Designing Epistemic Scaffolding in CSCL

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Abstract: In this paper, we propose an epistemic scaffolding framework to understand the support for epistemic change in computer supported collaborative learning (CSCL). Two types of epistemic scaffolding are differentiated based on existing literature and educational practices, namely, implicit and explicit epistemic scaffolding. Implicit epistemic scaffolding refers to the support (including tool, activities, resources, etc.) that has epistemic implications but is not made obvious to learners. Explicit epistemic scaffolding refers to the support that intentionally makes epistemic ideas explicit to learners to promote their epistemic understanding. Many of the CSCL environments have been designed with epistemic underpinnings, which could serve as implicit epistemic scaffolds. We propose that embedding explicit epistemic scaffolds in CSCL environments that are designed with implicit epistemic scaffolds is a promising way to maximize the power of support for epistemic growth.

Introduction

Epistemic cognition is a field that studies individual's epistemic related thinking, including understanding of the nature of knowledge, process of knowing, and achievement to epistemic ends (Chinn, et al., 2014; Hofer, 2016). The importance of promoting sophisticated epistemic cognition has been acknowledged by a growing number of researchers (Greene, et al., 2016; Sinatra & Chinn, 2011). Sophisticated epistemic cognition is not only an important educational goal itself, but also an important predictor of students' learning (Chinn, et al., 2011; Elby, et al., 2016). In recent decades, much progress has been made in understanding the nature of epistemic cognition, and its relation to other constructs (Chinn et al., 2011; Hofer & Pintrich, 1997; Khine, 2008), relatively less is known about the ways in which growth towards epistemic sophistication can be promoted (Brownlee, et al., 2001; Kienhues, et al., 2016). In this paper, we attempt to propose an epistemic scaffolding framework to understand the support for epistemic change. By *epistemic scaffolding*, we mean the support that could enable learners to achieve a higher level of epistemic sophistication. It encompasses both the supports for promoting the sophistication of tacit epistemic understanding (e.g., how people actually work on knowledge) and explicit epistemic understanding (e.g., how people talk about the nature of knowledge). In this paper, we will primarily focus on the epistemic scaffolding in science.

Even though the term epistemic scaffolding has not been mentioned often in the previous literature, it has been employed intentionally or unintentionally in some educational designs, theories, and technologies. Sandoval and Reiser's (2004) study is an example of explicitly using the term "epistemic scaffold" to refer to the support used to help students understand the epistemic aspects of inquiry. There are also some other studies and efforts that tried to support students' epistemic understanding (Carey, et al., 1989; Smith, et al., 2000), however, there has been little examination of the nature and pattern of epistemic scaffolding. In this paper, we differentiate two types of epistemic scaffolding, namely, implicit and explicit epistemic scaffolding, and discuss how they could be combined to maximize the power of support for epistemic change in CSCL.

Epistemic scaffolding

Scaffolding, in the traditional sense, is used to refer to the assistance provided by a more capable individual (e.g., tutor) to a learner to accomplish tasks that would be otherwise out of reach. The discrepancies between what an individual's actual competences are for accomplishing tasks alone and his/her potential competence for accomplishing the task with assistance is defined as the zone of proximal development (ZPD) (Vogotsky, 1978). ZPD defines the lower and upper bounds of developmental levels, and how providing support within these levels may promote learning. Researchers have identified few features that are essential for scaffolding (Puntambekar & Hubscher, 2005), including shared understanding, ongoing diagnosis, calibrated support, and fading.

The notion of scaffolding has evolved in the past decades, and the original notion does not adequately explain learning in complex learning environments. Especially in today's classroom, students are interacting not only with human agents such as teachers and peers, but also with increasingly complex tools and artifacts, from instructional materials in papers form, to computers and software, each embedded in a host of activities. The scaffolder is no longer the more capable person; rather, scaffolding is *distributed* among teachers, peers, activities, software, and resources, etc. (Puntambekar & Kolodner, 2005; Tabak, 2004).

