentation, and sense making in the moment.

Murphy and Alexander (2016/this volume) illustrate, through analysis of students' transcripts during discussions, the thoughtful reasoning of students as they engage with text, and how they weigh their views against those expressed by their peers as well as the content of the text. Barzilai and Zohar (2016/this volume) also examine the epistemic content of students' discourse for the thoughtful, reflective, metacognitive facets of epistemic thinking. Importantly, they recognize and acknowledge that not all epistemic thinking is reflective or metacognitive, and not all metacognition is epistemic in nature, important distinctions to keep in mind. These approaches have promise for examining epistemic cognition in context; however, one challenge is replicability. It may be difficult for others to replicate these methods without specific information on how to enact these discourse coding schemes and information on their reliability and validity.

Mason (2016/this volume) also describes efforts to meet the challenges of a "more contextualized measurement" of "epistemic beliefs in action" (p. 386). She and her colleagues have employed think-aloud methodology to examine which epistemic beliefs are brought into the service of epistemic cognition as students evaluate the trustworthiness of online information about controversial topics such as the health risks of cellphone use. Chinn and Rinehart (2016/this volume) also recommend the use of scenarios to provide the context needed to interpret their perspectives. They note "instead of examining whether people are relativists in general, educators should investigate the range of situations … that elicit relativistic responses and those that do not" (p. 466). In these cases, the goal is to go well beyond prior debates regarding the degree of domain generality versus specificity, which as Murphy and Alexander (2016/this volume) note have largely been settled, to examine the *process* of epistemic cognition in action as one thinks and reasons about knowledge within and across specific contexts and disciplines.

### *Expanding Conceptions of Epistemic Cognition to Include Motivation, Metacognition, and Conceptual Change*

One of the most intriguing aspects of epistemic cognition is exploring how thinking about knowledge influences and is influenced by other constructs such as motivation and emotion (Sinatra, Broughton, & Lombardi, 2014; Sinatra, Kienhues et al., 2014). Chen and Barger's chapter (2016/this volume) is devoted to the intersection of motivation and epistemic beliefs. They note that "epistemic beliefs give rise to students' motivation" (Chen & Barger, 2016/this volume, p. 428) but it seems just as likely that motivations give rise to epistemic cognition. Perhaps, as the field moves forward, the research agenda will be less about interactions among these constructs and more about how epistemic cognition is inherently a motivational, metacognitive, and conceptual change process.

In our review of the motivated reasoning literature (Sinatra, Kienhues et al., 2014), we discussed how individuals might process information more critically (e.g. finding flaws in a research design) when that information conflicts with a desired conclusion, or conversely, how individuals may be more reflective and willing to weigh both sides of an argument when they are motivated by accuracy goals (Kunda, 1990). Researchers clearly need to know more about the mechanisms at play when motivations, epistemic beliefs, and epistemic practices intersect, as well as the directionality or causality of these mechanisms on outcomes. The field also needs more fine-grained analyses of motivational constructs at play in epistemic cognition. For example, how does high versus low self-efficacy or high versus low task value impact an individual's thinking and reasoning about knowledge? Chen and Barger (2016/this volume) are clearly working towards fleshing these interactions out in their contribution. They note how beliefs about knowledge drive goal orientations towards knowledge, which then interact with individuals' self-efficacy, determining whether or not they are successful in meeting their epistemic goals. Their perspective helps explain why, when examined on their own, epistemic beliefs may be inconsistent predictors of outcomes. Chen and Barger have begun to articulate how motivation and epistemic cognition interact in important ways, and much remains to be done in this area.

There is little doubt that epistemic cognition is also interwoven with thinking dispositions and this has been well documented by several researchers (for an overview of this work see Stanovich, 2010). Thinking dispositions such as whether one is impulsive or reflective, or high or low in need for cognition, do matter and do relate to how one thinks about and with knowledge (Sinatra, Southerland, McConaughy, & Demastes, 2003). Individuals must be willing, either dispositionally or situationally, to do the heavy lifting that metacognitive, motivated epistemic reasoning requires. Higher levels of willingness to think deeply have been associated with a greater degree of acceptance of scientific explanations (Sinatra et al., 2003) and it seems likely that higher levels of willingness would be associated with higher levels of epistemic cognition.

It is also important that just as the field of conceptual change moved beyond the cold cognition view (Pintrich, Marx, & Boyle, 1993; Sinatra, 2005), so too must the field of epistemic cognition more fully explore motivations, as Chen and Barger (2016/this volume) have begun to do, as well as emotions. As can be seen in some of these chapters (Barzilai & Zohar, 2016/this volume; Chinn & Rinehart, 2016/this volume), both motivation and emotions play an important role in thinking about knowledge. Murphy and Alexander (2016/this volume) concur and note "the path to transformations in knowledge and ways of knowing that does not pass into the terrain of human emotions and motivations is far less likely to reach the level of examined understanding that we envision as necessary for deep or enduring changes in both knowledge and beliefs" (p. 450). This suggests that motivations and emotions influence the depth of processing and the degree of engagement needed for developing one's epistemic cognition.

The research on academic emotions (Pekrun & Stephens, 2012) has demonstrated that emotions are not only a part of learning; they are also directly influential in how and whether learning occurs at all. This research has led to the study of epistemic emotions or emotions "caused by the qualities of task information and the processing of that information" (Muis et al., 2015, p. 169). Muis et al. (2015) demonstrated that epistemic emotions, such as curiosity and surprise, influenced the type of learning strategy students used when studying conflicting texts about climate charge. Further, epistemic emotions mediated the relationship between epistemic beliefs and learning outcomes. Barzilai and Zohar (2016/this volume) discuss the impact of these epistemic emotions when individuals are aware they are feeling them. They note that these "epistemic metacognitive experiences" (Barzilai & Zohar, 2016/this volume, p. 415) can influence epistemic judgments, both when individuals are aware of them and when they are not. More studies that directly examine these interactions will help elucidate the role of motivational and emotions in epistemic cognition and help refine the expanding definition of epistemic cognition.

