

Northeast and Islands
Regional Educational
Laboratory

222 Richmond Street
Suite 300
Providence, RI 02903

e-mail:
info@alliance.brown.edu

web:
www.alliance.brown.edu

THE ROLE OF FACILITATION IN ONLINE PROFESSIONAL DEVELOPMENT:

Engendering Co-construction of Knowledge



Stephanie Feger and Melanie Zibit

The Education Alliance at Brown University

Since 1975, The Education Alliance, a department at Brown University, has helped the education community improve schooling for our children. We conduct applied research and evaluation, and provide technical assistance and informational resources to connect research and practice, build knowledge and skills, and meet critical needs in the field.

With offices in Rhode Island, New York, Puerto Rico, and the Virgin Islands, and a dedicated team of over 100 skilled professionals, we provide services and resources to K–16 institutions across the country and beyond. As we work with educators, we customize our programs to the specific needs of our clients.

Northeast and Islands Regional Educational Laboratory (LAB)

The Education Alliance at Brown University is home to the Northeast and Islands Regional Educational Laboratory (LAB), one of ten educational laboratories funded by the U.S. Department of Education's Institute of Education Sciences. Our goals are to improve teaching and learning, advance school improvement, build capacity for reform, and develop strategic alliances with key members of the region's education and policymaking community.

The LAB develops educational products and services for school administrators, policymakers, teachers, and parents in New England, New York, Puerto Rico, and the Virgin Islands. Central to our efforts is a commitment to equity and excellence. Information about all Alliance programs and services is available by contacting:

The Education Alliance at Brown University	Phone: 800.521.9550
222 Richmond Street, Suite 300	Fax: 401.421.7650
Providence, RI 02903-4226	E-mail: info@alliance.brown.edu
	Web: www.alliance.brown.edu

Authors: Stephanie Feger and Melanie Zibit

Editor: Cynthia Way

Designer: Patricia McGee

Copyright © 2005 Brown University. All rights reserved.

This publication is based on work supported by the Institute of Education Sciences (IES), U.S. Department of Education, under Contract Number ED-01-CO-0010. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of IES, the U.S. Department of Education, or any other agency of the U.S. Government.

About the Authors

Stephanie Feger is a Program Planning Specialist in Educational Technology at The Education Alliance at Brown University. Her research interests include the design and evaluation of online learning environments. Related publications include: “Steering Toward Others: Emergent Strategies for Facilitating in Practice-Based Learning Communities” with Melanie Zibit (2005), and “How to Develop a Coaching Eye” in the *Journal of Staff Development* (2004).

Melanie Zibit is a Research Associate at Boston College. She researches models and strategies for facilitating online learning, particularly mathematics online professional development. Her research has been funded by the National Science Foundation, the U.S. Department of Education, and GE. A speaker at national conferences, her articles include “Telementoring as a Collaborative Agent for Change” and “The Peaks and Valleys of Online Professional Development.”

Acknowledgements

Support for Professional Learning, a program of The Education Alliance at Brown University, seeks to develop effective tools and strategies for technology-based professional learning. Supported through funding from the Northeast and Islands Regional Educational Laboratory, the goal of the Investigations Online project is to develop and refine the content and features of online seminars that support educators using *Investigations in Number, Data, and Space*, a standards-based, K–5, mathematics curriculum.

We wish to acknowledge the support and collaboration of Mary-Beth Fafard, Martin Huntley, Kristine Woleck, Paul Hickman, Andee Rubin, Alida Frey, and Ellen Knudson in conducting this work. We thank Jennifer Borman, Tom Crochunis, Vanessa Dennen, Patti McGee, K. Ann Renninger, and Cynthia Way for their guidance and suggestions during the preparation of this paper.

We also thank the Investigations Online participants for sharing their experiences, insights, and challenges into coaching and teaching during the seminars.

This paper is also available from The Education Alliance’s online publications catalog at: http://www.alliance.brown.edu/db/ea_catalog.php

THE ROLE OF FACILITATION IN ONLINE PROFESSIONAL DEVELOPMENT: Engendering Co-construction of Knowledge

■ Abstract

This paper examines the role of facilitation in the Investigations Online seminars, which support the professional learning of elementary school teachers and mathematics specialists using the Investigations in Number, Data, and Space curriculum. Our study considered how a facilitator fosters collaborative discussion that leads to co-construction of knowledge among seminar participants. We used a mixed methodology, incorporating both quantitative and qualitative approaches. Based on a technique for analyzing text messages in online courses, we first assessed levels of teaching presence (Anderson, Rourke, Garrison, & Archer, 2001) through a comparative analysis of six Web-based seminars. Although facilitation in online professional development shares characteristics of teaching presence in online courses, we observed that professional learning entails the use of additional facilitation strategies. To further investigate the role of facilitation in the context of online discussions, we adopted a grounded theory methodology. Taking examples from these discussions, this paper describes a key strategy, “steering toward others,” that the facilitator uses to foster mathematical inquiry and build professional knowledge for teaching practice.

■ INTRODUCTION

Historically, teacher learning has been considered an individual endeavor, outside the realm of shared inquiry or knowledge building among educators (Huberman, 1983). With policy and educational standards setting collective expectations for student achievement, teachers must now develop their individual classroom practice with the larger goals of school and district in mind. Therefore, professional development that supports ongoing, collaborative learning is vital for improving student outcomes. In many instances, however, professional development is an isolated training event rather than an opportunity for teachers to actively learn in the context of their practice. This is particularly true of traditional professional development models where workshops are delivered and information presented, but content is often not tied to relevant curricula and practice (Loucks-Horsley, Hewson, Love, & Stiles, 1998). In addition to the limitations of traditionally structured professional development, the requirements of the teaching day itself make it difficult for educators to find time to work and learn together. For educators with scant time or resources available, online professional learning can be a particularly powerful option.

An online approach to professional development offers an innovative means for teachers to plan instruction, obtain feedback, and exchange resources with colleagues (Harasim, Hiltz, Teles, & Turoff, 1998). Expanding beyond a single location, an online professional learning community can form to meet the particular needs and interests of teachers around specific content or curriculum, connecting to their peers at a distance (Riel & Polin, 2004). The potential of online resources to support professional learning has been noted in recent studies for improving mathematics education (National Research Council, 2001; RAND Mathematics Study Panel, 2003). In particular the RAND Panel emphasizes “developing improved means for making mathematical knowledge that is useful and usable for teaching available to teachers,” citing “curriculum materials, technology, distance learning, and effective assessments” as examples of such tools (Summary, xvii). Web-based tools have been acknowledged as a means for social interaction that can help shape an open, fluid, and distributed environment for knowledge building—which Brown described as a “learning ecology” (2000, p. 19). But in order to make effective use of these resources, professional developers need to understand how to design and facilitate social interaction that supports learning (Lehtinen, 2003).

The Education Alliance at Brown University, through the Northeast and Islands Regional Educational Laboratory (LAB), has been investigating how online environments can be designed to support professional learning in content areas such as mathematics. The Investigations Online project designed a series of online

seminars that supported elementary school educators using the *Investigations in Number, Data, and Space* curriculum. The project developed two types of seminars¹: one focused on the coaching role for mathematics specialists working with classroom teachers, and another addressed the topic of assessing student work in teaching multiplication.

The overall aim of this research study was exploratory, seeking to understand the process of facilitation as a key element in the design of these seminars. Our study addressed two questions: (1) What is the role of the facilitator in the online seminars? (2) What strategies does the facilitator use to deepen participants' knowledge of mathematics and teaching? Analysis of six sessions led by the same facilitator provided a control on variation across the seminars, allowing a serious consideration of the practice. In this paper, we provide the theoretical background that informed our approach, describe our methodology, and present the results from our study on the role of the facilitator in the *Investigations* seminars.

¹ The seminars were developed with assistance from Paul Hickman and Alida Frey at the Center for the Enhancement of Science and Mathematics Education (CESAME) at Northeastern University, and Andee Rubin of TERC. CESAME and the LAB also collaborated in developing a Web-based network (<http://www.lab.brown.edu/investigations>) to support implementation of the *Investigations in Number, Data, and Space* curriculum.

■ THEORETICAL PERSPECTIVES

■ Support for Professional Learning

Professional development offers the potential for transforming privately held practitioner knowledge into a common professional knowledge domain (Eraut, 1995; Hiebert, Gallimore, & Stigler, 2002). In outlining the features of practitioner knowledge in the teaching profession, Hiebert et al. note that: (1) it is grounded in the classroom context in which teachers work and develops in response to specific problems of practice; (2) it is detailed and specific (e.g., points to the reading of a particular book or the teaching of a unit in a mathematics curriculum); and (3) it integrates knowledge of content and pedagogy in order to teach effectively (p. 6). Deborah Ball (1997) explains that teaching as a knowledge domain draws from varied sources including pedagogical knowledge, knowledge of the discipline (e.g., mathematics), and knowledge about students and their development. Moreover, in practice all of these sources are intertwined and are not easily extracted and synthesized into useable knowledge. In order to arrive at this professional knowledge base, Hiebert et al. advise that in contrast to a private teaching practice, “practitioner knowledge must be public,” (p. 7); professional knowledge must be “storable and shareable;” and finally, “to verify and improve professional knowledge requires a system of quality control” (p. 8).

Research on high-quality professional development provides guidance on improving practice through defining the characteristics that support professional learning for teaching (Elmore, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Ball & Cohen, 1999; Hawley & Valli, 1999). These characteristics articulate a set of principles where professional development is viewed as improving student learning through deepening teachers’ knowledge of content. Addressing the essential connection between the learning of teachers and that of their students, Elmore (2002) states that the focus of professional development should be on “enacted practice”—meaning, the combination of content (the what) and pedagogy (the how) of teaching and learning (p. 8). Accordingly, high-quality professional development needs to engage educators in active learning experiences, fostering knowledge of subject matter along with clinical skills that enable teachers to diagnose and develop next steps to guide student learning. Professional development should also be structured in ways that increase communication and collaboration with colleagues over time to ensure sustained attention to critical topics (National Staff Development Council, 2001).

Social Interaction and Online Learning Communities

A primary consideration for professional development that focuses on knowledge building is the importance of social interaction as a fundamental process of learning (Lave & Wenger, 1991; Brown & Campione, 1994; Bransford, Brown, & Cocking, 2000; Riel & Polin, 2004). Theories of situated learning (Lave & Wenger, 1991) point out that “learning is an integral part of generative social practice” (p. 35); novices learn through sharing and discussing their work with others who have greater expertise. Collins, Hawkins, and Carver (1991) suggest that a learning community can be characterized by the active participation, communication, and engagement with the skills involved in developing expertise, such as proficiency in solving problems and carrying out tasks in a domain. Social interaction underscores the importance of a learning community in making internal thought processes public, or “making thinking visible,” as a prerequisite for knowledge building (Collins, Brown, & Holum, 1991, p. 6).