Different forms of scaffolding have been designed to help students accomplish complex tasks. For example, soft and hard scaffolds (Brush & Saye, 2002) or adaptive and fixed scaffolds (Azevedo, et al., 2004) have been designed to provide students with support with different degree of flexibility. Soft/adaptive scaffolding is dynamic and situation specific. It requires teacher or peers to continually diagnose students' understanding and provide timely assistance. Hard/fixed scaffolds are static and can be planned in advance based on students' understanding. They can be embedded in multimedia and hypermedia to support students' learning while they use the tool (Brush & Saye, 2002). Scaffolding has also been designed to serve different functions, such as procedural, conceptual, and metacognitive scaffolding (Molenaar, et al., 2010). Procedural scaffolding guides learners to use certain tools and resources, or accomplish certain tasks. Conceptual scaffolding provides support for learners' conceptual understanding and helps them reason through difficult concepts or problems. Metacognitive scaffolding provides support for monitoring learning. In this paper, we propose *epistemic scaffolding*, the support for epistemic understanding, as a separate category and different from other types of scaffolding (see Figure 1).

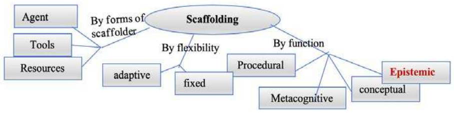

Figure 1. Types of scaffolding.

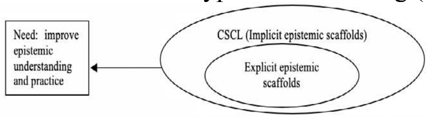

Figure 2. Synergistic epistemic scaffolding model.

To help illustrate this difference, consider a situation in which students engage in a scientific investigation of electrical conductivity. In this case, procedural scaffolding could support students with tasks such as setting up their experiments, and using tools etc. The support that helps students understand the mechanism of conductivity constitutes conceptual scaffolding; the support that helps students regulate the progress of their inquiry is metacognitive scaffolding. The support that helps them understand the role of theory and evidence in investigating the mechanism of conductivity is epistemic scaffold. Procedural scaffolding aims to assist learners' procedural activity of accomplishing a task; the conceptual scaffolding primarily aims to assist their understanding of the content knowledge of electricity; metacognitive scaffolding aims to assist the regulation of their cognitive activities and processes; whereas epistemic scaffolding aims to support their understanding of the nature of scientific inquiry--the role of theory and evidence in inquiry.

It should be noted that some of these scaffolds are usually intertwined. Take epistemic and conceptual scaffolding for example, conceptual scaffolding usually has implicit epistemic implications; while epistemic scaffolding is usually situated in a context where conceptual scaffolding is provided. As the above example shows, prompting students to understand why some materials conduct electricity is a conceptual scaffolding, while it also has the epistemic implication of the need for explanation. The guidance for helping students understand the role of theory and evidence in investigating conductivity is epistemic scaffolding, while it is also situated in the context of learning about electricity.

Types of epistemic scaffolding

Based on extant literature and educational practice, we distinguish two types of epistemic scaffolding: implicit and explicit epistemic scaffolding.

Implicit epistemic scaffolding

Implicit epistemic scaffolding refers to the support–including tools, activities, and resources–that has epistemic implications but is not made obvious to learners. For example, the activity of engaging students in inquiry that focuses on the relationship between explanation and evidence has the epistemic implication that evidentiary justification is an important part of scientific inquiry. Even though such underlying epistemology may not be made explicit to learners, it still has potential to influence students' epistemic thinking (Hofer, 2004; Perry, 1970).

