



# Seeing Through the Eyes of Collaborators: Using Toolbox Workshops to Enhance Cross-Disciplinary Communication

In: Enhancing Communication & Collaboration in  
Interdisciplinary Research

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Pub. Date: 2015

Access Date: January 3, 2022

Publishing Company: SAGE Publications, Inc.

City: Thousand Oaks

Print ISBN: 9781452255668

Online ISBN: 9781483352947

DOI: <https://dx.doi.org/10.4135/9781483352947>

Print pages: 220-243

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# Seeing Through the Eyes of Collaborators: Using Toolbox Workshops to Enhance Cross-Disciplinary Communication

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The emerging literature on the challenges of cross-disciplinary research emphasizes the critical importance of effective communication to project success, but mechanisms for developing such communication remain scarce. This chapter presents one approach to improving communication in cross-disciplinary research teams—the Toolbox method, a dialogue method rooted in the philosophy of science. Disparate views about the nature of phenomena studied and methods of inquiry can make research communication challenging for cross-disciplinary teams of scientific collaborators. The Toolbox method uses a philosophically based questionnaire in a workshop setting to guide dialogue about the nature and practice of science. This dialogue promotes understanding of diverse research worldviews within a team and helps participants identify potential conflict as well as common ground. The workshop can also reveal communication dynamics while helping build trust and mutual respect. This chapter provides background information on the nature and usefulness of the Toolbox, offers instructions for preparing and running a Toolbox workshop, outlines the necessary personnel and their roles, and provides examples of how to conduct a successful session. Follow-up activities and suggestions for using workshop results to improve team function and dynamics are also provided.

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## Introduction

Differences between scientific cultures make collaborative, cross-disciplinary research both powerful and perplexing—powerful because the combination of different orientations enables scientists to respond to complex problems in complex ways typically unavailable to investigators working from single perspectives, and perplexing because these responses require scientists to communicate effectively with representatives of different intellectual cultures (Jakobsen, Hels, & McLaughlin, 2004; Stokols et al., 2003).<sup>2</sup>

To help unleash the full potential of collaborative, cross-disciplinary research, we describe an approach to enhancing communication across disciplines that emphasizes dialogue about the fundamental assumptions and scientific approaches that typify those disciplines (cf., McDonald, Bammer, & Deane, 2009). Specifically, we supply a dialogue method—the Toolbox method—centered on a semistructured, philosophical conversation about research assumptions that takes place in a workshop setting, bringing collaborators together around a common, jointly constructed understanding of their specific combination of disciplines (Eigenbrode et al., 2007). Toolbox Project members have conducted 90 of these workshops (2006–2012) around the United States and provided feedback to participating teams about their communication dynamic. Post-workshop evaluations indicate that participants are overwhelmingly positive about the method as a way to improve awareness of disciplinary assumptions and group communication.

In this chapter, we develop the rationale and motivation for the Toolbox method—namely, that philosophical dialogue enhances the collaborative practice of teams conducting cross-disciplinary research and similar efforts. We present a detailed account of the Toolbox method to use as a guideline for those who wish to conduct a workshop of their own, highlighting what should occur, how to make it occur, and how to interpret what transpires during the workshop. Finally, we provide a synopsis of our ongoing efforts to improve the Toolbox method, fine-tune it for specific kinds of collaboration, and integrate the exercise into the broader context of improving communication within collaborative teams.

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## Framing

### The Toolbox Idea

One well-established way of enhancing collaborative communication is with dialogue, understood as the joint creation of “‘meaning and shared understanding’ through conversation” (McDonald et al., 2009, p. 2, quoting Franco, 2006, p. 814). Dialogue happens organically, of course, but it can also be structured through *dialogue methods* employed by groups as they work to develop their “collective communication competence” (Thompson, 2009). Among these methods are scenario planning, mind mapping, nominal group technique, and the Delphi technique (McDonald et al., 2009; Winowiecki et al., 2011). We offer the Toolbox method as a novel yet tested dialogue method that complements other available methods. While other dialogue methods support the performance of critical functions, such as conceptualizing problems and rapidly and inclusively making decisions, the Toolbox method is concerned more generally with cross-disciplinary research readiness. This method prepares teams to perform research functions by revealing and clarifying fundamental assumptions made by team members about the nature, conduct, and application of research. We propose that improved clarity at this deeper level allows teams to function more effectively by identifying and illuminating fundamental differences among their constituent disciplines (cf., Bammer, 2013). To achieve this, a conversation must be structured in a way that meets two requirements:

1. It makes the disciplinary assumptions of each participant salient to both the individual and the rest of the team.
2. It clarifies genuine differences and similarities among the assumptions in the team (e.g., disagreements about research practices of team members) and distinguishes them from superficial differences and similarities (e.g., merely verbal disagreements).