In knowledge-building environments (Scardamalia & Bereiter, 1994) such as online seminars, more experienced participants (including facilitators) do not remain on the periphery. They participate actively with less-knowledgeable participants, who also play an important role as they point out what is difficult to understand. Productive interaction takes place within the community, when knowledge is adapted and built upon by others. In the context of mathematical learning communities, it is particularly important to combine knowledge-building discourse and subject matter (Nason & Woodruff, 2004). Nason and Woodruff note that the mathematical problems posed by these communities are characteristically open ended, non-trivial, “and typically involve several ‘modeling cycles’ in which descriptions, explanations, and predictions are gradually refined, revised, or rejected” (p. 105). Thus, online discussion offers the potential to support professional learning through creating opportunities for extended mathematical discourse.

Because structures that support mathematical discourse and professional learning can be enhanced through social processes, social interaction is a primary consideration in designing online learning. But facilitating communication and knowledge-building discourse also requires someone who can guide learners in the application and misapplication of knowledge. Therefore, in addition to considering the principles of high-quality professional development, it is important to examine the role of the online facilitator and the particular strategies used to stimulate knowledge building.

Facilitation in Online Learning

The role of the facilitator in online professional development is new and emerging. The literature suggests various examples, including the role of an e-moderator to manage discussion (Salmon, 2000), or the more formal role of an online course instructor similar to the teaching role in academic settings (Dehler, 2004). Kleiman

(2004) offers examples of online professional development designed to improve teacher quality as required by the No Child Left Behind Act. One is the Florida Online Reading Program that offers courses facilitated by reading specialists. A second is a program in Milwaukee Public Schools that offers shorter online workshops facilitated by school staff. According to Kleiman, lessons learned from evaluating online professional development point to “the nature of the online interactions between learners and instructors” as a critical factor for successful learning (p. 10). Yet in a review of the research on interactions between teachers and students in higher education, Wallace (2003) notes that: “The work of online teaching, especially as it relates to interacting about subject matter, is not well described or researched” (p. 272). With the instructional role in online settings becoming increasingly important, there is a need for studies that focus on the role of a facilitator and how the role is developed and carried out.

Wallace (2003) notes that research on instructional roles in the online context is still at an early stage. This is due in part to early models of distance education that adopted traditional designs for learning where students worked on their own and teachers responded only when they were asked for help (p. 260). In contrast to the traditional view of an instructor as someone who imparts knowledge, the online facilitator is seen as someone who offers “guidance” (Palloff & Pratt, 1999), using strategies such as open-ended questions and synthesizing comments from the individual messages posted in a discussion (p. 74).

Bonk, Wisner, and Lee (2004) add that online instructors should not only support interaction but also need to know when to push individuals and groups further and when to step in to offer help to participants in constructing new knowledge. Striking a balance between supporting interaction and pushing participant inquiry, the facilitator is also described as instrumental in synthesizing distributed knowledge and guiding groups toward deeper insights (Collison, Elbaum, Haavind, & Tinker, 2000). This is akin to the model proposed through cognitive apprenticeship (Collins, Brown, & Newman, 1989), where learners acquire skills and knowledge in their social and functional context, through the modeling, coaching, and scaffolding of an expert, in this case the facilitator.

Although awareness of the communication strategies that foster interaction and learning in an online environment are important, engaging teachers in professional development also requires a thorough understanding of the classroom context and content area, such as mathematics. A similar model is advocated for the mathematics classroom (National Council of Teachers of Mathematics, 2000), where supporting the development of children’s mathematical thinking in the elementary grades requires more than merely being competent in teaching procedures for solving computational problems (Baroody, 2003; Nason & Woodruff, 2004). Teachers must also facilitate an understanding of the concepts and application of mathematics

(Ball & Cohen, 1999; Schifter, 1996), in order for students to engage in knowledge-building discourse as a primary mode of exchanging ideas and negotiating meaning (Scardamalia & Bereiter, 1994).

In our approach to the design of the online seminars, we viewed facilitation broadly—encompassing various communication strategies, while remaining grounded in the content and discourse of the discipline. In addition, although the facilitator in the Investigations seminars held deep knowledge of the mathematical content and curriculum, she also considered herself a learner who was able to identify with participants as they developed and tested their own knowledge. Our approach to facilitation required particular expertise to assist participants in bridging the gaps that they, or the teachers they are working with, had concerning their knowledge for teaching mathematics.

METHOD

Seminar Design

The principles of high-quality professional development and theories of social construction of knowledge through mathematical discourse served as foundational concepts for the design of the Investigations seminars. In addition, the seminars align with the features of practitioner knowledge outlined by Hiebert et al. (2002), in that the seminars are focused on classroom teaching, responsive to participants' day-to-day problems of practice, and based on specific knowledge of mathematics intrinsic to the *Investigations* curriculum. In conducting several seminar cycles, we considered these features as we developed and refined the key elements of the seminar design. These design elements include:

- 1 Learning materials, such as case studies of critical incidents in coaching, examples of mathematical problems posed by the curricula, focus questions, samples of student problem-solving strategies, and research articles;
- 2 A facilitator who uses strategies that foster interaction and learning in the online environment and supports the seminar dialogue;
- 3 Peer-to-peer interaction, which is supported by the seminar structure and asynchronous discussion tools to allow a sequenced progression of dialogue.

Seminar I – Coaching

The coaching seminar, *Leading the Way: Coaching Teachers Using Investigations*, was an eight-week session for coaches working with teachers in their classrooms. The seminar was designed to foster a process of inquiry and reflection that would help participants identify critical features of the coaching role and enhance their skills in supporting teachers in the classroom. Throughout the seminar, participants examined and analyzed case studies based on incidents of classroom practice. The purpose of the case studies was to provide diverse images of mathematics coaching that explored a variety of coaching strategies and issues. The cases served as a catalyst for discussion and as a common tool to support the inquiry in the learning community (Barnes, Christensen, & Hansen, 1994; Miller & Kantrov, 1998).

An emphasis of the seminar was the active participation of members of the online community. Participants read cases and research articles throughout the seminar, and each case was preceded by a mathematical problem related to the curriculum. Responding to the cases, associated focus questions, and peer-to-peer discussion entailed at least two online postings each week. At the conclusion of the seminar, participants drafted a discussion case based on their own work in coaching to share with the online community.

Seminar II – Student Work

The second seminar, Mathematics in the Works: Multiplication, Grades 3–5, was an eight-week session that built approaches to teaching multiplication through examining student work. This seminar focused on helping teachers deepen their knowledge about multiplication through gaining insights into the ways children develop an understanding of mathematical operations. The purpose of looking closely at student work was to analyze students’ strategies for solving problems and provide a common platform for participants to build their knowledge of the constructs underlying the curriculum and the implications for classroom practice (Kazemi & Franke, 2003; Lesh, Lovitts, & Kelly, 2000).

In the seminar, participants engaged in mathematical problem solving in order to deepen their content knowledge. Topics addressed various aspects of multiplication including: properties and strategies of multiplication, computational fluency, foundations of multiplication, and “scaling up” to bigger numbers and more complex problems. Participants examined student work from actual classrooms, including individual examples to make comparisons with other students’ work, examples from individual students over time, and examples from a whole class set. In their postings, participants were encouraged to cite specific aspects of the student work as evidence that supported their statements. Readings and resources from specific *Investigations* curriculum units and from other professional development materials further framed the discussions.

Participants

For the seminars, we recruited applicants by e-mail and Web notices through the CESAME Support Site for *Investigations* and professional networks. Applications came from urban, suburban, and rural communities and also from international schools. We selected participants based on criteria that included (a) the active use of the *Investigations* Support Web site, (b) the degree of coaching responsibilities in their jobs, (c) at least one year’s experience with the *Investigations* curriculum, (d) the socio-economic need of students, and (e) limited access to other professional development support. A total of 117 educators participated in the seminars. There were 57 participants in three coaching seminars and 60 participants in three student work seminars. The facilitator was involved in the design and conduct of the seminars and in coaching the “facilitator-in-training” who was preparing to take on this role in future online seminars. A profile of the lead facilitator is included in Appendix A.

■ Research Study

In this study, we took an exploratory and pragmatic approach to understanding the role of facilitation. We used mixed methods to collect and analyze data from the six online seminars (Rocco, Bliss, Gallagher, & Perez-Prado, 2003; Tashakkori & Teddlie, 1998). We applied both quantitative content analysis and qualitative analysis of the facilitative strategies using grounded theory. The study reflects a parallel/simultaneous mixed method design, where both types of data were “collected at the same time and analyzed in a complementary manner” (Tashakkori & Teddlie, 1998, p. 47). Although our approach was informed by theory regarding professional development and facilitation, we also were interested in developing new conceptualizations regarding how a skilled facilitator constructs the role in *medias res* of online professional development.

We were also informed about strategies directly from the seminar facilitator who, in commenting on her role, provided additional guidance for the study. In a written reflection, she described a strategy that she used to engage participants in the seminar discussion, and her comments, shown in the excerpt below, inspired us to ultimately define this strategy as “steering toward others”:

However, even in instances of explicit requests for information or need for clarification, I often steer participants toward others in the group who may be good resources or hold knowledge specific to a topic: “What resources have others found valuable in this work?” “Perhaps _____ has some further insights into this...” This serves to balance the need of the individual making the request with the need to continue to build a sense of community among all the participants. (Woleck, 2004)

During our first phase of analysis, we used an a priori coding scheme from a teaching presence framework that Anderson, Rourke, Garrison, and Archer (2001) originally developed in the context of distance learning in higher education. This framework guided our analysis of the facilitators’ postings based on the key constructs of (1) Instructional Design and Organization, (2) Facilitating Discourse, and (3) Direct Instruction.

In order to extend an understanding of the facilitative role in the context of the discussions, we adopted a qualitative approach using grounded theory methodology (Glaser & Strauss, 1967; Strauss & Corbin, 1990). Acknowledging the use of mixed methods, Strauss and Corbin propose that grounded theory may also be adapted and combined with other types of methodologies and that qualitative data may be useful in illustrating or clarifying quantitative findings (p. 18). In their techniques for generating theory, they also suggest that the procedures may apply to projects that involve theme analysis or concept development (p. 115), as ours did.

Data Sources

We collected data from three coaching seminars and three student work seminars (six total). Transcripts of the facilitators' postings were drawn from the archived textual data generated by the online discussions. Although the content of the seminars differed, the seminar structure itself was consistent. Weekly topics in the coaching seminar used the discussion cases during weeks one through five, and the student work seminar presented multiplication problems from the curriculum and examples of student problem solving in a similar weekly format. Subsequent weeks of the seminars featured individual case writing and teacher-as-researcher projects. The transcripts we reviewed included full data sets for topics discussed during the first five weeks of each seminar. To triangulate our data sources, we used questionnaire feedback gathered from the participants following each seminar and written reflections from the facilitator herself.

Given our interest in looking at the interactions between facilitator and participants, we focused on the threaded messages containing facilitator and participant responses as a productive starting point. Because our study aimed to provide an in-depth understanding of the strategies for facilitation in the Investigations seminars, we determined that including both types of seminars in the data sample would offer variation in topics but with the consistency of the same lead facilitator. In undertaking a systematic analysis of the transcripts, the large amount of data generated from each seminar prompted us to look at ways to reduce the data sample. Using a mixed methods approach, the teaching presence content analysis allowed for a preliminary categorization of the data thereby reducing the data sample. We further limited the sample through a process of coding and analysis during data collection (open sampling); this involved selecting portions of the transcripts that inform the development of emergent categories and their properties (Strauss & Corbin, 1990; Sarker, Lau, & Sahay, 2001).