### *Measuring Growth and Change*

The final measurement challenge that is highlighted by these chapters is that of documenting epistemic cognition growth and change. Murphy and Alexander (2016/this volume) devote their chapter to the connections between epistemic cognition and conceptual change. This is something that I have also explored in discussions of what Clark Chinn and I call *epistemic conceptual change* (Sinatra & Chinn, 2011), or the process of changing one's conceptual understanding of the nature of knowledge and knowing. Similarly, Murphy and Alexander (2016/this volume) discuss how individuals come to have "epistemic competence" (p. 440). They argue that the goal of change is to become more reflective. Key to advancing this perspective will be to identify what it is that changes as an individual becomes more reflective and acquires greater epistemic competence. While evidence of reflection can be clearly seen in the Quality Talk transcripts, less obvious is what changes, either conceptually or epistemically, as the result of such reflection.

Chinn and Rinehart might argue that what changes are individuals' epistemic stances. They have begun to articulate this in both their theoretical and empirical work (Chinn, Rinehart, & Buckland, 2014). Specifically, they note that epistemic competence involves a change in individuals' views about authoritative sources of knowledge, uncertainty, and realism, toward a more nuanced perspective on these aspects of knowledge. Barzilai and Zohar (2016/this volume) might argue that what changes is both individuals' epistemic metacognitive skills and knowledge as well as how reflective and metacognitively aware they are. The nature of these changes in one's conceptual understanding of knowledge, or epistemic conceptual changes, will need to be more fully explored by studying epistemic growth and development.

Next, what mechanisms promote epistemic change? Murphy and Alexander identify a potential catalyst in epistemic doubt (see Bendixen & Rule, 2004). Doubt can be a catalyst for intentional conceptual change (Sinatra & Pintrich, 2003), but not all change stems from doubt and not all change is intentional and reflective. However, it may very well be that epistemic conceptual change requires intentional reflection. Murphy and Alexander note that such reflection is metacognitive and strategic, as Muis has also demonstrated in her work on the self-regulation of epistemic change (Muis, 2007, 2008).

Barzilai and Zohar emphasize this reflective aspect of epistemic metacognition in their chapter (see also Hofer & Sinatra, 2010). Barzilai and Zohar explain that students need to not only understand epistemic norms but also engage in strategies that apply these norms. Therefore, in order to understand how epistemic thinking develops, it is also necessary to examine its strategic or practical aspects, or what others call epistemic practices. Furthermore, they argue that "distinguishing between the cognitive and metacognitive levels of epistemic thinking is necessary for explaining the capacity for reflecting on, criticizing, and improving epistemic practices" (Barzilai & Zohar, 2016/this volume, p. 412; see also Chinn & Rinehart, 2016/this volume; Kelly, 2016/this volume). In other words, researchers must examine what changes as individuals acquire and develop these epistemic and meta-epistemic skills and practices.

## META-META-META REFLECTIONS

In the opening of this chapter, I warned that this chapter contained my reflections about the contributors' reflections about individuals' reflections, which is a nested problem. I argued that despite the complexity of such a meta-meta-meta activity the endeavor may be worth the effort. In terms of where to start, I believe researchers in the field of epistemic cognition have to meet the challenges of construct definition by refocusing on the "cognition" in "epistemic cognition." I think it is imperative that these researchers meet the measurement challenges of moving away from self-report and towards documenting epistemic practices. I also argue that these chapters illustrate that researchers must move towards examining how epistemic cognition is inherently motivational and metacognitive in nature, and that its development is a process of epistemic conceptual change as Sinatra and Chinn (2011) conceptualized. Finally, researchers must look at epistemic cognition in context and consider what changes during epistemic growth and development, and researchers must be diligent in their search for the catalysts of change.

If members of this field indeed come to a better conceptual understanding of epistemic cognition, and they overcome the measurement challenges creatively, as the scholars in this volume have endeavored to do, then it is likely that this field will find that unpacking the complexity of epistemic cognition will indeed have proven worth the effort.

## NOTES

1 Note they do not claim this as their own original definition but rather that of Catherine Elgin.
2 However, it is possible to also consider aims, which are goals, to be motivations a la Chen and Barger (2016/this volume).

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# Section VI

## Future Directions for Epistemic Cognition Research

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# 30

## REFLECTIONS AND FUTURE DIRECTIONS

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Regardless of the terminology used, the chapters in this Handbook all converge upon a common point: epistemic cognition matters. As the modern world becomes more and more complex, it creates an ever-greater press for knowledge, something known from which people can begin to explore the questions that have not been answered, yet. Epistemic cognition is needed to sift through the vast amount of information encountered in the world to separate the justified claims from the questionable assertions, the reliable processes from the untrustworthy practices, and the availing beliefs from the recalcitrant dogma. People make myriad decisions each day based upon the results of previous acts of epistemic cognition (e.g. "I know that if I deposit money in this bank, it will be there to withdraw when I return" or "I know this finding was published in a journal I trust, so I do not need to verify it myself"). The great irony in epistemic cognition research is that the feeling of certainty, this sense of knowing what is and will happen in the world, is a necessary, frequent, often tacit everyday experience that nonetheless beguiles those who attempt to make explicit how or why that sense comes about. The research problem, and its importance, are both clear: effective epistemic cognition is necessary to navigate the complexities of the modern world, but how does it develop, what form or forms does it take, and how does it vary across the contexts in which people act?