As Klein ([Chap. 2](#), this volume) argues, there are a number of theoretical domains available that could provide structure for a conversation that aims to meet these two requirements—for example, applied linguistics, management, and philosophy. Each of these addresses a level of genuine difference. Linguistics focuses on the character of the languages used to talk about research, while management theory highlights organizational structures and dynamics. Philosophy, though, is best positioned to foreground conceptual assumptions that frame the research practices of the participants. The Toolbox approach to these

requirements exploits this advantage of philosophy and frames conversation in terms of the philosophy of science. The philosophy of science and its subdisciplines address the breadth of scientific practice, seeking common principles of this practice that constitute a conceptual framework inclusive of all scientific disciplines. Genuine differences about research assumptions across a team can be described as differences with respect to specific “common principles.” For example, one common principle is that the credibility of empirical claims depends on their evidentiary support. However, what counts as evidence, what form it takes, and how much is required to substantiate claims varies significantly across—and within—disciplines. Recognition that different attitudes toward evidence are each responses to a common principle makes them salient (Requirement 1) and establishes them as genuine and commensurable (Requirement 2). The framework of common principles supports discovery and comparison of different research assumptions, supplying common ground that collaborators can use to develop greater mutual understanding about their research practices. In addition, philosophical common ground can be neutral territory supporting vigorous dialogue that is relevant to the success of the project but abstracted from the potentially more contentious project-specific details in which collaborators may be personally invested (Black & Anderson, 2012).

The Toolbox method is based on the proposition that philosophical discussion concerning the practice of science and the nature of the world under investigation can engender mutual understanding about issues within and between disciplines that are rarely discussed among collaborators. These topics are addressed by the following questions: What methods are appropriate for answering scientific questions, and why? Must effective science employ hypotheses, and how should hypotheses be used? Does validation require replication? Is value-neutral scientific research possible? What is the inherent value of science to humankind? These and other questions related to the philosophical nature of research are assembled in the Toolbox instrument, a questionnaire designed to elicit and structure conversation in a workshop setting. The Toolbox instrument is described in detail in Section III of this chapter.

## Does It Work?

It is an assumption of our effort, and indeed the efforts of the contributors to this volume and other works on team science (e.g., Falk-Krzesinski et al., 2011; National Academy of Sciences, 2004; Pohl & Hirsch Hadorn, 2007), that improved communication leads to improved collaboration. The Toolbox method is unique in addressing the need for improved cross-disciplinary communication by inviting collaborators to examine their disciplinary assumptions about science and identify fundamental similarities and differences. The leading idea behind the Toolbox method is that enhanced understanding across a team will improve the efficiency and effectiveness of team communication. Specifically, development of mutual understanding should make it easier to integrate different disciplinary vocabularies and conceptual schemes, enabling more efficient information transfer; further, enhanced mutual understanding should positively impact team cohesion (Casey-Campbell & Martens, 2009). The literature suggests that understanding at this level supports collaborators as they grapple with a pressing research problem (e.g., Bracken & Oughton, 2006; McDonald et al., 2009; Ramadier, 2004), and we have gathered empirical evidence indicating that the Toolbox method is beneficial for team members. Specifically, we have collected and analyzed post-workshop questionnaire surveys from

35 of the 90 participating teams over the past 6 years. Of the 147 (of 285) participants who returned surveys, 84.9% indicated that the workshop had a positive impact on awareness of the knowledge, opinions, or scientific approach of teammates, and 77.4% reported a positive impact on their professional development (Schnapp, Rotschy, Hall, Crowley, & O'Rourke, 2012).

## Who Can Benefit and How?

While any participant in a Toolbox workshop can benefit from greater awareness of fundamental assumptions about scientific work, the intent of the Toolbox workshop is to improve understanding and communication within actively collaborating cross-disciplinary teams.<sup>3</sup> The teams that have participated in Toolbox workshops have varied significantly in character. They have been constituted by collaborating researchers, graduate students in team-based courses, undergraduate researchers in summer research experience programs, research-center leaders, experienced researchers newly interested in collaborative cross-disciplinary research, and otherwise unconnected individuals simply interested in the Toolbox method. Participating teams have also been engaged in a variety of efforts, including academic research, interdisciplinary teaching or mentoring, transdisciplinary or transprofessional work on complex problems, and outreach.

An important dimension of workshop variety is disciplinary composition, since this has implications for the diversity of research assumptions. Some of the teams have had broad disciplinary representation (e.g., a team comprising social scientists, economists, biologists, engineers, and educators) and others have been more narrow (e.g., one comprising computer scientists and evolutionary biologists); however, we have found that diversity of views on philosophical issues is not necessarily dependent on disciplinary breadth, as even people within the same discipline can differ significantly in their scientific assumptions. The key point, however, is that teams with different compositions, purposes, and levels of experience can engage with the Toolbox and learn from the activity.<sup>4</sup>

The Toolbox method is designed to enhance self- and mutual understanding of research assumptions within cross-disciplinary research teams. Participants report in their post-workshop questionnaires that the workshop has given them a heightened awareness of genuine differences among their professional and research perspectives, a better appreciation of the cross-disciplinary dimensions of their projects, and a reduction in conflict stemming from the erroneous belief that the team shares fundamental assumptions about research and its application.

## When Should a Research Team Employ the Toolbox Workshop?

The Toolbox workshop was originally conceived as a method best suited to research teams just beginning their work together, but we have conducted workshops for teams at all stages of collaboration. The Toolbox workshop can function to establish mutual understanding at the outset of a collaboration so communication about research decisions will go more smoothly. For this reason, it also has value early in a graduate or

undergraduate course that emphasizes team-based, interdisciplinary interaction or research. Other teams have reported that the exercise can be valuable if conducted after a team's research focus has matured, with the Toolbox serving to stimulate project-relevant dialogue needed for data integration, synthesis, or other cross-disciplinary goals. A few teams have also found repeated interventions with the Toolbox to be helpful (e.g., following membership turnover or team expansion). In other words, just as there are many ways to collaborate successfully (Klein, 1996), there are many stages in a collaboration where the Toolbox method can add value.