Data Analysis

Teaching Presence

We first analyzed the facilitators' messages using the teaching presence coding scheme established by Anderson et al. (2001) (see Appendix B). The teaching presence framework breaks down the role of the online teacher/facilitator into three categories: (1) Instructional Design and Organization, (2) Facilitating Discourse, and (3) Direct Instruction. Each of the three categories has a sub-set of indicators.

The first category, Instructional Design and Organization, describes the process of planning the online course, including the structure, evaluation, and interactive

components (p. 5). Facilitating Discourse refers to the ways in which the teacher models communication behaviors—encouraging participant dialogue and managing responses from more and less active participants (p. 7). Direct Instruction points to the presentation of content and development of inquiry through directing students’ attention to concepts necessary for knowledge building (p. 9).

Anderson et al. emphasize that subject matter expertise is a critical factor for online learning, particularly as it relates to Direct Instruction. Because we viewed subject matter expertise as characteristic of the lead facilitator’s approach, the indicator of Direct Instruction became an important lens from which to analyze strategies in the online professional development seminars. Among the benefits we saw in using the teaching presence framework were the reliability of the instrument having been established through an analysis of graduate-level distance education courses and the ease of learning and using the straightforward coding procedure.

Applying the teaching presence framework, we coded the facilitators’ postings from both types of seminars—a total of six seminars. The postings consisted of 279 messages, 269 analyzed from a single facilitator and 10 messages from the “facilitator in training.” The two researchers worked independently, analyzing each posting as a single message unit in applying the teaching presence coding scheme. The facilitators’ postings were coded as message units, with each message rated on whether it showed evidence of none, one, two, or three of the indicators of the teaching presence categories. We then compared the coding results and together discussed any discrepancies in the ratings.

Grounded Theory

Grounded theory analysis of the data began informally at first. Our procedure conforms to the grounded theory approach in which the researcher does not engage in his/her role as a detached observer (Strauss & Corbin, 1994, p. 280). In our own situation, one of the researchers was also involved in the planning and conduct of the seminars; keeping up with the discussions and communicating with the facilitator was a customary part of the work process. Thus, serving an integral role in the seminars provided relevant experience for building familiarity with the seminar activities and a way to become steeped in the discussion data. This “hands-on” perspective enhances what Strauss and Corbin (1990) term “theoretical sensitivity,” which they describe as “an awareness of the subtleties of meaning of data” on the part of the researcher (p. 41). The formal phase of analysis began as the researchers started working together to understand the facilitative strategies in the online seminars.

Grounded theory analysis is framed by the three basic coding procedures (open, axial, and selective) that also guide the sampling of data.

Open coding. The first stage of the grounded theory method is open coding, which “fractures the data” into segments that are labeled to form categories and are compared across the data sources (Strauss and Corbin, 1990, p. 97). As we read through the transcripts and recorded the teaching presence categories, we were also interested in the interplay of mathematical ideas and pedagogical issues for participants in the seminar discussion. Consequently, we flagged messages when we noticed the emergent “steering toward others” strategy that the facilitator had noted. At this stage, we identified messages that appeared to be stronger or weaker examples of this strategy. We then reviewed and discussed our selections together, identifying 36 facilitator posts (including threaded replies from participants) that showed strong evidence of the strategy in use. We completed the review by annotating our selections in a log that outlined what was happening in each particular seminar. In recording these notes, we also began to generate questions and speculate about the role of the facilitator. We built upon our initial observations through constant comparison across the seminars, making revisions to clarify our coding concepts.

Axial coding. During axial coding, data is put “back together in new ways” to explore relationships across the categories (p. 97). Through axial coding, we sought to unpack, refine, and link the concepts in the facilitators’ messages labeled during open coding. We used various dimensions of “action and interaction”—meaning, patterns of action and interaction among various “actors” as outlined in the grounded theory approach (Strauss & Corbin, 1994, p. 278). We analyzed the data asking specific questions: for example, is there a sequence or process in the interactions between the facilitator and participants? Is there evidence that the strategy is purposefully oriented? Are there examples of failed attempts? At this point in the analysis, we were striving not to develop formal or substantive theory, but “conceptual density” of the facilitator’s role in the online seminars that would provide rich concept development grounded in data with meaningful variation and robust examples (Strauss & Corbin, 1994, p. 274).

Selective coding. In the final stage, we consolidated core categories to extend and verify theory development. The process of selective coding is one where a storyline is explicated that links and validates the categories and sub-categories established in the previous phases of work (p. 116). According to Strauss and Corbin, the theory that is produced consists of “plausible relationships proposed among concepts and sets of concepts” (Strauss & Corbin, 1994, p. 278). The significance of such theory can be either substantive or formal, based on the situational context of the study (Strauss & Corbin, 1990, p. 174). A substantive theory arises from a study “in one particular situational context,” while formal theory examines phenomenon “under many different types of situations” (p. 174).

RESULTS

Teaching Presence

The concept of teaching presence is defined as “the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes” (Anderson et al., 2001, p. 5). We used the teaching presence framework to validate the intentional focus on mathematical content in the seminar design. Following the initial coding of the facilitators’ messages for assessing teaching presence, the coding results were evaluated for inter-rater reliability using Cohen’s kappa. The ratings for the coaching seminar were $S1 = .96$, $S2 = .96$, and $S3 = .89$, and for the student work seminar, $S1 = .92$, $S2 = .84$, $S3 = .87$. Ratings of .80 and above are deemed satisfactory using Cohen’s kappa, and this measure was used by Anderson et al. in establishing the reliability of their coding procedures.

Table 1 presents the results from the analysis of the facilitators’ messages in the six Investigations seminars, showing the frequency and percentage of the teaching presence categories. The percentages were calculated by dividing the total number of messages in a particular teaching presence category by the total number of messages posted by the facilitator.

TABLE 1: FREQUENCY AND PERCENTAGE OF TEACHING PRESENCE CATEGORIES IN FACILITATORS’ MESSAGES

	COACHING			STUDENT WORK		STUDENT WORK
TEACHING PRESENCE CATEGORIES	SEMINAR 1	SEMINAR 2	SEMINAR 3	SEMINAR 1	SEMINAR 2	SEMINAR 3
Instructional Design and Organization	18 60%	12 35%	19 51%	25 39%	26 39%	11 23%
Facilitating Discourse	29 97%	31 91%	33 89%	52 83%	51 76%	44 94%
Direct Instruction	26 87%	27 79%	31 83%	44 69%	52 78%	33 91%

In analyzing the data across the seminars, Facilitating Discourse emerged as the leading category and was evident in an average of 86% of all facilitator messages.

The category of Direct Instruction appeared in an average of 76% facilitator messages. Instructional Design and Organization was the least evident category with an average frequency of 40%. Examples from the analysis of both the coaching and the student work sessions further illustrate indicators of teaching presence in the facilitator's conduct of the seminars.

Instructional Design and Organization

Anderson et al. describe the category, Instructional Design and Organization, as building the curriculum and creating and integrating learning materials. In the Investigations seminars, the facilitator engaged in this task by developing resources such as discussion cases and working with the seminar design team to integrate these resources into the online environment. Repurposing materials such as lecture notes was also identified as an element of the Instructional Design and Organization category. Over time, the archived postings became a resource that the facilitator made use of in posting responses to participants. The negotiation of time lines for group activities and project work was also a responsibility of the facilitator. For example, the structure of the seminars included weekly stand-alone topics, and the facilitator set the curriculum through an initial posting and added a mid-week message to focus the discussion. The following message illustrates an aspect of Instructional Design and Organization in the student work seminar. The text in bold refers to the indicator from the teaching presence framework identified as *establishing time parameters*.

Note: In this and all other examples of messages from the Investigations seminars, original spelling and punctuation are preserved, and the names of participants and students are changed.

*After reading this message, click on the "Week 1 – Posting 1" message. This message posts the assignment and focus questions to consider for your first posting in week 1 and it refers you to a multiplication cluster problem to solve. You should find a hard copy of the cluster problem in the packet sent to you (if you have not received a packet, please let us know). The cluster problem is also posted in electronic form in this folder under the title "Cluster Problem." Please **post your response to the cluster problem work and focus questions in the folder labeled "General Discussion" by Wednesday of this week.***

Finally, Anderson et al. identify *designing methods* as another indicator for this category. We observed this indicator in the Investigations seminars in the development of small-group structures to enhance participant interaction, and this in fact led to further design changes in the seminar discussion structure overall (For a description of this change, see Lalli & Feger, 2005).

Facilitating Discourse

Carrying out the role of the online instructor as described in the teaching presence framework depends upon using skills in modeling discourse to maintain the interest and engagement of the learning community (Anderson et al., p. 7). This includes supporting participation, commenting upon student responses, identifying areas of agreement and disagreement in the discussion, and offering guidance as to how conflicting ideas might be examined and resolved in light of new understandings (p. 7). We observed indicators for Facilitating Discourse in the Investigations seminars. The indicator, *encouraging, acknowledging, and reinforcing student contributions*, was evident in the facilitators' in-depth comments—noted across all six seminars. This indicator is shown in bold in the example below. Here the facilitator acknowledges the contributions of a participant who has commented on the teacher-coach interaction presented in one of the discussion cases.

*Sharon made reference to the importance of the coach question that began the conversation with Ann, "What did you notice?" as an important moment in the interaction. Not only did this question provide the coach with valuable information regarding the teacher's understanding, it established a collaborative tone; **it was put forth in a "collegial manner" as Sharon pointed out.** Drawing on moments you note in the case or your own experience, how else does a coach establish trust, validate the teacher, and build a collaborative relationship?*

This example also underscores a point mentioned by Anderson et al. that a facilitator can stimulate social processes with a goal of enhancing collective learning through prompting and drawing participants into the discussion (p. 7). The facilitator also exhibited a scaffolding strategy, where she built upon the participant's comments. The facilitator then invited other participants to extend the point by sharing examples from their own experiences in working with teachers, which we noted as illustration of the steering strategy.

Additional indicators of Facilitating Discourse include *identifying areas of agreement/disagreement* and *seeking to reach consensus/understanding*. In this example from the coaching seminar, the facilitator highlighted an "area of disagreement" where there were divergent opinions on the timing of demonstration lessons:

Glad to hear this conversation on a very tricky and at times controversial issue in coaching! Just to let you know, we'll be looking more closely at the issues of modeling and demonstration lessons and possible variations and structures (pros and cons) during week 4 of the seminar...

Direct Instruction

The final category of the teaching presence framework, Direct Instruction, is an area where Anderson et al. stress the importance of “a subject matter expert in the critical discourse” (p. 9). Indicators include: *present content/questions, focus the discussion on specific issues, summarize discussion, confirm understanding through assessment and explanatory feedback, diagnose misconceptions, inject knowledge from external sources, and responding to technical concerns.*

Based on our coding and analysis of the Investigations seminars, Direct Instruction was a significant component of the facilitators’ messages. In the following message, we note two indicators of Direct Instruction as the facilitator does “*summarize the discussion*” of a student’s explanation of a cluster problem, and then “*present content*” regarding the student’s understanding of the operation of multiplication:

As I “visited” each of the folders, there were some common threads of discussion that cut across the folders. Many of you pointed to the language of “4 groups of 6” that Abigail used as significant in terms of demonstrating a level of understanding with regard to the operation of multiplication. Indeed, this explanation of her strategy suggests that Abigail is not relying on a rote procedure—some students as they encounter cluster problems will notice $40 - 4 = 36$, and subtract the answers to each of those problems (lining them up vertically as if performing a traditional algorithm) without conceptually understanding WHY that approach works and how it connects to the operation of multiplication. Abigail, however, understands that her approach works for this cluster because each piece of the problem relates to “groups of 6.”