The chapters in Section I of this Handbook make strong arguments for the developmental origins of epistemic cognition in children's initial attempts at logic, argument, and understanding others. Such youthful evaluations, of testimony from others and perceptions of the world, evolve into the tacit knowledge, beliefs, and practices that young children invoke in formal and informal learning environments. Reliable processes that work for young children (e.g. direct perception, asking for help from parents) become less reliable as these children age and face more complex challenges (e.g. "This website looks very professional, does that mean the information is trustworthy?" or "Whose testimony should I believe regarding climate change?"). The authors of psychological models of epistemic cognition have focused upon how children's initially viable beliefs about their world, which some researchers argue are knowledge is simple, certain, and taught to me by adult authorities, shape and are shaped by exposure to education and learning, how they develop along with maturing cognitive complexity, and how they predict learning outcomes.

Disciplines form as humans coalesce around each other and their ideas, and knowledge and normative practices emerge. As shown in the chapters in Section II of this Handbook, novices to disciplines experience varying degrees of disconnect between their "folk" knowledge and practices and those that others have deemed normative. Such disconnects require educators who are willing to help these novices acquire the tools for critical reflection and participation in these disciplines, such as science, history, mathematics, and literature. As the authors in this Section describe, education for greater expertise in the disciplines, and the transfer of expert-like practice to authentic settings, is no easy task.

The chapters in Section III make clear that epistemic cognition is not solely the province of formal educational environments or disciplines. The dynamic interactions between contexts, and their norms, can lead to both examined and unexamined consequences for how people engage their epistemic cognition, or not. Differences in epistemic cognition between formal and informal environments can shed light on the phenomenon itself, and how it shapes, and is shaped by, context. As argued in Section IV, without an understanding of the developmental origins of epistemic cognition, or the social, contextual, and disciplinary forces that shape its nature and expression, interventions designed to guide such development are likely underspecified. To truly understand the effects of epistemic cognition interventions, researchers must develop ways of assessing both short-term and long-term changes in people's views, behaviors, and understanding. Understanding epistemic cognition, and its development, requires efforts such as those outlined in Section V, including careful measurement that is informed by thoughtful conceptualization of the phenomena. Necessarily, these conceptualizations should be aligned with, and differentiated from, other factors affecting the human experience, both in terms of the products (e.g. knowledge versus other kinds of propositions) and processes (e.g. source evaluation versus need for closure) of epistemic cognition. Such conceptualizations would benefit from incorporating work across the many academic disciplines in which scholars are studying epistemic cognition.

When we decided to bring together authors who spanned psychological, disciplinary, and philosophical views of epistemic cognition, we knew some authors would be surprised to find their work characterized as epistemic cognition, and some authors may be even more surprised to see others' work characterized similarly. We believe the multi- and interdisciplinary scope of this Handbook is one of its greatest strengths. Taken together, the chapters in this Handbook advance the field's understanding of how epistemic cognition has been conceptualized, the diversity of cognitive processes related to and drawn on by epistemic cognition, and the cultural, social, and situational factors that influence epistemic cognition as it occurs across diverse contexts. At the same time, the chapters in this Handbook clearly illustrate that there is much that is not yet known about epistemic cognition. In this last chapter we reflect upon four salient issues: the proliferation of terms with some form of the adjective "epistemic" attached, key similarities and differences between domain-specific and situated views, how changes in epistemic cognition occur over time, and what epistemic cognition is and is not. We conclude this chapter with a multi- and interdisciplinary call for more collaborative research into epistemic cognition, and its effects, across contexts.

## PROLIFERATION OF TERMS

One noticeable trend in the literature is the increase in the number of terms that researchers have used to describe aspects of epistemic cognition, or the contexts and factors that interact with it. Alexander (2016/this volume) has called this the "epistemic lexicon" (pp. 98). Attaching the adjective "epistemic" to phenomena implies that there is something qualitatively different about their epistemic versions as compared to the non-epistemic ones, for example "epistemic emotions" have been differentiated from other "academic emotions" (Pekrun & Stephens, 2011). Some researchers have questioned whether so many terms are needed, or whether there is utility in differentiating "epistemic" versions of constructs and phenomena (e.g. Barzilai & Zohar, 2014; Hofer & Bendixen, 2012).

In this Handbook, we counted over 100 different variations of "epistemic" or "epistemological" terms (see Table 30.1 for a partial list). While we continue to believe that the field benefits from divergent thinking and research on what epistemic cognition is, we recognize that it is equally important to investigate the utility of these terms, and cull the ones that are synonymous, do not prove useful, or are not substantially different than the phenomena without the "epistemic" adjective. After carefully reviewing each chapter in this Handbook, and consulting other work in the field, we have identified four categories of "epistemic" *something* terms (see Table 30.1). This review does not include terms used to describe the field overall (e.g. epistemic cognition, epistemic beliefs, epistemological beliefs, personal epistemology), or epistemic development or change, as these terms have been discussed well elsewhere (e.g. Bendixen, 2016/this volume; Bråten, 2016/this volume; Hofer & Bendixen, 2012; Kitchener, 2002; Sinatra, 2016/this volume).

### *Processes, Products, and Standards*

Barzilai and Zohar (2014, 2016/this volume) have argued that the field we are calling epistemic cognition is better described by a more omnibus term, epistemic thinking, which is comprised of two aspects: epistemic cognition and epistemic metacognition. They show how various phenomena within the field of epistemic cognition could be conceptualized as cognitive or metacognitive processing focused upon the epistemic. Many authors in this Handbook use language from models of cognition and metacognition (e.g. Flavell, 1979; Nelson & Narens, 1994) or self-regulated learning (e.g. Winne, 2001) to describe how people think about epistemic issues. For example, metacognitive processing language, such as that described by Winne (2001), can also be used to posit how epistemic cognition occurs: when a person's monitoring of content (e.g. a text) results in the recognition of an epistemic issue (e.g. is this text a reliable source for knowledge?), the person enacts epistemic activity, processing, or reasoning (e.g. evaluation of the source of the text) that creates epistemic products or stances (e.g. identifying the author of the text as a reputable researcher in a particular field) that could be compared to epistemic criteria or standards (e.g. reputable researchers are reliable sources for knowledge) to determine whether those products were adequate (e.g. evidence that a text's author is a reputable source is sufficient to resolve the epistemic issue), or in need of further refinement through additional epistemic activity.