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## Toolbox Do-It-Yourself

In addition to the Toolbox workshops we have facilitated, some research teams have conducted workshops independently, based on a reading of Eigenbrode et al. (2007). To facilitate such “do-it-yourself” workshops we have developed an updated guide to conducting and interpreting a Toolbox workshop that employs the latest version of the instrument and draws on our experience delivering workshops for diverse teams. The method has five primary elements: (1) preparing for a workshop, (2) the Toolbox instrument, (3) conducting the workshop, (4) post-workshop analysis, and (5) follow-up activities.

## Preparing for a Workshop

It is important for one of the members of a team that plans to conduct a Toolbox workshop to assume the role of workshop organizer. Four important tasks for the organizer prior to the workshop are as follows:

- *Compile information about the team.* The organizer should seek answers to several questions about the team, including, Why is the team participating in the Toolbox workshop—is it to improve their functionality or merely to learn about the Toolbox approach? How many participants will there be? Who are they (e.g., students, administrators, researchers, practitioners)? What is the team's history (e.g., is the team just assembling, or have they worked together for a long time)? What is the nature and focus of the collaboration (e.g., fundamental or applied research, addressing a particular stakeholder-driven issue, classroom project)? This information will guide judgments about the nature of the workshop and the instrument employed. For example, newly formed teams may require more time for members to introduce themselves to one another before feeling comfortable enough to speak openly about their research assumptions. Also, we have found that the opportunity for engaged dialogue seems to be greatest in workshops with fewer than 10 participants (cf., Krueger & Casey, 2000); larger teams may wish to divide into two or more workshop groups, which could entail additional planning and resources.
- *Secure a venue.* Sessions require a comfortable space that can accommodate the team and allow audiorecording if desired. Participation by some team members via video-link has been successful, but high-quality connections are desirable.
- *Distribute preparatory reading.* This should include literature providing information about the purpose

and nature of the Toolbox workshop, explanation of its focus on philosophical themes, and discussion of its potential benefits for cross-disciplinary research teams. Eigenbrode et al. (2007); Crowley, Eigenbrode, O'Rourke, and Wulforth (2010); or O'Rourke and Crowley (2012) can function in this role.

- *Obtain Institutional Review Board approval (if required).* If the information obtained from the team before, during, or after the workshop will be used for research purposes, it is important to obtain Institutional Review Board approval and participant consent prior to collecting data. (See <http://grants.nih.gov/grants/policy/hs/> for more information.)
- *Notify participants about data collection.* If data about the participants or the workshop are to be collected for research purposes, the participants should be apprised of this fact before they gather for the workshop.

Two additional tasks, to be described in the next two subsections, are determining the specific character of the Toolbox instrument to be used in the workshop and determining the personnel to run it.

## Understanding and Building Your Toolbox Instrument

The Toolbox instrument is a set of modules, each comprising a core question and probing statements that concern philosophical aspects of science. Each probing statement is associated with a 5-point Likert-type scale, along with selections for “don't know” and “not applicable,” that participants are asked to score prior to the dialogue. For “do-it-yourself” purposes, the Likert-type scale encourages participants to take a position as a springboard for discussion. The instrument also comes with a demographic table that gathers various pieces of participant information (e.g., gender, discipline(s), years of experience in cross-disciplinary work). Three Toolbox instruments have been developed, targeting different audiences: cross-disciplinary research involving STEM<sup>5</sup> disciplines, research in the translational health science domain (Schnapp et al., 2012), and research in the translational climate science domain.<sup>6</sup> This chapter focuses on the STEM Toolbox instrument, which comprises six modules, three of which are built around core questions exploring epistemic dimensions of science (i.e., how scientific knowledge is created) and three around core questions exploring metaphysical dimensions of science (i.e., the nature of the world under study).<sup>7</sup> The module areas and core questions for this Toolbox instrument are as follows:

Epistemological questions:

- *Motivation:* Does the principal value of research stem from its applicability for solving problems?
- *Methodology:* What methods do you employ in your disciplinary research (e.g., experimental, case study, observational, modeling)?
- *Confirmation:* What types of evidentiary support are required for knowledge?

Metaphysical questions:



- *Reality*: Do the products of scientific research more closely reflect the nature of the world or the researcher's perspective?
- *Values*: Do values negatively influence scientific research?
- *Reductionism*: Can the world under investigation be reduced to independent elements for study?

In the Toolbox instrument, each core question in a module is followed by five to seven statements designed to probe specific aspects of the core question and stimulate discussion. There are 34 probing statements in all. As an example, the Motivation Module (Figure 11.1) demonstrates the general layout and nature of the probing statements; the full Toolbox instrument can be accessed at <http://www.sagepub.com/orourke>.

**Figure 11.1 The Motivation Module, Part of the Epistemology Section of the Toolbox**

### **I. Motivation**

**Core Question:** *Does the principal value of research stem from its applicability for solving problems?*

1. The principal value of research stems from the potential application of the knowledge gained.

*Disagree*

*Agree*

1   2   3   4   5                      I don't know                      N/A

2. Cross-disciplinary research is better suited to addressing applied questions than basic questions.

*Disagree*

*Agree*

1   2   3   4   5                      I don't know                      N/A

3. My disciplinary research primarily addresses basic questions.

*Disagree*

*Agree*

1   2   3   4   5                      I don't know                      N/A

4. The importance of our project stems from its applied aspects.

*Disagree*

*Agree*

1   2   3   4   5                      I don't know                      N/A

5. The members of this team have similar views concerning the motivation core question.

*Disagree*

*Agree*

1   2   3   4   5                      I don't know                      N/A



Although the complete Toolbox instrument addresses philosophical concepts that are relevant to most projects, not all teams will have the time to explore the full instrument. The modular nature of the Toolbox allows teams to select a subset of modules for their workshop, tailoring their experience to the areas most pressing or interesting for them. Consider two examples: A policy-oriented team may wish to conduct a short session on the Values Module; a team that is struggling to reconcile qualitative methods with quantitative methods may wish to focus on the Methodology and Confirmation Modules. This tailored approach enables teams to select modules highlighting conceptual aspects of scientific research that they find especially interesting or relevant.