In the first case, the facilitator synthesized various comments made by participants, noting how they agreed that the student’s articulation of “4 groups of 6” provided an explanation of the cluster problem that adequately demonstrates an understanding of the mathematics. She built upon this idea by interjecting comments that refer participants to common misunderstandings that students might have about multiplication and how they might be represented. The facilitator then contrasted that misconception with the approach used by the student, in this case pointing to evidence from the student’s work that validated her understanding of multiplication. Here the facilitator did more than simply “*diagnose a misconception*” on the part of the seminar participants—one of the indicators of Direct Instruction. The facilitator was clarifying concepts related to students’ understanding of multiplication and how they may misconstrue mathematical ideas. These examples point to evidence of Direct Instruction, and they also show some of the intricacies of facilitation when situated in the repertoire of practice that draws upon both subject matter knowledge of mathematics and how that knowledge might be applied in the classroom.

Additional Facilitative Strategies

Some of our observations about facilitative strategies were not captured in the teaching presence framework. We also noticed strategies such as supportive scaffolding (Dennen, 2004), and we identified examples where we viewed evidence of the lead facilitator's steering strategy. For example, the seminar facilitator commented that there were times when there was a need for postings "with a much more direct tone" (p. 4). The facilitator mentioned that she made these kinds of direct postings to "clarify information (or misinformation) or address requests with regard to specific mathematical ideas, resources, or pedagogical issues" (p. 4). These examples conform to the indicators of Direct Instruction in the teaching presence framework. But the facilitator also mentioned that she made direct postings to keep participants "grounded in the cases or student work at hand" so that the seminar did not turn into a session where the focus was "to 'solve' the classroom dilemmas and larger school issues that many will share in their postings" (p. 4). This moves beyond the paradigm of Direct Instruction.

In her paper on this topic, the facilitator cites the importance not only of "acknowledging, confirming, and validating the participants' postings and comments," but also "the manner in which a facilitator poses questions, probes participants for deeper conversations, prompts further reflection, or extends discussions" (Woleck, 2004, p. 3). The strategy of probing questions is noteworthy. The seminar facilitator explains that this "involves 'listening' to the points and concerns that participants are raising in relation to an artifact of the seminar being discussed," before making decisions about where to focus attention in the discussion. The facilitator mentions two purposes for using questioning and probing. First, they push participants to reflect on issues and thereby "build deeper meaning and connections for themselves." Second, extending the discussions in this way "also lends itself to a community of learners" that can open up dialogue with other participants in the seminar. She adds that it is through questioning and probing that "the discourse remains open, rather than coming to a close with some 'final word' from me as the facilitator." This highlights the depth that we see in the facilitator's strategies for engaging social interaction among the seminar participants. Thus, in addition to assessing levels of teaching presence, we were also interested in looking at the moves that the facilitator made during the seminar and what happened when they took place. We were investigating a dynamic view of facilitation that would yield insights not only in the aggregate, but also in particular instances where the facilitator's intentions might be revealed. Through the grounded theory approach, we were able to further explore how the facilitator's actions influenced the exchange in the online discussion.

■ Grounded Theory

Developing Categories

As a result of open coding, we framed an initial set of categories (see Appendix C), which we continued to merge, refine, and group together through axial coding (see Appendix D). As Strauss and Corbin (1990) note, “In axial coding we begin to fit the pieces of the puzzle together” (p. 211). They suggest the use of a visual diagram (p. 217) and coding paradigm to aid in building links and understanding relationships between categories and sub-categories (p. 96).

We then created a diagram (see Table 2) to visualize the categories that we had defined during axial coding and to assist in the process of selective coding. At this point, we began to consider relationships between the categories that would extend to theory development about facilitation in the online seminars.

TABLE 2: MAPPING MAJOR CATEGORIES

SUB-CATEGORIES FOR COACHING SEMINAR	CORE CATEGORIES FOR PRACTITIONER KNOWLEDGE	SUB-CATEGORIES FOR STUDENT WORK SEMINAR
<ul style="list-style-type: none"> ■ Mathematical concepts ■ Mathematical reasoning ■ Questioning 	↔ Mathematics ↔	<ul style="list-style-type: none"> ■ Mathematical concepts ■ Robust strategies ■ Communicating mathematically ■ Computational fluency
<ul style="list-style-type: none"> ■ Curriculum resources 	↔ Curriculum ↔	<ul style="list-style-type: none"> ■ Modeling mathematical concepts ■ Planning next steps ■ Mathematical discourse ■ Problem-solving strategies
<ul style="list-style-type: none"> ■ Thinking systemically ■ School culture ■ Identity 	↔ Context ↔	<ul style="list-style-type: none"> ■ Student development of mathematical ideas
<ul style="list-style-type: none"> ■ Demonstration lessons ■ Interpersonal classroom dynamics ■ Knowledge gaps ■ Modeling 	↔ Practice ↔	<ul style="list-style-type: none"> ■ Studying algorithms ■ Thinking through students’ strategies

The center column presents the core categories that emerged during selective coding and how these core categories might connect to the sub-categories noted in both types of seminars. We defined these core categories for practitioner knowledge as: mathematics, curriculum, context, and practice. During selective coding, we also sought to verify the core categories for practitioner knowledge that we viewed being developed through the interactions between the facilitator and participants. Next, we present examples of how we verified the core categories in the context of the coaching and student work seminars.

Mathematics. Through the method of constant comparison across the coaching seminars, we observed a repeated emphasis on the part of the lead facilitator for participants to address the definition of mathematical concepts such as place value. In one seminar discussion, the facilitator referred to place value as a “core mathematical idea.” The facilitator characterized this focus on the mathematics as a large part of what coaching is—namely, supporting teachers in deepening their own understanding of mathematical concepts and terms, so that they can facilitate this understanding for students. Of specific interest were questioning strategies that a coach might pose for a teacher’s consideration as a way to support children’s understanding of the mathematics at different grade levels, or stages of fluency within a grade-level group.

In the student work seminars, the utility of questions for deepening mathematical understanding was also noteworthy, but in this case the focus was first on examining the student’s development and communication of mathematical ideas as presented in the work sample. From there, the discussion moved to posing questions that a piece of work might raise for participants in their teaching, followed by determining a series of follow-up questions grounded in the mathematics that a teacher could pose to a student. Thus, the core category of mathematics arose in both seminars as an important part of the facilitator-participant interaction and instrumental for building practitioner knowledge.

Curriculum. Implementing the *Investigations* curriculum requires a dramatic change in instructional strategies for many elementary teachers (Collopy, 2003). The use of the various explanatory resources such as Teacher Notes and Dialogue Boxes was a specific topic in the coaching seminar. A particular focus of the discussion concerned how to encourage teachers to use these materials and how coaches could structure the use of these resources into professional development activities.

Throughout the student work seminar, there was a focus on how the curriculum builds and teaching expectations shift as a student’s mathematical understanding develops from year to year. The facilitator pointed participants to examples in the curriculum that extend students’ understanding of multiplication using various representations in the *Investigations* units where models such as arrays are used

throughout grades 3–5. Another reference is called the “Start With” problem, essentially “worked” examples (Atkinson, Derry, Renkl, & Wortham, 2000), which help scaffold student approaches to problem solving. Students are provided with a first step for solving computational problems, allowing them to build more complex strategies for multiplication such as moving up from single- to double-digit multiplication examples. Thus, in both seminars we found a link between the sub-categories of curriculum resources and the utility of the curriculum in developing students’ mathematical ideas, thereby verifying curriculum as a second core category.

Context. Examples from the coaching seminars pointed to the larger stage of circumstances and events in which participants work. Coaching discussions sometimes focused on specific issues of teaching and learning, such as how cross-grade understanding could serve as a leverage point for extending support of mathematics reform beyond individual classrooms. More frequently, the discussion of context was situated in the larger issues of coaching in a school or district. Although the coaching role was defined as supporting teachers in developing their mathematical understanding, coaches were often working with individuals who were not always receptive to having someone in their classroom. Coaches needed to stay attuned to the larger social, cultural, and political realities arising in their work.

In the student work seminar, the classroom itself became the setting for understanding context in relation to building practitioner knowledge. The seminar provided a reflective context for looking at student work in relation to understanding, but often the reflexive nature of teaching emerged. The facilitator then needed to pull the seminar back from responses that solely focused on “What are the next steps for this student” to the prior question of “What questions do you have around this student’s work?” The facilitator often pushed the participants to be specific in their discussions when reviewing student work, asking them to think through and articulate the actual questions that they might pose for an individual student to target a particular problem or a whole class to launch a discussion. Thus, context, whether situated in the school, district, or classroom, was an important frame of reference and a core category for building practitioner knowledge.

Practice. In the coaching seminars, the focus on practice was two-fold. It involved examining the knowledge, skills, and strategies of the coaching role and how the role is carried out in classroom interactions with teachers. Discussions in the seminar developed in response to the specific demands of coaching practice such as methods for conducting demonstration lessons or interpersonal dynamics with teachers and administrators. But beyond discussion of structuring activities, it was the mathematics itself raised in the interactions between the facilitator and participants that served to bridge the coaching role and teaching practice. While acknowledging the external demands, such as state testing and accountability or resistance to the curricula that coaches mentioned as challenges in their practice,

the facilitator refocused the discussions for the purpose of supporting teachers in understanding the mathematics and the implications for student learning. The stance that the facilitator brought to the discussion was to encourage the articulation of mathematical concepts as they are applied in practice.

Throughout the student work seminar, participants compared their analysis of student strategies and discussed whether they provided a strong foundation for deepening mathematical understanding. Participants explicated and reformulated the multiplication problems posed in the seminar and also conjectured about whether a student's strategy could be generalized. In one example, a participant mentioned that "based on the student work samples, I would predict that [the students] have developed strategies that can be applied easily to larger numbers." The facilitator acknowledged this comment asking the participant to test out her prediction by applying the students' strategies to larger numbers. In doing so, she underscored the need to push for understanding as the basis of inquiry in practice. These instances provided confirming evidence for the core category of practice through linking practitioner knowledge with mathematical discourse.

Illustrating the Steering Strategy

Our initial understanding of the steering toward others concept was refined and extended through further analysis. In both types of seminars, we noted that the strategy of steering toward others could be viewed as an interaction directed toward an individual, as in the facilitator's comment, "You may be interested in 'visiting' Jessica's posting in the Blue folder." The strategy could also be directed to a group: "Let's open that up for some discussion as well—what is it that teachers need to know across grade levels?" Moreover, the facilitator was not simply steering toward another's knowledge of practice, or even tacit knowledge based on context, but toward collectively needed knowledge of the mathematics and the curriculum: "... this may be a good place for us to push ourselves as well in terms of communicating mathematically."