The frequent use of terminology and ideas akin to those in models of metacognition or self-regulated learning was in notable contrast to the less frequent, but still salient, use of terminology regarding specific disciplinary practices. Many of the authors in Section II, and some in Section III, either directly or indirectly refer to epistemic norms within disciplines regarding specific reliable practices or processes (e.g. control of variable strategies, historical empathy and reasoning). Kelly (2016/this volume) makes the most explicit case for the need to include such specific reliable practices within epistemic cognition research, from a perspective of viewing knowledge as situated and contextual. More research is needed to determine whether epistemic cognition can be sufficiently modeled using ideas from metacognition and cognition models, and one potential source of misfit could be whether those models can adequately account for discipline-specific reliable processes, epistemic standards, and outcomes.

### *Motivation and Affect*

In the epistemic cognition literature, the factors that can influence the processes and products of epistemic cognition go by many names, such as epistemic aims (Chinn, Buckland, & Samarapungavan, 2011). Chinn and Rinehart (2016/this volume) describe epistemic aims as "goals related to developing some sort of representation of how the world is" (pp. 461). On the other hand, Buehl and Fives (2016/this volume) expand upon this term to include teachers' goals when helping others acquire information, knowledge, or understanding. Whereas epistemic aims seem to have a more contextual or situated aspect to them, the terms epistemic values, virtues, and vices (Chinn et al., 2011) and epistemic or epistemological dispositions (Buehl & Fives, 2016/this volume; Lee, Goldman, Levine, & Magliano, 2016/this volume) imply a more person-centered, stable proclivity to view knowledge and knowing in particular ways (e.g. need for closure, absolutism). Clément (2016/this volume) argues for a seemingly even more person-focused and stable aspect of epistemic cognition in his discussion of the epistemic vigilance hypothesis (Sperber et al., 2010), which outlines an innate, biologically based set of epistemic cognition processes. One prominent question is whether epistemic aims, goals, dispositions, emotions, etc., are fundamentally different in kind, frequency, or impact compared to their non-epistemic counterparts (cf. Sinatra, 2016/this volume). Another critical question is the degree to which these factors are maturational versus learned or contextual.

### *"Sophisticated" Epistemic Cognition*

The realization that the "sophistication" of epistemic cognition is more nuanced, and situated, than originally conceptualized (cf. Greene, Sandoval, & Bråten, 2016/this volume) has led to some difficulty determining the proper terminology to describe this idea (Chinn et al., 2011; Hammer & Elby, 2002; Hofer & Bendixen, 2012; Sandoval, 2012). The terms in Table 30.1 reflect this changing view of the optimal forms of epistemic cognition; it is clear that many researchers are no longer willing to characterize particular beliefs, views, or stages as universally "sophisticated." This begs the question of what criteria should be used to judge the adequacy of epistemic cognition both in and between contexts. One emerging idea is that, ideally, people should be able to adapt their epistemic cognition to match the norms of the context in which they enact their thinking (e.g. epistemic adaptiveness). Murphy and Alexander (2016/this volume) refer to this ability as epistemic competence. Such views are promising, but if borne out by research, will require careful consideration of how to teach people to reconcile their own epistemic ideals and standards with those of the various contexts in which they learn and act.

### *Tasks and Contexts*

The increase in terminology used to describe the products, processes, and desired functioning of individuals' epistemic cognition has coincided with an expanding list of ways to describe the epistemic qualities of phenomena outside of the individual, including the epistemic aspects of various tasks and contexts (see Table 30.1). Whether epistemic cognition is enacted or not is likely due in some part to intraindividual factors (e.g. epistemic aims, Chinn, Buckland, & Samarapungavan, 2016/this volume; epistemic awareness, VanSledright & Maggioni, 2016/this volume). Nonetheless, many researchers have developed terms to differentiate tasks that seem to require epistemic cognition (e.g. evaluating the reliability of multiple conflicting sources to construct an argument) from those that seem less dependent upon epistemic cognition (e.g. memorizing the acronym PEMDAS for order of operations in mathematics). As researchers explore how epistemic cognition varies, or not, across tasks, it will be important to document and account for the intended, and unintended, epistemic challenges (Barzilai & Zohar, 2016/this volume), demands (Lee et al., 2016/this volume), or character (Elby, Macrander, & Hammer, 2016/this volume) of those tasks. However, we would caution against assuming that tasks with epistemic demands are always desirable, and that those lacking any epistemic character are inherently poor. As Bråten (2016/this volume) discusses, the likelihood of a person successfully traversing the epistemic aspects of a task is dependent upon the person's familiarity with the relevant content and epistemic norms, as well as the context. It seems likely that some minimum amount of declarative and procedural knowledge is needed for epistemic competence in a particular discipline or context.