## The Toolbox Workshop

We now focus on conducting a Toolbox workshop, emphasizing the roles of the facilitator and other personnel who are not members of the dialogue team. We describe the workshop experience in detail, emphasizing how typical workshops unfold, some of the team interactions a facilitator might expect, and examples of effective facilitator responses.

### Workshop Personnel

Workshop personnel are involved in the session but are not members of the dialogue group. The facilitator is the most important nonparticipant and is indispensable to a successful Toolbox experience. The facilitator must effectively execute five primary functions:

- Introduce the session
- Answer questions from the participants about the Toolbox concept, the Toolbox instrument, and the workshop structure prior to the dialogue
- Help the team find connections between dialogue topics in the Toolbox instrument *without becoming part of the dialogue*
- Ensure that the team has the opportunity to address all the toolbox modules
- Prompt participants to clarify their statements or provide further details

In executing these functions, the facilitator should be careful to encourage the participants to explore on their own the issues raised in the instrument and should avoid trying to direct or control the discussion. Specific examples of approaches a facilitator might use effectively are presented in the following section. For several reasons, someone outside the team should serve as facilitator. A team member who serves as facilitator will necessarily abstain from participating in the dialogue, thereby compromising the value of the workshop for the team. Open and frank discussion may be inhibited if the facilitator is a team member with a leadership role (e.g., a faculty team leader facilitating a workshop that includes student research associates). The impartiality of a facilitator is critical to ensuring a balanced exploration of the Toolbox instrument. Perception of the facilitator as external to the team tends to promote a more formal attitude among participants, which can encourage more conscientious participation.

If a team wishes to record and transcribe or further analyze their workshop dialogue, a recorder should also be present. The primary task of the recorder is to create a record that enables a transcriber to assign speakers to each statement within the transcript. One way to do this is by associating each new speaking turn with a speaker (using participant codes—see below) and a distinctive word or phrase to make it clear to the transcriber which comment is associated with that turn (see Figure 11.2). The recorder may also note nonverbal cues or other incidents. Some teams may also wish to include a third nonparticipant who functions as an observer, focusing on communication process elements such as energy dynamics, body language, and other nonverbal forms of communication. The facilitator, recorder, and observer can later share their impressions of the activity during debriefing with the team (see p. 236) but should not speak with one another during the session. It is important to consider the size of the team and the space where the workshop will be held when determining whether to include an observer. For small teams (three to four participants), three nonparticipants in the room can inhibit dialogue.

**Figure 11.2 Excerpt of Recorder Notes From a Typical Toolbox Workshop**

Speaker	Question	Keywords/ Observations	Speaker	Question	Keywords/ Observations
4	general		5	How motivation	... how define interests ...
1	"	NIA's	1	"	... how we define & pplied ...
4 ?			laughter		
1 ?			1	"	you're the lead ...
5	demographic	who am I	3		the students we will attract ...
8		reph	10		impediments to Inter-D Sci
" general	--		1	dem X-disup	trans-D.
5		who am I ...	3, 1, 10, 9, ..		general - dem of X-disup
4		irony later?			
5		odd duck?	3	"	
1		bristle?	10	"	1st agent Hel play
4			JD	"	clarity
general	team Q's	do don't know	7	"	ideal is when get lots of stimulation ..
8	"		chuckles		
general			5	"	Kind of X-disciplinary. These disciplines need to work ...
7			chuckles		
4	team Q's	repeating scores.	10	"	" a @ that can only be answered ... "

### Running a Workshop

The typical structure of the workshop is as follows: (a) collection of participant information, (b) facilitator introduction, (c) participant introductions, (d) pre-dialogue instrument distribution and completion, (e) dialogue, (f) post-dialogue instrument distribution and completion, and (g) debriefing. Full workshops can be

completed in 2 to 3 hours. In what follows, we will describe each of these stages in turn.

*Collection of Participant Information.* If there is a desire to keep track of the participants for any reason (e.g., to contact them after the workshop), they should be asked to sign in at the beginning of a workshop and provide their names and contact information. If data will be collected, they should also be assigned participant codes and be asked to indicate their consent to be research subjects. The participant code should be assigned in a straightforward way (e.g., beginning with one person and continuing in sequence around the room) and is used by the recorder to keep track of participant speaking turns anonymously. It is also copied by the participants into the demographic form on the Toolbox instrument so Likert-scale reactions can be associated with workshop comments. If signed consent forms are required per an organization's Institutional Review Board, this is also an appropriate time to distribute and collect those.