We also noted that these core categories were intertwined with facets of mathematical content and pedagogy. In response to the facilitator's steering, key aspects of the knowledge domain were emerging as participants engaged in building a professional knowledge as outlined by Hiebert et al. (2002). Through sharing and discussing their thinking and problem solving with a focus on the mathematics, participants were making "practitioner knowledge public," and also making it "shareable and stored in the online discussion." Additionally, the facilitator, with her professional expertise, provides for quality control by serving as means for "verifying and improving professional knowledge."

This steering strategy was a successful way to acknowledge and empower participants as well as to make visible important points that participants raised. In describing her

strategy, the facilitator said, “Often too I will reflect on the points brought forth in participant postings and the issues that the given learning materials were intended to raise for discussion.” As we continued to investigate the patterns of discourse and learning throughout the seminars, we found that the facilitator was not only steering participants toward one another but also was steering toward other areas with a deeper perspective in mind. Through our analysis, we observed that the facilitator was making visible more profound questions and issues such as mathematical problem solving, teacher and coaching practices, evidence of student mathematical understanding, and fostering student development. We see this process as steering more broadly. Following are samples of discourse from the seminars—one from the coaching seminar that exemplifies the evolution of our understanding of steering toward others and a more detailed one from the student work seminar that illustrates our later understanding of the steering strategy.

Coaching Seminar Example

During the coaching seminar, there was a lively discussion of how the curriculum builds across grade levels. The facilitator picked up on the issue raised in one of the participant’s messages and commented:

Lisa mentioned the value of teachers developing an understanding of mathematical ideas across grade levels in Investigations, of knowing not only the mathematics at their own grade level, but also seeing the connections across the program K–5.

This comment opened up the possibility for the facilitator to develop the issue, and she articulated a series of questions for the group to consider in detail:

Let’s open that up for some discussion as well—what is it that teachers need to know across grade levels? How can cross-grade conversations and learning happen? What are the structures that can support that?

In this example of steering toward others, the facilitator extended comments made by one of the participants to clarify the value of cross-grade understanding of the curriculum. Instead of responding directly to Lisa, she redirected the topic to solicit the distributed knowledge of the group. Her questions probed both for (1) the kinds of cross-grade understandings that are needed and (2) how these kinds of conversations can happen. Based on our initial observations, we outlined the facilitator’s steering toward others strategy as follows:

- (a) Awareness of a request for information or a need for clarification around an issue,
- (b) Foregoing a direct response,
- (c) Redirecting the discourse to amplify details of a given practice mentioned in a participant’s posting by prompting for the wider range of knowledge distributed across the group.

In the first part of this example, we saw the facilitator steering toward the circumstances, events, and environment within which mathematics coaching takes place. Through further analysis, we began to discern a more global approach to steering that appeared throughout the seminar dialogue.

Later in the same week’s discussion, participants responded to the facilitator’s questions on the cross-grade understanding (presented here as “vertical understanding”)—the notion that teachers need to deepen children’s understanding of mathematics as they move from grade to grade. One participant mentioned:

Our district will hold a two-week math academy this summer where the focus will be to give teachers a vertical understanding of how students develop mathematically K–8.

Continuing with this line of discussion, participants shifted the focus from a rationale for aligning the curriculum across grade levels to sharing practical suggestions for professional development activities that address vertical understanding. At this point, the conversation centered on teacher training in using *Investigations*—what teachers need to know across grade levels, and when and how to provide training. Then one participant moved the dialogue forward more substantively. Referencing pedagogy related to vertical understanding, she commented:

Knowledge of how the curriculum builds vertically is important so teachers don’t work too long and too hard for ‘mastery,’ which they thought happened with traditional practice of rote procedures.

The facilitator added that she is also “trying to sort out when is the optimal time” for focusing on cross-grade alignment and included examples from her own classroom coaching work and meetings with grade-level teachers.

In this example, steering touched upon the experience of seminar participants in their coaching role in the classroom, the school, and ultimately the district. Through the steering strategy, the dialogue extended from classroom work with individual teachers to systemic mathematics reform with the coach as an agent

for change. Thus, this example captures a broader conceptualization of steering globally. In the seminar the steering strategy brought opportunities for the facilitator to engage participants in discussion around particular situations, but we also saw moments where participants digressed from the main point. Often in these instances, the facilitator skillfully guided the discussion back on track to re-engage participants in a central topic. This re-engaging was another instance where we had to rethink our conception of the facilitator's steering strategy to encompass steering more broadly as a way to elicit new knowledge in the seminar.

With this reformulation of the steering strategy, we turn to an example from the student work seminar that demonstrates both steering toward others and steering more broadly. It highlights the facilitator's ability to continually bring the conversation back to key points, while at the same time being respectful of participant perspectives.

Student Work Seminar Example

In this week of the seminar, participants were asked to solve the cluster problem of 6×36 , describe what mathematical ideas and understandings they used to solve it, and then analyze fourth-grade student Abigail's work. The purpose was to cite evidence from the work sample to support their observations about the student's understanding of mathematics and at the same time to deepen their own understanding of subject matter. (Cluster problems allow students to build on what they know using smaller, easier problems to help them solve a harder problem). Mid-week, the facilitator summarized participants' responses, noting that many "cited Abigail's clarity in making the point of 4 groups of 6," and many also wondered how she solved the other "smaller" problems in the cluster and noted how they would have pushed her to explain her thinking for each of those problems.

The facilitator, using steering toward others, pointed to the comments of one participant who reflected on how if she were the teacher:

...she might ask Abigail to explain how she solved 6×20 and 6×40 ...she would like to probe Abigail's thinking further about these two smaller problems specifically in order to determine how Abigail makes sense of multiplying by ten and multiples of ten.

The facilitator noted that she was "curious as to how others would expand the explanation that Abigail wrote." She added that some of the groups mentioned that they would have liked an explanation with greater depth. The facilitator, steering toward the group, asked, "I think this may be a good place for us to push ourselves as well in terms of communicating mathematically....How would you articulate the strategy she used?"

Further along in the posting, again using steering toward others, the facilitator noted:

You may be interested in “visiting” Jessica’s posting in the Blue folder. There, she follows her review of Abigail’s work with a series of questions that the piece raises for her, questions that she would pose to Abigail in the classroom. This is a very powerful use of student work ...examining the piece and determining those follow-up questions, grounded in that single piece of work and the mathematics at hand, that you the teacher would pose to a student.

One participant stated: “If I know that a student is secure on a concept, I may not require that he include an explanation.” This brought a response from the facilitator that raised the level of discussion to the topic of interpreting student understanding: “Of course the challenge in that is to have the evidence that allows us to ‘know’ with confidence that in fact the student does ‘know it.’” Another participant, branching off in the discussion, mentioned that state standards demand more complete explanations of student work in preparation for the test, “even though we ‘know’ some students have a strong grasp of the underlying math concepts.” So now the topic of assessment moved from the discussion of student work to issues of accountability. One participant commented:

We’ve got a state math portfolio here that is required in 4th, 8th, grades... Teachers at the 4th and 8th grade levels get a great deal of support around understanding what good problem-solving and high-quality explanations of mathematical thinking look like, as well as scoring portfolio problems but most of us can’t afford to take the time off from school to go to network meetings and get this information, so we flounder and we’re terribly inconsistent.

The facilitator then steered more broadly to redirect the conversation to the larger question of “evidence of student understanding”:

We do of course have an obligation to make certain that students are prepared for the state assessments they must take, but I think the question we should always ask ourselves in terms of a student’s explanation is ‘What evidence do I see of student understanding?’ ‘Has this student demonstrated full understanding of the mathematical content in this problem?’ SO then the question for all of us to consider is can a student demonstrate such understanding only with a lengthy verbal paragraph? Or can evidence be in the form of number sentences as well? What other models might also demonstrate understanding in a piece of student work?

Instead of answering the question of whether evidence can be either verbal or number sentences, a participant moved back to questions of what counted as evidence for an explanation:

As I work with teachers and see how each and every one of them has a different perspective on what a “good” explanation should look like, I find myself wondering if what I suggest to them is actually what TERC intended when they wrote the curriculum and assessments. Can you offer any additional insights—have they come to a consensus?

This brought a response from another participant confirming the same dilemma: “I, too, wish there was a right answer to this question. The teachers I work with have different expectations of evidence and justification when problem solving.”

The final posting in this thread was from a teacher who reflected on the difficulties of getting students who are procedurally strong to provide explanations about their problem solving:

I am forever challenged with those students who just know how to do math. They are so fluent in their operations that they have difficulty explaining, in writing, their strategies as they work through multiplication (as well as division) clusters. I have found that math journals and math portfolios are a great reference to understanding a student's thinking with regards to algorithms and operations. Yet, I still need to look into the minds of these proficient math learners. Any suggestions?

In this example, the facilitator pointed to one participant's statement of powerful questioning strategies that she suggested teachers might use with their students. She also stimulated higher level thinking when steering broadly; she asked the group to articulate what an explanation with greater depth would look like in this student's work, inviting a collective approach to constructing knowledge.

In review, our initial conceptualization of steering toward others was that the facilitator used this strategy to raise awareness of specialized knowledge that a member of the group might hold. However, we then discovered that the steering strategy also served to deepen discussion and collective knowledge of mathematics in the seminar. By pressing for explanations of greater depth, the facilitator was steering the group toward communicating about mathematical content. Instead of focusing solely on their own particular situations and accountability systems, participants engaged in a more powerful mathematical discourse that centered on the development of children's thinking about multiplication.

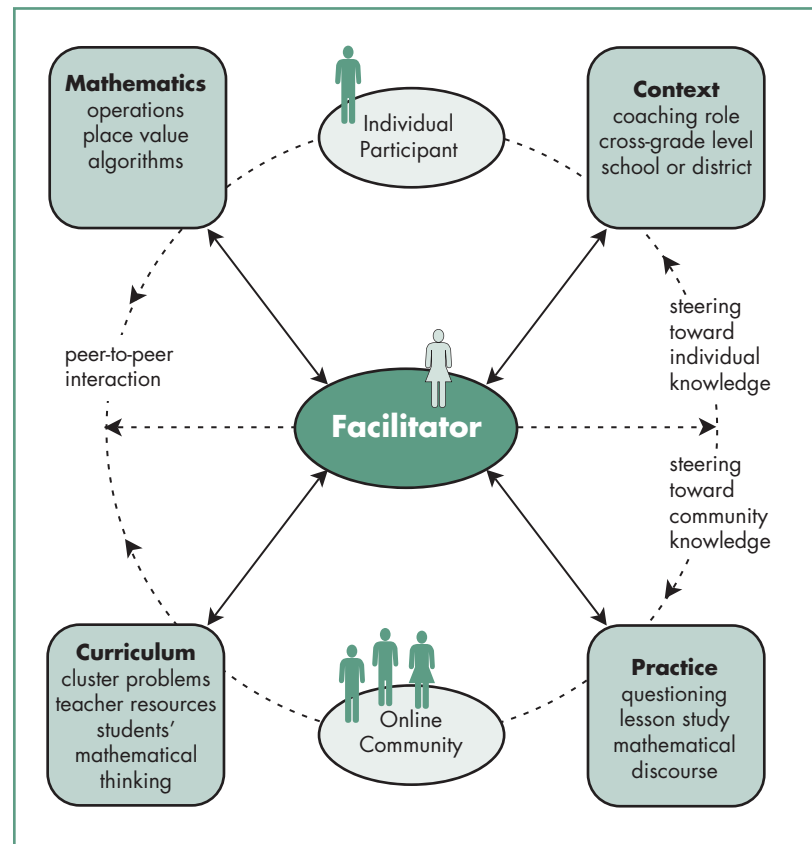
Defining a Theory

To further analyze the steering strategy, we entered the final phase of grounded theory, selective coding, in which the object is to develop a theory of relationships among the previously identified core categories (Creswell, 1998). The researchers reviewed the notes, memos, and diagrams from the previous phases of work and discussed preliminary ideas for the storyline based on an analysis of each seminar, with comparisons made across the seminars. According to Strauss and Corbin (1990), the storyline is “the conceptualization of a descriptive story about the central phenomenon of the study” (p. 119). The emerging storyline illustrated aspects of the role of the facilitator in both types of online seminars.