There have been numerous calls for increased scholarly attention upon the epistemic aspects of contexts, with a similarly numerate list of terms used to capture these aspects (see Table 30.1). Some of these terms refer to the epistemic qualities of disciplines (e.g. epistemic landscape, parameters) while others refer to the physical, psychological, or sociological spaces in which people find themselves (e.g. epistemic climate, community). As Bricker and Bell (2016/this volume) discuss, epistemic cognition occurs within and beyond the classroom, and can be very different depending upon context. More research is needed to understand the kinds of epistemic messages that disciplines and contexts send, how they are interpreted, and how they interact in contexts where multiple epistemic systems are salient (Greene, 2016/this volume). Again, the likelihood of enacting epistemic cognition is almost certainly an interaction between intraindividual factors (e.g. epistemic awareness, knowledge of relevant epistemic norms, motivation) and aspects of context (e.g. the clarity of instructions to jurors; Weinstock, 2016/this volume). Researchers need clear terminology that captures the dynamic interaction between what people perceive, what they do, and the ways in which contexts require, support, or dissuade epistemic cognition.

### *Summary of Terms*

Scientific progress involves, among other things, a process not unlike environmental selection, where useful terms and ideas become more prominent, and less useful ones eventually fade away. Nonetheless, some active pruning of terms, including the intentional selection of a particular term to be used instead of a number of others, seems needed. In addition, it seems clear that paradigmatic views of knowledge, put simply as "knowledge in the head" versus "knowledge as the interaction of people and context," would dictate choices among many of the terms in Table 30.1 (see Greene et al., 2016/this volume). Better understanding, and investigation, of these views of knowledge would help to integrate findings from across the disciplines focused upon epistemic cognition.

## LAYERS OF CONTEXTS FOR EPISTEMIC COGNITION

As noted in the introduction to this Handbook and demonstrated throughout many of the chapters that followed, the contextual nature of epistemic cognition is in many ways now taken for granted by researchers. Domain-general models of epistemic cognition have slowly evolved into domain-specific or even task-specific ones, if not fully contextualized ones (Chinn et al., 2011; Hofer & Sinatra, 2010; Muis, Bendixen, & Haerle, 2006; Sandoval, 2016/this volume). Yet, there is a good deal of variability both in the forms of cognition theorized and the phenomena thus identified and studied by researchers interested in epistemic cognition. There are multiple layers of context that can be identified as situations where epistemic cognition occurs and its nature can be variably described. The chapters in the Handbook make clear that researchers are considering these contexts in sometimes quite different ways. Articulating these differences is one way to point to productive directions for research.

### *Multiple, Overlapping Contexts of Epistemic Cognition*

People have cause to think about what they know, whether they can trust some new claim to knowledge, and so on in a wide range of overlapping contexts. It is now quite clear that people's epistemic cognition is sensitive to the differences in these contexts. What such differences mean with respect to the cognitive structures and processes individuals use to navigate their way through these multiple, often overlapping contexts is not well understood.

School is often treated as one context for epistemic cognition, but multiple contributors to this Handbook show that students often experience it as multiple contexts. The chapters on learning in the disciplines show that students often display different forms of epistemic cognition when learning history versus science, for example. Bendixen (2016/this volume) reviews a broad range of research about learning in elementary school that shows how learners construe various contexts during their school day. At the same time, there are aspects of school shared across specific subject matter contexts, perhaps the most important being that school work is often experienced as unrelated to life outside of school.

Bricker and Bell (2016/this volume) provide examples of how students' epistemic cognition can be studied as they move through the contexts of their daily life. They draw attention to the social and cultural aspects of context in ways that emphasize how shifts in context shift the goals people pursue, including epistemic aims. As they suggest, research on epistemic cognition moving forward must find ways to characterize the multiple contexts through which people move, when and how such contexts evoke epistemic aims, and the forms of epistemic cognition people use to meet those aims (Greene, 2016/this volume).

### *Cognitive Processes versus Collective Practices*

One way to consider shifts in context is to examine the difference between individual cognitive processes and collective practice. Kelly (2016/this volume) explicitly frames his focus on epistemic cognition as a feature of collective work, and his frame highlights the ways in which epistemic aims emerge through interaction and how the reliable processes to satisfy those aims are also shaped by the interactions of participants. This cultural psychology perspective shows how individual cognition is, at least partially, responsive to collective activity. As epistemic cognition scholars move toward capturing social features of specific contexts, such as the epistemic climate of a classroom (Muis & Duffy, 2013), researchers must bear in mind that such features are themselves interactional accomplishments achieved by groups of people.

Analyses of interaction can show how individual members of groups can contribute to framing what it means to explain the rock cycle (Rosenberg, Hammer, & Phelan, 2006), to make a good topographical map (Enyedy, 2005), or argue scientifically (Ryu & Sandoval, 2012). Such analyses make individual cognition visible only momentarily, however. The recognition that cognition is contextual and social does not obviate a concern for the individual, cognitive consequences from collective activity. One of the challenges for epistemic cognition research moving forward is to create methods that can link individual cognitive processes and collective practice, to describe and explain their mutual influence in specific ways. Bricker and Bell's (2016/this volume) description of the tendency for research participants to interpret individually oriented tasks as school-like is one challenge to this effort, as it suggests that invoking "natural" epistemic aims during research studies can be difficult.

Related to this is the challenge of synthesizing findings across studies of collective practice or individual processing carried out by different researchers often working from different theoretical perspectives. One way synthesis might be supported would be for researchers to be explicit about the epistemic aims research tasks are intended to trigger, and collect evidence (i.e. a kind of manipulation check) on the epistemic aims participants actually seem to pursue during those tasks. It might then be possible to organize research synthesis around epistemic aims and their pursuits, rather than broader categories of epistemic cognition. That is, the operating epistemic aim might be a fruitful aspect of context to explicate in order to aggregate findings across a range of studies.