Some of the technological tools could also provide implicit epistemic scaffolding. For example, CoMPASS, is an etextbook that is designed to facilitate students' science learning (Puntambekar & Stylianou, 2005). It visualizes connections among science concepts, helping students see how concepts and principles are related to each other. It uses both concept maps and text as representations to facilitate students' navigation and inquiry. The concept map mirrors the interrelated structure of the science concepts and phenomenon. The underlying epistemic idea guiding the design is that scientific knowledge is coherent and connected, rather than fragmented. It could serve as implicit epistemic scaffolding for promoting students' understanding of the structure of knowledge (Hofer & Pintrich, 1997). Knowledge Forum®, previously known as CSILE (Computer Supported Intentional Learning Environments), is a computer-supported collaborative learning platform designed to support students' knowledge building (Scardamalia, 2004). In Knowledge Forum, ideas could be connected and built upon each other for further improvement. Here the epistemic implication is that knowledge is socially constructed and is tentative (Lin & Chan, 2014).

Explicit epistemic scaffolding

Explicit epistemic scaffolding refers to the support that intentionally makes epistemic ideas obvious to learners to promote their epistemic understanding and practice. there are different ways in which scaffolding could make epistemic ideas explicit, including explicit in epistemic structure, explicit in epistemic criteria, and explicit in epistemic goal.

ExplanationConstructor (Sandoval, 2003) is an example of explicit epistemic scaffolding that makes the epistemic structure of inquiry explicit. ExplanationConstructor is an electronic journal that was designed for students to generate explanations. It linked question, explanation, and evidence in the interface, suggesting the importance of and connections among question, explanation, and evidence in scientific inquiry. Knowledge Forum is another example of making the structure of collective inquiry explicit to students through providing prompts for notes writing, such as "*your explanation cannot explain*", "*a better theory*", and so on.

Epistemic criteria are standards scientists use to evaluate the validity and accuracy of scientific products, such as arguments, models, and evidence (Pluta, et al., 2011). However, they could also be used as explicit epistemic scaffolds when presented to, or constructed by students as standards to evaluate scientific process and products. For example, Ryu and Sandoval (2011) examined students' understanding of the epistemic criteria for argumentation, they found that explicitly using and talking about the epistemic criteria for argumentation were helpful for improving students' epistemic practice. Similarly, Lin and Chan (2018) designed an instruction to let students reflect on the epistemic criteria of good collaborative discourse, and found it promoted students' epistemic understanding about the social constructive nature of science.

Some studies also showed the importance of making epistemic goal explicit to students. For example, Schauble and colleagues (1995) found that students did better in inquiry after the instruction about the goal of experimentation.

It should be noted that in many educational practices, explicit epistemic scaffolds are most often not used on their own, but are usually combined with implicit epistemic scaffolds. In the next section, we will discuss how implicit and explicit epistemic scaffolds could be integrated to maximize the power of support for epistemic change in CSCL contexts.

Designing synergistic epistemic scaffolding in CSCL

As we discussed earlier, the notion of distributed scaffolding suggests that multiple forms of supports could exist and interact with each other in a learning environment. Building on this idea, Tabak (2004) distinguished three patterns of distributed scaffolding: differentiated scaffolds, redundant scaffolds, and synergistic scaffolds. These patterns demonstrated how various scaffolds (e.g., resources, software, teachers, peers) could work together to support students' learning. Differentiated scaffolds refer to the way multiple forms of supports are individually provided to support students' different needs. Redundant scaffolds involve multiple supports for addressing the same need. Synergistic scaffolds refer to the multiple supports that co-occur to address the same need.

Building on Tabak's framework on synergistic scaffolds, we propose that embedding explicit epistemic scaffolds in implicit epistemic scaffolds is a promising way to maximize the power of support for students' epistemic development in CSCL (Figure 2). We emphasize their relationship as embedded because explicit epistemic scaffolds need to be situated in implicit epistemic scaffolds as well as mirror the objects of implicit epistemic scaffolding. For example, if the implicit epistemic scaffolds focus on the coordination between claim and evidence, the explicit epistemic scaffolds need to be provided within the implicit epistemic scaffolds, and they also need to mirror the evidence-based nature of science.