A significant theme in the coaching seminar storyline was the development of a coaching identity—the “coaching eye” (Feger, Woleck, & Hickman, 2004, p. 14), which coaches need in order to manage the complex situations that arise when their work enters a wider context. We saw the context of coaching—the circumstances and events ranging from working with teachers in the classroom to training and advocacy at the school and district level—as an important aspect of the interactions between the facilitator and participants. The facilitator helped participants navigate this unfamiliar terrain as they acquired the skills and abilities to transform their knowledge of mathematics to these new roles. In the student work seminar, the source of the storyline was mathematical discourse as it related to practice. The facilitator promoted inquiry into practice by asking the group to articulate what a mathematical explanation with greater depth would look like. These questions were often expressed as “pushing ourselves” or scaffolding questions that a teacher would pose to students to reveal the child’s thinking about mathematics. In this way, the facilitator’s actions focused on supporting participants in navigating the domain of teaching mathematics from a student-centered perspective.

Diagram 1 illustrates the storyline that emerged from both types of seminars showing the role of the online facilitator.

DIAGRAM 1: REPRESENTATION OF SEMINAR FACILITATION



As presented in this diagram, the facilitator's role involved a complex set of interactions that we see as actively navigating the group's engagement with the core categories of mathematics, curriculum, context, and practice. These categories encompass both individual perspectives and a shared knowledge base for the seminar. The diagram's arrows indicate the flow and processes of interaction among individual participants, the online community, and the facilitator. Through strategies such as steering, the facilitator played a pivotal role in guiding the development of a learning community.

The role of the online facilitator focused less on imparting knowledge but rather on eliciting ideas through extended discussion. Guided by the facilitator, participants explored and shared their teaching experiences, discussed their mathematical reasoning, exchanged multiple approaches to solving a problem, and reflected on their strategies for working with students. The facilitator played a critical role in engaging participants, extending their thinking and reflection, and fostering collaboration and community to maximize learning. This conceptualization aligns with the research addressed earlier in this paper regarding the development of knowledge-building discourse through access to a learning community (Nason & Woodruff, 2004; Scarmadela & Bereiter, 1994). Moreover, online formats such as the Investigations seminars allow teachers to engage in knowledge-building discourse as a primary mode for testing mathematical ideas and negotiating meaning that leads to deeper understanding.

■ DISCUSSION

■ Building a Dynamic Understanding of Facilitation

In conducting this study of the Investigations seminars, we sought to learn about the role of the facilitator and the strategies used to guide the online discussion. The choice of the teaching presence framework for analyzing the role of the facilitator provided a monitoring tool to organize the discussion data along constructs that we saw as important in our seminar design. As expected, we saw the facilitator engage in Instructional Design through development of curriculum and setting time parameters. We also observed the facilitator acknowledging contributions and drawing participants into the discussion; this confirmed Facilitating Discourse as significant strategy in understanding the role. The category of Direct Instruction, with its emphasis on subject matter expertise, was most relevant. Although we had a sense that teaching presence would provide a comparable set of strategies from which to gauge Direct Instruction in the seminars, we also acknowledged that online professional development as exemplified in the Investigations seminars was different from an online course. Direct Instruction refers to the content expertise of an instructor in the higher education setting where Anderson et al. tested the instrument, but Direct Instruction takes on even more multi-faceted qualities in the context of online professional development.

A particular emphasis of the seminar design was to have participants engage in doing the mathematics themselves, and the facilitator played an active role in framing mathematical ideas and how they are enacted in the curriculum. Specifically, the content of the Investigations seminars not only included knowledge of mathematics subject matter, but also required that the facilitator have a deep understanding of the specified curriculum, facility with a range of professional development activities, clinical skills and expertise in observing classroom practice, and insights into children's thinking about mathematics. Although subject matter expertise in mathematics was a critical component, the facilitator also needed to be cognizant of the needs of professional practice. This again points to the rich and detailed knowledge base (Borko & Putnam, 1995) of professional practice that draws upon and connects to the dynamics of learning as it happens in the classroom.

Based on further analysis from the Investigations seminars, we identified situations where the facilitator used a crucial strategy for building knowledge and fostering peer-to-peer interactions by “steering participants toward others in the group who may be good resources or hold knowledge specific to a topic” (Woleck, 2004). Our initial analysis indicated that the facilitator was steering toward others. Our study showed that the facilitator not only was steering participants toward one another, but also steering the group toward larger issues of mathematical problem solving and practice.

Steering toward others is a complex phenomenon that requires keeping a sense of where the community is—and where it has potential to go. At times this is a difficult balance for the facilitator. There were instances in the Investigations seminars (e.g., multiplication cluster problems) where some participants picked up on the strategies and others did not. Our analysis showed that there was a need to balance where the community was, so that in steering toward others the facilitator was also mindful to steer back toward the community.

Further Questions

Our findings on the facilitator’s role and the steering toward others strategy raised further questions: What makes steering toward others unique as a strategy? How does steering toward others contribute to understanding facilitation in online professional development? And what is the impact of using steering toward others in online facilitation?

To address these questions in this discussion, we group our findings around three principles used to categorize types of knowledge building and expertise in learning communities: (1) Content—types of knowledge required for expertise; (2) Method—ways to promote the development of expertise; and (3) Sociology—social characteristics of learning environments (Collins, Hawkins, & Carver, 1991, p. 220). Applying these three principles to an analysis of steering amplifies its meaning for facilitation in an online learning community. With Content, steering focuses on making connections with the concepts and processes of teaching mathematics, particularly those core categories that we found through our grounded theory analysis. For Methods, steering takes on the sense of coaching. For Sociology, steering stimulates mutual collaboration between participants to engender a learning community.

Content

Knowledge that teachers use is “craft” knowledge, characterized by its concreteness and contextual richness (Grimmett & MacKinnon, 1992). Skillful teachers do not operate from a set of principles or theories alone but rather build multiple scripts through experience in contextualized situations (Bolster, 1983). The content of the seminars centered around cases and student work—and are “windows” into a world of a complex set of events that are meant to emulate real-life teaching situations (Merseth, 1996). The seminar content offers the unique potential of providing participants with performance-based experiences to deepen their understanding and skills. They provide avenues for participants to grapple with classroom-based problems and devise strategies for influencing student learning. Effective case method instruction requires extensive, specialized skills; it is important to be thoroughly familiar with the subject at hand and also to understand how to apply the material in authentic situations.

Thus, we found that a facilitator needs to be grounded not only in the concepts of mathematics but also needs to understand how to teach those mathematical processes—reasoning, problem solving, communication, and making connections—that characterize deep mathematical understanding. It is the facilitator’s knowledge of mathematical teaching that allows her to spark cognitive dissonance and challenge participants to find solutions that are just beyond the learner’s ability. The facilitator must have command of the complex mix of practitioner knowledge, both explicit and tacit, to determine which points are important to raise for further examination.

In regard to content, the steering strategy seems to mediate discussions, refer to points that help participants see connections among mathematical concepts, and challenge them to articulate their mathematical ideas. The facilitator steers the conversation around key points related to content. In describing her moves, the lead facilitator said that at times she “challenges the mathematical thinking and beliefs of participants and knows when it is appropriate to bring up an issue.”

Teaching Methods

The learning that comes through cases and student work comes from the experience that is created around the learning materials, from the discussions, reflections, and the work that group participants do to learn from the seminar resources and from one another. The facilitator pushes participants to identify critical factors and to articulate and justify their thinking. The facilitator acts as a coach, “observing participants while they carry out a task and offering hints, scaffolding, feedback, modeling, prompting with reminders, and new tasks aimed at bringing their performance closer to expert performance” (Collins, Hawkins, & Carver, 1991, p. 222).

The facilitator’s explanation of her methods include statements that are characteristic of coaching: “pushing participants to extend their thinking, asking for evidence of understanding, framing a question to raise an idea worth revisiting, suggesting further exploration by asking ‘I wonder.’” In reflecting on the role, the facilitator notes how it is a complicated “dance” of knowing when and how to ask questions or to give guidance, and this is characteristic of the steering strategy. Steering when understood in the sense of coaching is a method that helps participants attune their skills and understanding whether in relation to comments from others, reflections about student work, a participant’s own classroom experiences, or the larger context of the teaching environment. Steering toward others was an effective focusing device for the group, and this was reflected in participants’ comments on their seminar experience. One commented, “I often found that I was thinking about math even more than usual, and that’s a lot!” Another found, “Getting at the mathematical emphasis of the lesson” was of particular value. And another commented, “I was able to get insights into the depth of the mathematics. This was something I could not get on my own.”

The Sociology of the Learning Environment

At the heart of the Investigations seminars is a collaborative problem-solving environment. Collaboration occurs as participants work on a common activity, sharing materials, observations, and hypothesis (Granott, 1993), along with guidance from an expert facilitator. We found that even when the facilitator directed her comments to an individual, it was always with the goal of enhancing collective learning, citing key points that prompted others to reflect and contribute comments to the discussion.

It is this orientation and awareness of fostering a collaborative learning environment that makes steering toward others an important contribution to online professional development. In this particular online setting, participants were geographically dispersed and formed a heterogeneous group—factors that make it more crucial to continually nurture collaboration. When it is successful, participants in online professional development evolve into a learning community—a “learning environment in which the participants actively communicate about and engage in the skills involved in acquiring expertise, where expertise is understood as the practice of solving problems and carrying out tasks in a domain” (Collins, Hawking, & Carver, 1991, p. 226). The domain in the case of Investigations is the profession of mathematical teaching.

A strategy of steering toward others encourages participants to share and learn from each other and to develop a common repertoire of knowledge and specific ways of addressing similar (often shared) problems and purposes (Shaffer, 2005). Many of the comments from participants about what made the Investigations seminars useful for their professional development relate to the sense of community. These include: “being part of a group of colleagues who had similar interests”; “a support system”; and “reading how others handled situations that were common to the ones I faced and learning from their experience was probably the most valuable aspect of the seminar.”

What makes steering toward others a unique and useful strategy is that it fosters the development of a professional knowledge base within an online learning community. The lead facilitator’s steering toward others strategy made it possible for a diverse group of educators to evolve into a learning community where participants actively engaged in sharing ideas while furthering their own learning and at the same time advancing the collective knowledge of the group.