### *Knowledge as Contextual*

Research on epistemic cognition inevitably contends with the variability of philosophical and psychological perspectives on the nature of knowledge. These variations abound in the chapters in this Handbook in ways outlined in the introduction. Both Kelly (2016/this volume) and Chinn and Rinehart (2016/this volume) explicitly assert the contextual nature of knowledge, drawing largely from philosophy and sociology of science. Many of the chapters in this Handbook show that epistemic cognition is contextual; that is, how people think about what and how they know is contextualized. These are related but different forms of contextualization, and they frame different questions for research. One question concerns the extent to which people see knowledge as contextual, both their own and others'. Epistemic cognition scholars have long asked about individuals' perceptions of the complexity of knowledge, generally with a focus on tentativeness. Contextuality is a separate facet of knowledge, and there is much more to learn of the extent to which people see knowledge claims as contextual, or what makes them so.

A separate question concerns the obverse of the now accepted contextual nature of epistemic cognition: what aspects of epistemic cognition, or belief, generalize and how? To the extent that research showing the contextual nature of epistemic cognition has cast doubt on extant developmental models and mechanisms, it generates a need for research that can explain what people generalize across the contexts of epistemic cognition they encounter, how such generalization occurs, and what are its consequences for future epistemic cognition.

## EPISTEMIC DEVELOPMENT AND CHANGE

Much current research on epistemic cognition is rooted in Perry's (1970) longitudinal interview studies at Harvard, resulting in a scheme describing the development of students' thinking about knowledge and the process of knowing during the college years. That Perry's focus on development has been retained by several prominent scholars in the field (e.g. Baxter Magolda, 2008; King & Kitchener, 2002; Kuhn, 2001) implies that change has been at the forefront of epistemic cognition research for decades. After all, change is at the heart of any developmental process, with development generally described as "the progressive series of changes in structure, function, and behavior patterns that occur over the life span of a human being" (VandenBos, 2007, p. 274).

When researchers interested in epistemic cognition interventions discuss change, however, they tend to distinguish between epistemic change that may result from interventions and change occurring during epistemic development (Kienhues, Ferguson, & Stahl, 2016/this volume; Muis, Trevors, & Chevrier, 2016/this volume). In doing this, they describe epistemic development as a slow and broad maturational or naturalistic process of change, and the form of change resulting from interventions as a more rapid and specific, more or less enduring, adaptation to environmental influences that does not depend on maturation. This distinction seems problematic for several reasons. First, distinguishing between epistemic development and epistemic change in a way that parallels the distinction between maturation and learning in classic educational and developmental psychology literature (e.g. Cronbach, 1962; Johnson & Medinnus, 1965), with maturation being genetically controlled and learning resulting from environmental stimulation, is problematic because epistemic development to a large extent may depend on systematic, organized schooling, which can hardly be described as being naturalistic or devoid of environmental stimulation. Second, describing epistemic change as independent of maturation seems to overlook the possibility that interventions to change epistemic cognition may be more or less successful depending on the more general developing epistemic thinking of individuals, be it genetically or environmentally determined. Finally, researchers trying to distinguish epistemic change from epistemic development may fail to take into consideration that more rapid and specific changes in epistemic cognition resulting from interventions designed to promote such change may generalize to influence individuals' developmental trajectories as described by Perry (1970) and his successors within the developmental approach (e.g. Baxter Magolda, 2008; King & Kitchener, 2002; Kuhn, 2001). Much further work, conceptual as well as empirical, is thus needed to clarify the relationship between the form of epistemic change targeted by epistemic interventions and the form of epistemic change described by developmentalists, including the possibility for mutual influences between those forms (Sinatra, 2016/this volume). Moreover, the underlying mechanism of change needs to be tested in future experimental (i.e. intervention) work as well as in longitudinal developmental studies.

Several models or mechanisms of epistemic change have been suggested in the literature. For example, Elby and Hammer (2010) described how the activation of fine-grained epistemological resources in a specific context over time may form a stable network with belief-like qualities (i.e. an "epistemological frame") that is typically activated in that context and sometimes generalized across contexts. According to them, such change may involve volition on part of learners but not necessarily result in new epistemic beliefs because much epistemic change consists of the stabilization and generalization of already existing resources.

More widely adopted by epistemic intervention researchers, however (see Section IV), is the mechanism of change proposed by Bendixen and colleagues (Bendixen, 2002; Bendixen & Rule, 2004; Rule & Bendixen, 2010), involving epistemic doubt, volition, and resolution strategies. Whereas this may seem like a plausible way to describe the cogs of epistemic change, Bråten (2016/this volume) notes that this mechanism really needs empirical backing. Thus, there is plenty of room for increased clarity regarding the exact components involved in epistemic change, whether the same components are involved in all forms of change, and whether they need to appear in any fixed order. For example, if different components and different orderings of components may be involved, it is conceivable that the exact nature of the mechanism instigated by an intervention may influence the longevity and generality of the epistemic change taking place. Regarding long-term epistemic development in relation to a more abrupt epistemic change due to specific interventions, it is also highly pertinent to investigate whether the same mechanism of change components are involved or whether there are different mechanisms underlying the two forms of epistemic change. To the extent that the mechanism of change normally unfolding over longer periods of time is merely compressed in shorter time periods during interventions, consistent with Vygotsky's (1978) experimental-genetic approach, the amount of compression could also indicate the endurance and generality of a particular intervention. That is, shorter and less extensive interventions, implying more compression, might lead to more short-lived and specific effects than longer and more extensive interventions, implying less compression. In brief, more attention to the potential mechanisms of change by means of diverse methodologies such as think-alouds, interviews, and observations is needed in both intervention and developmental studies (Mason, 2016/this volume). Moreover, extensive crosstalk between researchers conducting interventions to change epistemic cognition and researchers engaged in longitudinal studies of epistemic development is needed to clarify the nature of the mechanisms of change that are involved in the two settings, as well as the similarities and differences between them.