*Facilitator Introduction.* Workshops begin with a preamble by the facilitator, addressing the following points:

- *The structure of the session.* After a self-introduction, the facilitator will describe how the workshop is organized and what participants will do.
- *The purpose of the session.* Based on the character of the team as revealed by the preliminary information collected, speak to the opportunities that exist to develop their communicative and collaborative capacities in the workshop. Emphasize the importance of understanding the research assumptions of one's collaborators and the power of philosophical dialogue to enable collaborators to see the research landscape through each other's eyes, thereby enhancing mutual understanding and scientific communication.
- *The organization of the Toolbox instrument.* Note the modules to be discussed by the team and why they were selected. Indicate that each module comprises a core question and probing statements, each of which is accompanied by a numeric scale of agreement. Remind participants that the “don't know” and “not applicable” categories are acceptable choices.
- *The nature of the statements.* Explain that the probing statements are intended to promote dialogue. Some of the terms used in the statements may seem vague or ambiguous. Participants should be encouraged to address this as part of their discussion—coming to a mutual understanding of the different interpretations of these terms is part of the exercise. Some of the statements contain absolute terms (e.g., *must*, *never*, *always*). This is intentional and designed to elicit distinct reactions on the Likert scale but, more important, to motivate discussion that seeks more precise or measured understanding of the issue raised by the prompts.
- *The nature of the dialogue.* Explain that the dialogue will begin once the Toolbox instruments have been completed. There is no one starting point within the Toolbox—where a team begins will depend on what issues are of greatest interest to participants. Explain that the facilitator will not participate in the dialogue but will encourage movement around the instrument to ensure coverage. Indicate that the participants should discuss the core questions and probing statements rather than engage in an abstract discussion of the instrument or workshop, as the debrief will afford opportunity for that discussion.

- *Detail about data collection.* As indicated above, participants should be notified in advance if data will be collected from them for research purposes; further, they should be asked to provide consent to be research subjects prior to delivery of the preamble. Even so, the preamble should be used to ensure that participants fully understand the planned uses of these data. If the session will be audiorecorded, explain why and how the recording will be handled and archived. Remind participants that all data collected will remain confidential.
- *Follow-up activities.* If data will be collected, what will be done with them? At the very least, the workshop will generate Likert reactions as recorded on the instruments used by the participants, and these could be collected and stored as data. Any follow-up analysis or conversation about data collected during the workshop should be described.

*Participant Introductions.* Although not necessary if the participants know one another, a brief introduction by each participant sets the tone for a session. In particular, setting aside time for participants to describe themselves (e.g., what discipline(s) they represent and how much research experience they have) can contribute to the formation of a temporary community that supports a candid exchange of assumptions. The goal is to help generate the comfort and trust necessary for an engaged and honest dialogue (Bracken & Oughton, 2006; Lewicki, McAllister, & Bies, 1998).

*Pre-Dialogue Instrument Distribution and Completion.* After the introductory remarks and participant introductions, the facilitator distributes the Toolbox instrument and instructs the participants to respond to each of the 34 statements using the Likert scales. This will take about 15 minutes. Participants should be encouraged to make notes on the instruments about their scoring decisions or other thoughts they might have about the prompts. This can be useful during the dialogue to help participants remember the reasons they selected a certain score. Participants will likely change their minds about various prompts but should be encouraged not to change their Likert scores during the discussion if the organizer has planned to collect a second Toolbox instrument after the dialogue.

*Dialogue.* After each participant has completed the Toolbox, the facilitator will invite anyone in the team to initiate the discussion by commenting on a core question or probing statement that intrigues them. The dialogue can continue for up to 2 hours. For some teams, 2 hours may feel inadequate, while other teams will have covered the material in a shorter time. The facilitator must judge when to close the dialogue based on available time and group energy level.

There will be concerns about the specific language used in some of the prompts. As noted above, not all the terms used in the instrument have precise, unambiguous meanings, and we intentionally do not provide a glossary of the terms used. By leaving the terms undefined, the Toolbox instrument makes room for participants to articulate during the dialogue how they understand these terms and the scientific or philosophical concepts they denote and to move toward common ground even in the short time of one session. This is valuable because it requires participants to articulate tacit commitments they may not have considered clearly before, and it can enable negotiation among collaborators about how the terms should be understood in the context of their project. Note, for example, the following exchange, which likely would not

have happened if the instrument came with definitions for key terms such as *science*:

Participant 9:	Well, I put a “one” [strongly disagree] because I don't believe the world is independent of the investigators. But if I were focusing on the first part of the thing, “scientific research aims” [to identify facts about a world independent of the investigators], then I probably would have said, “Yeah, I agree with that.”
Participant 1:	I think it depends on how you define science. The conventional definition of science, which equates almost to experimentation, you would put “yes.” But science is being reinterpreted through Habermas and different philosophers about research.

Leaving key terms undefined frees participants to think more broadly about different aspects of the research process, such as this exchange about basic and applied research:

Participant 7:	I would like us to think about our definitions of basic and applied research... I think of some of the social-science type research I do as basic, because I'm trying to understand human behavior. But to me, applied research has taken on sort of an unrealistic definition, and is often considered less valued than basic research.
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The above statement was shortly followed by this one:

Participant 3:	One of the challenges is that there's a vocabulary thing, and what I find actually quite funny in a lot of peer-reviewed papers is people will do an absolutely, perfectly good piece of work. But then because they feel this tension about being applied, they try to show how they've also done something basic, and they start—to put it bluntly—bullshitting their way around.
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There is no single formula for successful workshop facilitation because teams differ widely in engagement, composition, and group dynamics. Ideally, facilitator involvement in the dialogue will be minimal, but some involvement can be necessary, including responses to direct questions or concerns about the workshop process and suggestions to break a silence and move the team along. These responses require tact and restraint to avoid disrupting the flow of the discussion. Generally, the facilitator should interrupt active discussion only when a participant directly asks a question. Procedural questions should be answered as succinctly as possible. If participants ask about the meaning of a word, the facilitator should remind them that group discussion of vague or ambiguous words is a valuable part of the Toolbox process by saying something like this:

Facilitator:	“Values” is one of those words that we use to get participants to think about their meaning. So becoming clear on what that term means in different contexts is a goal of this particular set of statements.
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If necessary, the facilitator can draw out details about participant views when they are important to the unfolding dialogue, particularly when the conversation becomes stalled. Sometimes this can involve simply asking a participant to explain his or her Likert score:

Facilitator:	So what <i>did</i> cause you to circle four there?
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At other times, a direct appeal for expanded discussion will be helpful:

Facilitator:	So I'll just ask, as facilitator—did others find selecting a score impossible or difficult?
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The facilitator should also ensure that each module of the Toolbox is discussed, although the importance of this will be based on the team's goals and the available time. In our experience, it is more important to spend time on each of the modules than on each of the prompts, not all of which may speak to a given team. Comprehensive coverage of the modules can be accomplished by encouraging participants to discuss other areas of the Toolbox when the conversation becomes excessively focused on a single prompt or module:

Facilitator:	I'm curious, in light of this conversation about social construction, what your responses were to the preceding statements in that section?
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On the other hand, a long discussion about a particular prompt may reveal important differences in research approach among team members, and further discussion—perhaps even after the Toolbox—might be warranted.

Near the end of the dialogue, the facilitator may invite conversation about undiscussed parts of the Toolbox to ensure participants consider, however briefly, other concepts that interest them:

Facilitator:	You did discuss a lot that pertains to [prompts] 22 and 27 with respect to values, so I'm going to ask in the last 10 minutes if there are questions in [the Values Module] or anywhere else in the Toolbox where you felt that we didn't cover something that was intriguing to you.
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The facilitator should take note of prompts that generate pronounced philosophical difference. These can be revisited by the team after the workshop, either in team meetings or subsequent Toolbox discussions. (See the section on p. 237, “How to Build on the Toolbox Workshop.”) How the team addresses these differences—which may not be problematic—will depend on team goals and the context of their project.

*Post-Dialogue Instrument Distribution and Completion.* It is an important part of the Toolbox method to complete a post-dialogue instrument. This helps participants lock in awareness of how their perspectives have been influenced by the Toolbox dialogue. When we conduct Toolbox workshops, we do this immediately after the dialogue; however, it is also an option to e-mail the instrument to the participants for completion after the session. This may be necessary given time or logistical constraints in the workshop session, and it may be desirable because it allows time for ideas to percolate—although it should be sent within a few days to minimize the impact of non-workshop-related influences.

*Debriefing.* The final part of the workshop should be a debrief conducted by the facilitator. The debrief provides an opportunity for the team to reflect on the experience. Participants are often eager to offer personal reactions and suggest ways to improve the activity, and it is important that they have an opportunity to do so as part of the workshop. The debrief can be centered on questions such as these:

- What are the most interesting things you learned during the workshop?
- Are there aspects of scientific research that you would have liked to talk about but were not included in the Toolbox?
- Do you think the team would benefit from additional time with the Toolbox?
- Do you have additional comments or questions?

These questions provide an opportunity for teams to summarize the experience for themselves and identify issues for further discussion by the team. The facilitator should close the workshop by explaining any post-workshop activities and products that will be produced, such as transcripts or Likert-score analyses, as described in the next section. If follow-up reactions from the participants will be collected via a survey instrument, this should also be mentioned at the end of the workshop.

## Analyzing Toolbox Data

The workshop can generate two types of data available for subsequent analysis: a transcribable audio file and the pre- and post-dialogue Likert-scale reactions to the probing statements. Analysis and reflection on these data are important parts of the method, helping the team make sense of the experience and improve its communication and collaboration. Data of both sorts can reveal important characteristics of individual teams that can help them work more effectively together. For example, careful review of the transcript or audio file can support reflection on the research assumptions discussed during the dialogue, revealing for the team areas of potential conflict.

Transcripts can be examined for the number, distribution, and order of speaking turns and total time speaking by participants, which can reveal structure and relationships within the team (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). The length of discussion and number of participants contributing to discussion of a particular core question or probing statement can help identify issues important to the team.

A summary of pre- and post-dialogue Likert scoring can reveal patterns in the views held by the team. For example, team members may agree on issues such as the importance of applied science and the role of stakeholders but disagree on the validity of reductionist methods. Examination of pre- and post-dialogue scores can show whether these views were stable or changed during the workshop. Many of the prompts in the Toolbox instrument are intended to engender discussion rather than serve as the basis for rigorous analysis.<sup>8</sup> Nonetheless, the scores can be used by the team to reflect on their experience. The scores can be visualized by using standard graphing programs to display pre- and post-dialogue reactions in a variety of ways, such as displaying the reactions of all participants to each prompt (see [Figure 11.3](#)).



**Figure 11.3 Pre- and Post-Workshop Likert Scores**

NOTE: The magnitude of each symbol indicates how many respondents chose that score for that question. For questions 22 and 28, the change of many participants' answers from "?" to a numeric scale suggests that discussion relevant to this question may have clarified team members' views on the probing statement.