■ Implications

In order to discuss the implications of our work for designers and facilitators of online professional development, we turn back to the work of Hiebert, Gallimore, and Stigler (2002), and the questions they posed for transforming practitioner knowledge into a knowledge base for the profession. The Investigations seminars illustrate each of Hiebert et al.'s three points, and these have implications for designers and facilitators of online professional development alike.

Making knowledge public. The seminars allowed participants to present and share their thinking and problem solving about mathematics and to make their knowledge public in their collaboration with colleagues. The opportunity to engage in mathematical problem solving and discuss a variety of strategies based upon principles for scaffolding students' learning such as efficiency, accuracy, and flexibility (Russell, Smith, Storeygard, & Murray, 1999) were important features of the seminar design.

Sharing knowledge with others in the profession. Hiebert et al. describe the need for indexing professional knowledge so that it can be shared with others in the profession and note that a shared curriculum is the most natural structure for accomplishing this (p. 8). The *Investigations* curriculum served as this foundation in the online seminars and was a common language or frame of reference for engaging in mathematical discourse.

Defining a mechanism of verifying and improving professional knowledge. Hiebert et al. point to expertise to guide practitioners in application of knowledge. As we have described it and this study shows, the facilitator played an essential role in serving as a means of "quality control" (p. 9) in guiding the seminar discussions and responding to participants' concerns.

■ Limitations

A limitation of this study is that its findings primarily drew upon the postings of one lead facilitator. The particular knowledge, skills, and style that one brings to an instructional role are important factors to consider and, of course, vary based on individual interests and competencies. The Investigations seminars were not at a level of scale where data was available from multiple, experienced facilitators. We do see the potential for extending the seminars to other facilitators, thereby opening up this work to larger scale study. Although we have developed findings that assess facilitation strategies and offer a theory as to how the facilitator carried out the role in this instance, we do not view them as explanatory of facilitation in online professional development generally.

■ Future Research

Future studies could also address: (1) the extent to which the teaching presence methodology is useful in different online professional development venues, including those who may assume the role of facilitator in the Investigations seminars; (2) whether steering toward others and steering more broadly can apply to the Investigations seminars when facilitated by different people; and (3) whether these same strategies apply to a wider range of online professional development. Finally, this study presents an example of facilitation as a multi-faceted role that involves extensive interaction with participants. Additional studies could examine different levels of facilitative interaction across multiple learning experiences to improve understanding of this role in the context of online communities.

REFERENCES

- Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. (2001, September). Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks* 5(2) 1–17. Retrieved August 16, 2005, from <http://www.aln.org/publications/jaln/v5n2/index.asp>
- Atkinson, R. K., Derry, S. J., Renkl, A., & Wortham, D. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research*, 70(2), 181–214.
- Ball, D. L. (1997). Developing mathematics reform: What *don't* we know about teacher learning—But would make good working hypotheses? In S. Friel & G. Bright (Eds.), *Reflecting on our work: NSF Teacher Enhancement in K–6 Mathematics* (pp. 77–111). Lanham, MD: University Press of America. Retrieved August 16, 2005, from http://lsc-net.terc.edu/media/data/media_000000000752.pdf
- Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes & L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3–32). San Francisco: Jossey-Bass.
- Barnes, L. B., Christensen, C. R., & Hansen, A. J. (1994). *Teaching and the case method*. Boston: Harvard Business School Press.
- Baroody, A. J. (2003). The development of adaptive expertise and flexibility: The integration of conceptual and procedural knowledge. In A. J. Baroody & A. Dowker (Eds.), *The development of arithmetic concepts and skills: Constructing adaptive expertise* (pp. 1–33). Mahwah, NJ: Lawrence Erlbaum.
- Bolster, A. (1983). Toward a more effective model of research on teaching. *Harvard Educational Review*, 5(3), 294–398.
- Bonk, C., Wisner, R. A., & Lee, J. Y. (2004). Moderating learner-centered e-learning: Problems and solutions, benefits and implications. In T. S. Roberts (Ed.), *Online collaborative learning: Theory and practice* (pp. 54–85). Hershey, PA: Information Science Publishing.
- Borko, H., & Putnam, R. (1995). Expanding a teacher's knowledge base: A cognitive psychological perspective on professional development. In T. Guskey & M. Huberman (Eds.), *Professional development in education: New paradigms and practices* (pp. 35–65). New York: Teachers College Press.
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000, December). *How people learn: Brain, mind, experience, and school* (expanded ed.). Washington, DC: National Academy Press.
- Brown, J. S. (2000, March/April). Growing up digital: The web and a new learning ecology. *Change*, 10–20.

- Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229–270). Cambridge, MA: MIT Press/Bradford Books.
- Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator* 15(3), 6–11, 38–46. Retrieved August 16, 2005, from http://www.21learn.org/arch/articles/brown_seely.html
- Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453–494). Hillsdale, NJ: Lawrence Erlbaum.
- Collins, A., Hawkins, J., & Carver, S. (1991). A cognitive apprenticeship for disadvantaged students. In B. Means, C. Chelemer, & M. S. Knapp (Eds.), *Teaching advanced skills to at-risk students: Views from research and practice* (pp. 216–43). San Francisco: Jossey-Bass.
- Collison, G., Elbaum, B., Haavind, S., & Tinker, R. (2000). *Facilitating on-line learning: Effective strategies for moderators*. Madison, WI: Atwood.
- Collopy, R. (2003). Curriculum materials as a professional development tool: How a mathematics textbook affected two teachers' learning. *The Elementary School Journal*, 103(3), 287–311.
- Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.
- Dehler, C. (2004). The pedagogy and design of online teacher professional development. *Society for Information Technology & Teacher Education International Conference Proceedings (SITE)*. Atlanta, GA.
- Dennen, V. (2004). Cognitive apprenticeship in educational practice: Research on scaffolding, modeling, mentoring, and coaching as instructional strategies. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology* (pp. 813–828). Mahwah, NJ: Lawrence Erlbaum.
- Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education*. Washington, DC: Albert Shanker Institute. Retrieved August 16, 2005, from http://www.ashankerinst.org/Downloads/Bridging_Gap.pdf
- Eraut, M. (1995). Developing professional knowledge within a client-centered orientation. In T. Guskey & M. Huberman (Eds.), *Professional development in education: New paradigms and practices* (pp. 227–252). New York: Teachers College Press.
- Feger, S., Woleck, K., & Hickman, P. (2004). How to develop a coaching eye. *Journal of Staff Development* 25(2). Oxford, OH: National Staff Development Council (NSDC).
- Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(3), 915–945.

- Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory*. Chicago, IL: Aldine.
- Granott, N. (1993). Patterns of interaction in the co-construction of knowledge: Separate minds, joint effort, and weird creatures. In R. Wozniak & K. Fischer (Eds.), *Development in context: Acting and thinking in specific environments* (pp. 183–207). Hillsdale, NJ: Lawrence Erlbaum.
- Grimmett, P., & MacKinnon, A. (1992). Craft knowledge and the education of teachers. *Review of Research in Education*, 18, 385–456.
- Harasim, L., Hiltz, S. R., Teles, L., & Turoff, M. (1998). *Learning networks: A field guide to teaching and learning online*. Cambridge, MA: MIT Press.
- Hawley, W. D., & Valli, L. (1999). The essentials of professional development. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 127–150). San Francisco: Jossey-Bass.
- Hiebert, J., Gallimore, R., & Stigler, J. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? *Educational Researcher*, 31(5), 3–15.
- Huberman, M. (1983). Recipes for busy kitchens: A situational analysis of routine knowledge use in schools. *Knowledge Creation, Diffusion, Utilization*, 4(4), 478–510.
- Kazemi, E., & Franke, M. L. (2003). *Using student work to support professional development in elementary mathematics* (Document W-03-1). Seattle, WA: University of Washington, Center for the Study of Teaching and Policy.
- Kleiman, G. (2004). *Meeting the need for high quality teachers: E-learning solutions*. NCLB 2004 Summit presentation. Newton, MA: Education Development Center, Inc. (EDC). Retrieved May 23, 2005, from <http://www.nclbtechsummits.org/summit2/s2-presentations.asp>
- Lalli, C. B., & Feger, S. (2005). *Gauging and improving interactions in online seminars for mathematics coaches*. Providence, RI: The Education Alliance at Brown University.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Lehtinen, E. (2003). Computer-supported collaborative learning: An approach to powerful learning environments. In E. DeCorte, L. Verschaffel, N. Entwistle, & J. Van Merriënboer (Eds.), *Powerful learning environments: Unravelling basic components and dimensions* (pp. 35–53). Oxford, UK: Elsevier Science Ltd.
- Lesh, R., Lovitts, B., & Kelly, A. (2000). Purposes and assumptions of this book. In A. Kelly & R. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 17–33). Mahwah, NJ: Lawrence Erlbaum.
- Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin Press.

- Merseeth, K. (1996). Cases and case methods in teacher education. In J. Sikula (Ed.), *Handbook of research on teacher education* (pp. 722–744). New York: MacMillan.
- Miller, B., & Kantrov, I. (1998). *Casebook on school reform*. Portsmouth, NH: Heinemann.
- Nason, R., & Woodruff, E. (2004). Online collaborative learning in mathematics: Some necessary innovations. In T. Roberts (Ed.), *Online collaborative learning: Theory and practice* (pp. 103–131). Hershey, PA: Idea Group Publishing.
- National Staff Development Council. (2001). *Standards for staff development*. Retrieved May 23, 2005, from <http://www.nsd.org/standards/index.cfm>
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.
- National Research Council. (2001). *Improving mathematics education: Resources for decision making*. Committee on Decisions That Count, Steve Leinwand and Gail Burrill (Eds.). Mathematical Sciences Education Board, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.
- Palloff, R. M., & Pratt, K. (1999). *Building learning communities in cyberspace: Effective strategies for the online classroom*. San Francisco: Jossey-Bass.
- RAND Mathematical Study Panel. (2003). *Mathematical proficiency for all students*. Santa Monica, CA: Author.
- Riel, M., & Polin, L. (2004). Online learning communities: Common ground and critical differences in designing technical environments. In S. Barab, R. Kling, & J. Gray (Eds.), *Designing for virtual communities in the service of learning* (pp. 16–50). Cambridge, UK: Cambridge University Press.
- Rocco, T. S., Bliss, L. A., Gallagher, S., & Perez-Prado, A. (2003, Spring). Taking the next step: Mixed methods research in organizational systems. *Information Technology, Learning, and Performance Journal*, 21(1), 19–29.
- Russell, S. J., Smith, D., Storeygard, J., & Murray, M. (1999). *Relearning to teach arithmetic: Multiplication and division*. Parsippany, NJ: Dale Seymour Publications.
- Salmon, G. (2000). *E-moderating: The key to teaching and learning online*. London: Kogan Page.
- Sarker, S., Lau, F., & Sahay, S. (2001). *Using an adapted grounded theory approach for inductive theory building about virtual team development*. ACM SIGMIS Database, v.32, n.1, Winter 2001. Retrieved May 23, 2005, from <http://portal.acm.org/citation.cfm?id=506745&dl=GUIDE&coll=GUIDE&CFID=45758134&CFTOKEN=90696629>
- Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge building communities. *Journal of the Learning Sciences*, 3(3), 219–225.