Regardless of the exact mechanism of epistemic change, the conditions that can set such a mechanism in motion deserve careful attention from researchers. These conditions are summarized by the term "dissonance" in Bendixen's work (Bendixen & Rule, 2004; Rule & Bendixen, 2010), indicating that individuals perceive their current thinking about knowledge and knowing to be out of step (i.e. dissonant) with new information. Moreover, the new information creating such dissonance and, thereby, starting the mechanism of change is typically described in terms of multiple conflicting perspectives on an event, topic, or issue by researchers discussing epistemic cognition interventions (see Section IV). However, as noted by Bråten (2016/this volume), working with multiple conflicting perspectives in educational settings may require adaptive epistemic cognition at least as much as it promotes it, a view consistent with cognitive flexibility theory (Spiro, Coulson, Feltovich, & Anderson, 1994; Spiro, Vispoel, Schmitz, Samarapungavan, & Boerger, 1987) as well as preliminary empirical findings (Bråten & Strømsø, 2006; Jacobson & Spiro, 1995). Thus, while designing and implementing interventions that create sufficient conditions for epistemic change should doubtless be high on the list of priorities among epistemic cognition researchers, using multiple conflicting perspectives as a pedagogical means may not be equally beneficial for all learners. For example, some students may need to build a knowledge base by producing accurate and coherent summaries of important information from single textbook-like sources before they are confronted with multiple conflicting perspectives in a content area, and others may require some additional scaffolded support in multiple perspective contexts (Bråten, Gil, & Strømsø, 2011). Also, teachers may provide scaffolded support by assigning tasks involving work with multiple perspectives that can be completed in groups where less resourceful students participate in discussions and shared writing, or other task-relevant production, with more resourceful peers (Schwarz, 2003). In any case, without designing and implementing epistemic cognition interventions that are differentially adapted to the individual differences of learners, including their epistemic cognition, it is difficult to see how epistemic cognition researchers can translate their work into meaningful educational practice.

## WHAT IS EPISTEMIC COGNITION, AND WHAT IS IT NOT?

Finally, despite our conviction that there are real advantages to resisting the urge to too quickly lay down boundaries, we acknowledge the benefits that would arise by achieving some kind of consensus as to what epistemic cognition is, and is not (Alexander, 2016/this volume; Barzilai & Zohar, 2014; Chinn, Rinehart, & Buckland, 2014; Hofer, 2016/this volume). The proliferation of terms, described previously, and the integration of ideas from developmental psychology, educational psychology, disciplinary education, learning sciences, and philosophy, has made the field of epistemic cognition seem quite large, indeed. Arguments for domain-specificity, and contextuality, of the phenomena suggest that more domain-general conceptualizations of epistemic cognition (e.g. epistemic metacognitive skills; Barzilai & Zohar, 2014) must, at minimum, be supplemented with a bevy of discipline-specific epistemic norms, reliable processes (e.g. control of variable strategies in science, historical empathy) and epistemic ideals (e.g. falsifiability in science, elasticity in history). Studies of epistemic cognition in informal settings suggest important differences from formal settings that should also be captured (Bricker & Bell, 2016/this volume). These findings are one aspect of a larger argument about the situated nature of epistemic cognition (Kelly, 2016/this volume; Sandoval, 2016/this volume). After finishing the chapters in this Handbook, readers can be forgiven for feeling that the scope of the field of epistemic cognition is overwhelmingly, and unmanageably, massive. The desire to draw tighter boundaries around the field is a natural and reasonable one.

Chinn et al. (2014, 2016/this volume) have argued that one way to identify what is and is not epistemic cognition is by determining the individual's epistemic aims, or lack thereof. The argument is that epistemic cognition is a subset of cognition, determined by the nature of the person's aims. Barzilai and Zohar (2016/this volume) have taken a different approach, arguing that epistemic thinking is comprised of cognition and metacognition about the epistemic. This conceptualization allows them to posit how research in cognition and metacognition can inform investigations of what people do and think when the object of their thinking is knowledge, or processes of knowing. Sinatra (2016/this volume) suggests that epistemic cognition is the process, and epistemic beliefs and knowledge, among other things, are the content upon which this process acts. Finally, of course, there continues to be productive work on epistemic cognition as a developmental process (Barzilai & Weinstock, 2015; Iordanou, Kendeou, & Beker, 2016/this volume), as sets of dimensions or theories (Bråten & Ferguson, 2014; Hofer, 2016/this volume), and as contextualized epistemological resources (Danielak, Gupta, & Elby, 2014; Elby et al., 2016/this volume).

Ultimately, the progress of scholarship on epistemic cognition will determine what it is and is not. Each of these conceptualizations, and the many epistemic "*something*" phenomena that populate this Handbook, can and should be pursued through ongoing research. Their viability is an empirical question that will likely require quantitative, qualitative, and mixed methods, and multiple studies, to resolve (Kelly, 2016/this volume; Mason, 2016/this volume). At the same time, productive lines of inquiry, and likely unproductive lines, can be identified through rigorous reviews of the philosophical, psychological, and educational literatures. As we believe this Handbook shows, before any particular subdiscipline or group of scholars makes a decision about what epistemic cognition is or is not, it would be wise to engage in more cross- and interdisciplinary thinking and research.

## CONCLUSION

This Handbook serves as evidence that there is much to be gained from reading broadly across the many academic disciplines that consider epistemic issues and ideas. Directions for new research, and potential explanations of seemingly contradictory findings, can often be found outside of one's own training or focus. At the same time, it is not possible for a single researcher to become an expert in education, psychology, philosophy, and all the other disciplines in which issues of epistemic cognition have become ever more salient. Familiarizing oneself with these literatures is crucial, but pursuing expertise in all of them is folly. Instead, the science of epistemic cognition must depend upon the division of cognitive labor, as all scholarly disciplines do, to synthesize and integrate the collective wisdom of each academic discipline into a larger, and more powerful, epistemic system. Philosophers doing naturalized epistemology would benefit from partnerships with education researchers. Psychologists wishing to describe and predict how laypeople conceptualize knowing should do so while considering the normative efforts of philosophers and disciplinary educators. Education researchers who restrict their scholarly lens to the classroom are likely to have a myopic, and overly contextualized, view of what epistemic cognition is, and how it happens. Colleagues across the disciplines can help each other identify and resolve the expertise blind spots, Gordian misconceptions, and motivated reasoning that challenge everyone who invests deeply in their work. It is our hope that this Handbook leads to profitable new connections between ideas and scholars, within and across scholarly boundaries. We can think of no more reliable process for knowing than through discourse, reflection, research, and partnership within and among the disciplines and scholars who study epistemic cognition.