Some studies on science education and teachers' epistemology have provided evidence for the importance of including both implicit and explicit scaffolds to support epistemic cognition, for example, Khishfe and Abd-El-Khalick (2002) compared explicit and implicit inquiry-oriented approach on students' understandings of nature of science, and found that more participants from the explicit approach improved their nature of science views. Brownlee et al. (2001) employed both implicit and explicit approaches to foster preservice teachers' epistemic cognition and also found positive results. They (Brownlee, et al., 2017) noted that to make the design effective, explicit reflection needs to be embedded in the contexts of actual teaching practice, which aligns with our proposal on the embedded structure of implicit and explicit epistemic scaffolding.

We propose that synergistic epistemic scaffolding is especially important for fostering epistemic growth in CSCL. Many of the CSCL tool and environment have been designed with epistemic underpinnings which may serve as implicit epistemic scaffolds to help students experience alternative ways of working on knowledge and ideas. For example, Knowledge Forum was designed to engage students in collaborative theory building (Scardamalia, 2004); Web-based Inquiry Science Environment (WISE) was designed to support students' knowledge integration(Linn, 2006); and ExplanationConstructor was designed to help students build coherent explanations (Sandoval & Reiser, 2004). However, students may not understand these underlying epistemic ideas and therefore may not perform as expected. We argue that if we make the epistemic aim and epistemic criteria of the designed CSCL explicit to students, it may promote apt epistemic performance.

Some studies have provided evidences for the effectiveness of synergistic epistemic scaffolding for promoting epistemic cognition in CSCL. For example, Lin and Chan (2014) embedded epistemic reflection in computer-supported knowledge-building environment to promote students' understanding of theory-building nature of science. They designed an epistemic model--Little Scientists Worksheet--to help students reflect on their own inquiry experience. The worksheet included epistemic ideas such as "improvable ideas" and also graphs to illustrate how scientists advance their community knowledge, which mirrored students' own inquiry process on Knowledge Forum. When students used these epistemic ideas as criteria to reflect on their inquiry, their epistemic practice were improved. In another study, Lin et al. (2018) embedded explicit epistemic reflection in students' collective inquiry using VidyaMap, which is a new generation of CoMPASS, and found that *reflecting on the epistemic role of the tool for inquiry* promoted students' inquiry and learning from VidyaMap.

Discussion and future research

This paper proposes an epistemic scaffolding framework to understand the support for fostering epistemic cognition in CSCL. We identified two types of epistemic scaffolding: implicit and explicitly epistemic scaffolding, and proposed that embedding explicit in implicit epistemic scaffolds might help maximize the power of support for promoting epistemic growth. This epistemic scaffolding framework could enrich the literature on epistemic cognition and scaffolding, broadening the research agenda in both areas. On the one hand, it could enrich the epistemic cognition field by allowing researchers to explore a wider variety of questions informed by scaffolding literature. For example, fading, calibrated support, and ongoing diagnosis have been regarded as the key features of scaffolding. Future research could examine the fading of epistemic scaffolding, diagnosis of support for epistemic cognition, and the interaction of epistemic scaffolds with other types of scaffolding. On the other hand, it could enrich the scaffolding literature by adding a new type of support--epistemic scaffolding--to the existing cluster of scaffolding, in parallel to procedural, conceptual, and metacognitive scaffolding, etc., which could help us better understand the nature of support in complex learning environment.

This is an initial attempt to conceptualize epistemic scaffolding. The distinction between implicit and explicit epistemic scaffolding needs to be further clarified and developed in future research. More empirical studies are needed to examine the effectiveness of synergistic epistemic scaffolds in CSCL and to understand the nature of implicit and explicit epistemic scaffolding and their relations to other scaffolding, for example, given a certain CSCL context, what kinds of explicit epistemic scaffolding might provide better support; how do implicit and explicit epistemic scaffolding interact with other types of scaffolding (e.g., metacognitive scaffolding), and what kinds of interaction might be more effective to support students' epistemic cognition and learning? These are the questions we can further explore. We are hoping that the new questions brought up by this epistemic scaffolding framework could help open up new possibilities for exploring ways of fostering epistemic growth in CSCL.

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