- Schifter, D. (1996). A constructivist perspective on teaching and learning mathematics. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives and practice* (pp. 73–91). New York: Teachers College Press.
- Shaffer, D. (2005). Epistemic games. *Innovate Journal of Online Education*, 1(6). Retrieved August 16, 2005, from <http://www.innovateonline.info/index.php?view=article&id=79>
- Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage.
- Strauss, A., & Corbin, J. (1994). Grounded theory methodology: An overview. In N. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research* (pp. 273–285). Thousand Oaks, CA: Sage.
- Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.
- Wallace, R. (2003). Online learning in higher education: A review of research on interactions among teachers and students. *Education, Communication & Information* 3(2), 241–280.
- Woleck, K. (2004). Reflections from an online facilitator. Unpublished manuscript. Providence, RI: The Education Alliance at Brown University.

■ APPENDIX A

■ Profile of the Online Facilitator

In developing the Investigations Online seminars, Kristine Woleck has been active both as a designer and facilitator. A mathematics educator, Woleck combines her subject matter knowledge with a strong interest in exploring how children develop their mathematical thinking and helping teachers gain insights into students' ideas. Her educational background includes an undergraduate degree in Child Development and a graduate degree in Leadership in Mathematics Education. As an elementary school teacher, she acquired firsthand experience in using the *Investigations* curriculum in the classroom, and now works with teachers as a staff developer and coach in Connecticut. Woleck has written articles on “tricky triangles”—how children communicate mathematical ideas through their drawings. Her work has appeared in publications for National Council of Teachers of Mathematics, the Eisenhower National Clearinghouse, and in the *Journal of Staff Development*. She authored the discussion cases used in the Investigations coaching seminar and developed the curriculum for the student work seminar.

In writing about her online role, she describes how she scaffolds learning in the seminars through building relationships with participants that in turn develop a sense of community among the group. For Woleck, while establishing trust and a safe environment for participants to share their thoughts is important, “this role of facilitator as “nurturer” alone—simply acknowledging, confirming, and validating the participants’ postings and comments—falls short in terms of sparking growth and change in participants” (Woleck, 2004, p. 3). She adds, “Perhaps most critical in terms of fostering growth is the manner in which a facilitator poses questions, probes participants for deeper conversations, prompts further reflection, or extends discussions” (p. 3). She notes that through these moves—questioning, probing, and extending discussion—the facilitator is often able to push participants to reframe their thinking on a topic and reshape understandings in light of new perspectives. She explains that this kind of questioning might call for postings with a much more direct tone: “Even in instances of explicit requests for information or need for clarification, I often steer participants toward others in the group who may be good resources or hold knowledge specific to a topic” (p. 5).

■ APPENDIX B

■ Teaching Presence

INDICATORS	EXAMPLES
INSTRUCTIONAL DESIGN	
<ul style="list-style-type: none"> ■ Setting curriculum ■ Designing methods ■ Establishing time parameters ■ Utilizing the medium effectively ■ Establishing netiquette 	<ul style="list-style-type: none"> ■ This week we will be discussing... ■ I am going to divide you into groups. ■ Please post by Wednesday. ■ Try to address issues others have raised. ■ Keep your messages short.
FACILITATING DISCOURSE	
<ul style="list-style-type: none"> ■ Identifying areas of agreement/disagreement ■ Seeking to reach consensus/understanding ■ Encouraging, acknowledging, or reinforcing student contributions ■ Setting climate for learning ■ Drawing participants in, prompting discussion ■ Assess the efficacy of the process 	<ul style="list-style-type: none"> ■ Mary has a compelling counter example to your hypothesis, would you care to respond? ■ I think Joe and Mary are saying essentially the same thing. ■ Thank you for your insightful comments. ■ Don't feel self-conscious about thinking out loud. ■ Any thoughts on this issue? Anyone care to comment? ■ I think we're getting a little off track.
DIRECT INSTRUCTION	
<ul style="list-style-type: none"> ■ Present content/questions ■ Focus the discussion on specific issues ■ Summarize the discussion ■ Confirm understanding through assessment and explanatory feedback ■ Diagnose misconceptions ■ Inject knowledge from diverse sources ■ Responding to technical concerns 	<ul style="list-style-type: none"> ■ He says...what do you think? ■ I think this is a dead end. Let's look at... ■ The original question was...We conclude... ■ You have made some good points but should also consider... ■ His perspective may be missing some points. ■ Additional resources that might help are... ■ Here is how you attach an image.

(Anderson, Rourke, Garrison, & Archer, 2001)

■ APPENDIX C

■ Initial Categories From Open Coding

Coaching seminars

[ADDRESSING TEACHER KNOWLEDGE GAPS] How do you deal with knowledge gaps that teachers might have about teaching at different grade levels?

[COACH AS AGENT FOR SYSTEMIC CHANGE] When should a coach leverage his or her access to push math reform across grade levels?

[CURRICULUM RESOURCES] How to use Teacher Notes and Dialogue Boxes with teachers

[IDENTITY—IN ASSUMING THE COACHING ROLE] Validating coaching role as responsible for teacher growth; handling personal conflicts about helping children vs. being responsible for teacher growth

[INTERPERSONAL DYNAMICS] In what ways do you deal with blockers and resistance? How do you interpret silence on the part of the teacher? How responsive should coaches be to changes in classroom dynamics?

[MATHEMATICAL COMMUNICATION] What do teachers need to understand to facilitate math discussions with children?

[MATHEMATICAL CONCEPTS] Mathematical discourse—Can you define your understanding of place value?

[MATHEMATICAL REASONING] Examining students' use of systematic reasoning, examine strategies, process standard, metacognitive strategies—How do you push teachers to support this type of inquiry with their students?

[NEED FOR EXTERNAL PERSPECTIVES AND FEEDBACK] Approaches to demonstration lessons; using others' perspectives

[PERSONAL UNDERSTANDING OF THE COACHING ROLE] What are the metaphors for coaching from everyday life that influence perceptions of this role?

[QUESTIONING AND SOLICITING STRATEGIES] Refining questioning schemas, encouraging teachers to use questioning strategies

[SCHOOL CULTURE AND REFORM] How does math reform connect to overall culture and direction of the school?

[SUPPORTING TEACHER GROWTH] Range of ideas regarding mathematical voice

[USING CURRICULUM RESOURCES] Developing strategies to motivate teachers to use the curriculum resources effectively

[VALUE OF EXTERNAL INNOVATIONS] Examining lesson study as an ideal learning opportunity

Student work seminars

[ARTICULATING QUESTIONS] Pushing participants for more specificity in articulating next steps for class as a whole

[CHILDREN'S COMMUNICATION] Talking through problems in addition to concrete materials and visuals; referring to earlier discussion on children's language

[COMMUNICATING MATHEMATICALLY] Asking class to articulate what an explanation with greater depth would look like; posing scaffolding questions; deepening mathematical knowledge through examples.

[COMPUTATIONAL FLUENCY] Being flexible

[DEVELOPING FLUENCY] Using the "breaking into parts" strategy

[DEVELOPMENT OF A CORE SET OF STRATEGIES] Timing the study of algorithms

[DEVELOPMENT OF MATHEMATICAL IDEAS] Balancing students' feeling secure and being flexible in their strategies as a foundation for competence

[EXPLANATIONS FOR ADDING A ZERO—WHY IT WORKS] Asking teachers to articulate children's thinking about math concepts

[HOW TO FACILITATE STUDYING AN ALGORITHM] Considering what questions, timing, and support are needed

[MAKING THINKING PUBLIC] Pushing the group to apply a student's strategy and share their work

[MODELING MATH CONCEPTS] Using representations and digi-blocks

[PROBLEM SOLVING AND COMMUNICATION] Staying attuned to the language of children as they describe the language of groups; posing questions about wanting student work to have deeper explanation

[PROBLEM-SOLVING STRATEGIES] Trying to generalize problem-solving strategies; determining from a range of strategies which are the best fit

[ROBUST STRATEGIES] Pointing to an example that shows a relationship between number sense and the operation of multiplication

[SCALING UP TO MORE COMPLEX PROBLEMS] Developing children's computational strategies across operations based on number sense, operations and relationships

[WRITTEN COMMUNICATION] Recording and notation as part of computational fluency

■ APPENDIX D

■ Refined Coding Scheme

Coaching seminars

[CURRICULUM RESOURCES] How to use resources; strategies for motivating teachers

[DEMONSTRATION LESSONS] Ongoing struggles, pros and cons, external feedback

[IDENTITY] Coaching role, teacher growth, mathematical voice, mutual responsibility, metaphors

[INTERPERSONAL CLASSROOM DYNAMICS] Blocking, resistance, silence, classroom dynamics' influence on coaching interactions

[KNOWLEDGE GAPS] Teachers, articulation across grade levels

[MATHEMATICAL CONCEPTS] Developing discourse about mathematical ideas, place value, operations

[MATHEMATICAL REASONING] Student communication, teacher facilitation, metacognitive strategies, reflection

[MODELING] Lesson study, importing innovation

[QUESTIONING] Schemas, strategies

[SCHOOL CULTURE] Learning community, barriers to learning

[THINKING SYSTEMICALLY] Cross-grade understanding of curriculum, coach as agent for developing understanding across grades

Student work seminars

[COMMUNICATING MATHEMATICALLY] Staying attuned to children's language

[COMPUTATIONAL FLUENCY] Flexibility, recording, notation, visuals, children's language

[COMPUTATIONAL STRATEGIES] Children's development, operations, complex problems

[MATHEMATICAL CONCEPTS] Children's thinking, add a zero explanations

[MATHEMATICAL DISCOURSE] Pushing ourselves, scaffolding questions

[MODELING MATHEMATICAL CONCEPTS] Use of questions, use of manipulatives

[PLANNING NEXT STEPS] Specificity, whole class

[PROBLEM-SOLVING STRATEGIES] Generalizing, fluency, types of mathematical problems, range of strategies, explaining "best" solution

[ROBUST STRATEGIES] Number sense and operations

[STUDENT DEVELOPMENT OF MATHEMATICAL IDEAS] Security, flexibility, competence

[STUDYING ALGORITHMS] Approaches, questions, timing, support, communication

[THINKING THROUGH STUDENTS' STRATEGIES] Pushing the group, making thinking visible

THE EDUCATION ALLIANCE AT BROWN UNIVERSITY

Northeast and Islands Regional Educational Laboratory (LAB)

LAB Directors and Board

Adeline Becker
Executive Director, The Education Alliance

Mary-Beth Fafard
Executive Director, The LAB at Brown University

Peter McWalters
Chair, LAB Board of Governors

Aminda Gentile
Vice Chair, LAB Board of Governors

Board Members

Rafael Aragunde Torres

Alice Carlan

Richard H. Cate

Charles F. Desmond

Edward J. Doherty

David Driscoll

Michele Forman

Susan A. Gendron

Noreen Michael

Richard P. Mills

Elizabeth Neale

Peter J. Negroni

Basan N. Nembirkow

C. Patrick Proctor, Sr.

Robin D. Rapaport

Betty J. Sternberg

Lyonel B. Tracy

Northeast and Islands Regional Educational Laboratory

222 Richmond Street
Suite 300
Providence, RI 02903

e-mail:

info@alliance.brown.edu

web:

www.alliance.brown.edu