**Table 30.1** Categories and lists of epistemic "something" terms, and the chapter authors who used them

| Category | Term | Handbook Authors Who Use the Term |
|---|---|---|
| **Processes, products, and standards** | | |
| Processes | Epistemic activity or activities | Chinn & Rinehart; Elby et al.; Strømsø & Kammerer; Weinstock |
| | Epistemic assessments | Barzilai & Zohar |
| | Epistemic awareness | VanSledright & Maggioni |
| | Epistemic decisions or decision-making | Clément; Hofer |
| | Epistemic evaluations | Barzilai & Zohar; Chinn & Rinehart; Clément |
| | Epistemic judgments | Barzilai & Zohar; Chinn & Rinehart; Hofer; Kienhues et al.; Murphy & Alexander |
| | Epistemic monitoring | Barzilai & Zohar |
| | Epistemological moves | Brownlee et al. |
| | Epistemic planning | Barzilai & Zohar |
| | Epistemic practices | Barzilai & Zohar; Chinn & Rinehart; Greene; Kelly; Sandoval |
| | Epistemic or reliable processes | Barzilai & Zohar; Buehl & Fives; Chinn & Rinehart; Hofer; Kelly; Sinatra |
| | Epistemic reasoning | Barzilai & Zohar; Hofer |
| | Epistemic strategies | Barzilai & Zohar; Hofer; Muis et al. |
| | Epistemologically self-regulated thinking | Moshman & Tarricone |
| | Epistemic thinking | Barzilai & Zohar; Hofer |
| Products | Epistemic attitude | Bendixen; Buehl & Fives; Elby et al.; VanSledright & Maggioni |
| | Epistemic claim | Hofer |
| | Epistemic conceptual change | Hofer |
| | Epistemic products | Buehl & Fives; Chinn & Rinehart |
| | Epistemic or epistemological stance | Bråten; Chinn & Rinehart; Hofer; Sodian & Kristen |
| | Epistemic states | Sodian & Kristen |
| | Epistemic status | Barzilai & Zohar |
| | Epistemic understanding | Barzilai & Zohar; Hofer |
| Standards | Epistemic criteria | Barzilai & Zohar; Chinn & Rinehart; Iordanou et al. |
| | Epistemic ends | Barzilai & Zohar |
| | Epistemic ideals | Chinn & Rinehart |
| | Epistemic norms | Greene; Iordanou et al.; Sandoval |
| | Epistemic standards | Barzilai & Zohar |

| Category | Term | Handbook Authors Who Use the Term |
|---|---|---|
| **Processes, products, and standards** | | |
| Motivation and affect | Epistemic aims | Barzilai & Zohar; Buehl & Fives; Chinn & Rinehart; Chen & Barger; Lee et al.; Mason |
| | Epistemic dispositions | Buehl & Fives; Lee et al. |
| | Epistemic emotions | Muis et al. |
| | Epistemic goals | Barzilai & Zohar; Mason |
| | Epistemic interest | Barzilai & Zohar |
| | Epistemic values, virtues, vices | Chinn & Rinehart; Lee et al.; Mason |
| | Epistemic vigilance hypothesis | Clément |
| "Sophisticated" epistemic cognition | Epistemic adaptiveness | Kienhues et al.; VanSledright & Maggioni |
| | Epistemic competence | Muis et al.; Murphy & Alexander |
| | Epistemic orientation | Weinstock |
| | Epistemic perspective | Brownlee et al.; Depaepe et al.; Lee et al. |
| | Epistemic preference | Clément |
| | Epistemic senses | VanSledright & Maggioni |
| Tasks and contexts | Epistemic aspects | Bendixen; Kienhues et al. |
| | Epistemic challenge | Barzilai & Zohar |
| | Epistemic character | Elby et al. |
| | Epistemic climate | Hofer; Muis et al. |
| | Epistemic community | Chinn & Rinehart; Murphy & Alexander |
| | Epistemic cultures | Kelly |
| | Epistemic demands | Bendixen; Lee et al. |
| | Epistemic issue | Barzilai & Zohar; Hofer |
| | Epistemic landscapes | VanSledright & Maggioni |
| | Epistemic matters | Barzilai & Zohar; Buehl & Fives; Chinn & Rinehart |
| | Epistemic messages | Muis et al.; VanSledright & Maggioni |
| | Epistemic nature | Barzilai & Zohar; Buehl & Fives; Depaepe et al. |
| | Epistemological orientation | Bendixen |
| | Epistemic parameters | Weinstock |
| | Epistemic problem | Elby et al.; VanSledright & Maggioni |
| | Epistemic property | Barzilai & Zohar |
| | Epistemic question | VanSledright & Maggioni |

(*Continued*)

**Table 30.1** (Continued)

| Category | Term | Handbook Authors Who Use the Term |
|---|---|---|
| **Processes, products, and standards** | | |
| | Epistemic requirement | Barzilai & Zohar |
| | Epistemic spaces | Weinstock |
| | Epistemic systems | Greene |
| | Epistemic task | Bendixen |
| | Epistemology | Bricker & Bell; Elby et al.; Sandoval |

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