The Likert reaction summaries, the transcripts, and transcript analyses can help teams identify areas that warrant further attention as they continue their collaborative work. These areas could include problematic conceptual differences or more project-specific issues. The Likert score summaries and transcript or audio file can also be shared with new team members, easing their transition into the collaboration.<sup>9</sup>

## How to Build on the Toolbox Workshop

As a stand-alone exercise, a Toolbox workshop can help a team understand the diversity of views among its members about fundamental aspects of science and collaboration. These insights can inform a team's approach to formulating research questions, structuring collaborative effort, and generating products consistent with its goals. The Toolbox Project has also developed follow-up activities to capitalize on workshop insights. Such activities are part of a more comprehensive set of practices designed to enhance group communication and collaboration skills, which are interdependent and necessary for cross-disciplinary success (see Klein, [Chap. 2](#), this volume). Below we describe a few follow-up activities that the Toolbox

Project has used with collaborating teams.

NOTE: The magnitude of each symbol indicates how many respondents chose that score for that question. For questions 22 and 28, the change of many participants' answers from "?" to a numeric scale suggests that discussion relevant to this question may have clarified team members' views on the probing statement.

### Reflection

Several teams have indicated that they continue to discuss their Toolbox experience during their ongoing work together. Some have dedicated post-workshop meetings to reflecting on the experience and digesting summary documents when these have been generated. In the Toolbox Project, we distribute a post-workshop survey and use this when developing our response to the participating team. Self-administered workshops could employ a similar survey to guide follow-up discussion. Useful prompts include the following:

- Describe the key discovery for you as an individual scientist during the dialogue.
- Explain why you think (or do not think) participating in the Toolbox workshop helped your professional development.
- From your experience with this team, explain whether you think mutual understanding of one another's philosophical orientations and disciplines is important for interdisciplinary team function.
- How have your individual views on the philosophical basis of your disciplinary science shifted since completing the workshop? Explain whether the Toolbox workshop contributed to that shift.
- What philosophical aspects of scientific research were not well covered through the Toolbox?

### Follow-Up Workshops

Several teams have requested a second workshop, in some cases involving new members. A few of these have been conducted at one of the team member's homes in the evening in a relaxed atmosphere. In this setting, exploration of the Toolbox prompts can become deeply personal, contributing in diverse ways to group coherence and understanding. Follow-up workshops need not cover the entire scope of the Toolbox instrument, instead focusing on modules or prompts that have emerged as important for the team.

### Customized Toolbox Instruments

The Toolbox in its current form is modular, which facilitates the creation of specialized core questions and prompts that pertain specifically to the team. As indicated earlier, we have created two new instruments for translational health science and climate science, developing modules that are appropriate to teams working in those contexts. These contexts put in play different philosophical issues, such as the challenge of harmonizing evidential standards between the bench and the clinic and cultivating trust between natural resource managers and academic scientists.<sup>10</sup> Both instruments were designed collaboratively with teams who ultimately used them in pilot workshops. Another approach is to insert into the relevant modules customized prompts submitted by team members that target specific issues of concern for the team. To retain the texture of Toolbox prompts, these should focus on abstract or conceptual dimensions of the team's

collaborative work. In the principal case where we employed this method, the team spent most of their follow-up workshop discussing these customized prompts, which included, “It is possible to combine qualitative and quantitative approaches from different disciplines to answer interdisciplinary questions,” and “Verbal communication (e.g., phone, Skype, face-to-face) with all team members present is critical for team success.”

### Other

Additional follow-up activities include concept mapping and specialized case analysis. Cross-disciplinary projects can benefit from concept mapping to delineate the systems under investigation and identify research questions and integration opportunities (Heemskerk, Wilson, & Pavao-Zuckerman, 2003; Morse, [Chap. 12](#), this volume). These exercises can be enriched using the insights gained from a Toolbox workshop, indicating on the map the concepts and activities related to important philosophical dimensions within the team. Maintaining and adjusting these maps as the project progresses can be a helpful way to revisit these aspects of the research effort.<sup>11</sup> Specialized case-study analysis involves developing focused, detailed vignettes that emphasize conceptual issues that arose for the team in the workshop. For example, a team of biologists and engineers might identify *hypothesis* as a concept that divides them; armed with this information, they could then describe situations in which these differences could threaten the success of their collaborative project. The vignettes then could be distributed among team members and discussed in a follow-up meeting. Also available are exercises designed to promote collaborative decision making, aid in the formulation of research questions, illuminate group dynamics, and enhance mutual understanding and awareness (e.g., McDonald et al., 2009; Repko, 2008; Winowiecki et al., 2011).

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## Conclusion

The Toolbox workshop can be thought of as an “epistemological intervention”—that is, an interruption of day-to-day research business designed to highlight the styles of knowledge making distributed across a collaborating team (O'Rourke & Crowley, 2012). This intervention can be extremely valuable in addressing complex problems for teams that work across disciplines. Teams of this type can devote significant effort to determining how to collaborate successfully and may struggle if differences in research approaches used by different members go unidentified. Such differences, especially if not uncovered early in a team's life, can complicate the work of the team and even make it dysfunctional, resulting in a degraded effort.

Having a group conversation about underlying assumptions can engender mutual understanding and improve communication about science that continues throughout the life of the project. The Toolbox method is designed to generate just such a discussion, making these assumptions salient by exposing the philosophical “landscape” of a team during a single workshop. Prospective participants may balk at the idea of spending 3 hours “talking philosophy,” even if it is philosophy of science. However, we like to think that this type of conversation is analogous to turning on a desk lamp before sitting down to work—a small investment of time, energy, and attention that can pay big dividends down the road.

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## Take-Home Messages

- Effective communication across disciplines is important to the success of cross-disciplinary research teams.
  - Guided discussion about philosophical aspects of research (e.g., epistemology, metaphysics) provides an opportunity to illuminate team dynamics and research worldviews in an abstract landscape while avoiding project-specific baggage.
  - The Toolbox workshop provides cross-disciplinary research teams with a framework for engaging in discussion about concepts fundamental to scientific practice, promoting mutual understanding among team members about their disciplinary perspectives and practices.
  - The do-it-yourself instructions identify the essential aspects of running a Toolbox workshop and provide suggestions for post-workshop activities to enhance the experience for participants.
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## Acknowledgments

This material is based on work supported by the National Science Foundation under Grant No. SES-0823058 and IGERT Grant No. 0114304. Any opinions, findings, conclusions, and/or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

This chapter is much improved thanks to comments received from Gabriele Bammer, Troy E. Hall, Graham Hubbs, Julie Thompson Klein, and David Stone.

We thank all additional members of the Toolbox Project and Toolbox collaborators who have contributed to the approach presented in this essay: Carolyn Hovde Bohach, Brian Crist, Ruth Dahlquist, Troy E. Hall, Renée Hill, Justin Horn, Graham Hubbs, Ian O'Loughlin, Sara Pepper, Dan Schmidt, Lynn Schnapp, Lori Stinson, David Stone, Brianne Tice Suldovsky, Andrew Turner, Chris Williams, and our project advisers Frank Davis, Paul Griffiths, and Julie Thompson Klein. We are grateful to the participants of the “Enhancing Communication in Cross-Disciplinary Research” conference held in Coeur d'Alene, Idaho, in October 2010 for stimulating discussion of these issues.

We are also grateful to the more than 700 participants in 91 workshops conducted in the United States and Canada since 2006.

<sup>1</sup>See Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, ‘translations’ and boundary objects: Amateurs and professionals in Berkeley’s Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science*, 19, 387–420 (especially p. 393). For additional discussion of boundary objects, see Griffiths and Stotz, [Chapter 10](#), this volume.

<sup>2</sup>We use the term *cross-disciplinary* to denote the range of efforts that involve integrating different disciplines

to various degrees, including *multidisciplinary*, *interdisciplinary*, and *transdisciplinary* efforts (cf., Morse, Nielsen-Pincus, Force, & Wulforth, 2007). We also intend it to accommodate *translational* efforts that involve the integration of disciplinary research with various professions (e.g., natural resource management, medicine) and stakeholders. This type of research is known as *transdisciplinary* in some circles, adding to the potential confusion that we seek to avoid by using a more generic term (see Klein, 2008).

<sup>3</sup>We distinguish between *groups* and *teams*, taking the latter to be groups that exhibit greater cohesion and a common identity (Fiore, 2008).

<sup>4</sup>In principle, the idea of enhancing cross-disciplinary communication through philosophical dialogue is not limited in application to *scientific* collaborations; however, the structured intervention we have designed is based on an instrument created with scientific collaborations in mind. We have used this instrument with nonscientific teams and found it to be less effective at creating common ground among participants. The Toolbox Project is working on extending the intervention into these directions through the development of new instruments that relate more effectively to less research-focused teams.

<sup>5</sup>The STEM fields are science (including social science), technology, engineering, and mathematics.

<sup>6</sup>“Translational” refers to the transfer of research knowledge from its point of origin (e.g., a laboratory) out into the world. In the health sciences, translational research is popularly known as “bench-to-bedside” research and typically involves nonresearch partners such as doctors, nurses, K–12 educators, and patients (National Institutes of Health, 2011). We extend the translation metaphor to climate science and other research that involves participation of nonacademic partners, such as natural resource managers and growers (Greenland & Leach, 2008; Musacchio, 2008).

<sup>7</sup>See Eigenbrode et al. (2007) for further elaboration.

<sup>8</sup>This is so for two reasons. First, as we have noted, many of the statements contain terms that are vague or ambiguous, giving rise to conflicting initial interpretations that are occasionally revealed to be terminological in character; thus, wide variation in initial scoring need not signify wide cognitive variation. Likewise, similarities in scores may not signal agreement. Second, the Likert scales are intended at least in part to spur dialogue by presenting the appearance of difference, motivating participants to talk about the statements.

<sup>9</sup>The Toolbox Project team is available as a partner in data analysis and other aspects of the Toolbox experience. After Toolbox Project–facilitated workshops, we can provide a complete analytic report that includes the perceptions of the session facilitator and recorder, a synopsis of a post-workshop questionnaire, summaries of Likert-score and transcript statistics, a complete copy of the transcript, and suggested next steps for the participating teams. The Toolbox Project maintains a database developed from the workshops we have conducted, including transcripts, Likert scores, and demographic data. Partnership with the Toolbox Project makes possible comparative analysis across other teams selected on the basis of variables important to the participating team. In addition, the Toolbox Project team (see <http://www.cals.uidaho.edu/toolbox/>) can assist with the creation of project-specific modules, suggest new tools for team development, and provide “Train the Trainers” workshops for teams interested in developing the Toolbox idea further.

<sup>10</sup>For more details about the translational health science instrument, see Schnapp et al. (2012).

<sup>11</sup>We have employed concept maps extensively in the National Science Foundation Integrative Graduate Education and Research Traineeship (IGERT) projects at the University of Idaho. The six IGERT teams in the current project have explored this approach, and it has contributed to their thinking about research design, integrative research questions, and available integration opportunities; our impression is that it has promise if conducted iteratively as a project concept is developed.

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