What Do New Views of Knowledge and Thinking Have to Say About Research on Teacher Learning?

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The education and research communities are abuzz with new (or at least re-discovered) ideas about the nature of cognition and learning. Terms like "situated cognition," "distributed cognition," and "communities of practice" fill the air. Recent dialogue in *Educational Researcher* (Anderson, Reder, & Simon, 1996, 1997; Greeno, 1997) typifies this discussion. Some have argued that the shifts in world view that these discussions represent are even more fundamental than the now-historical shift from behaviorist to cognitive views of learning (Shuell, 1986).

These new ideas about the nature of knowledge, thinking, and learning—which are becoming known as the "situative perspective" (Greeno, 1997; Greeno, Collins, & Resnick, 1996)—are interacting with, and sometimes fueling, current reform movements in education. Most discussions of these ideas and their implications for educational practice have been cast primarily in terms of students. Scholars and policy-makers have considered, for example, how to help students develop deep understandings of subject matter, situate students' learning in meaningful contexts, and create learning communities in which teachers and students engage in rich discourse about important ideas (e.g., National Council of Teachers of Mathematics, 1989; National Education Goals Panel, 1991; National Research Council, 1993).

Less attention has been paid to teachers—either to their roles in creating learning experiences consistent with the reform agenda or to how they themselves learn new ways of teaching. In this article we focus on the latter. Our purpose in considering teachers' learning is twofold. First, we use these ideas about the nature of learning and knowing as lenses for understanding recent research on teacher learning. Second, we explore new issues about teacher learning and teacher education that this perspective brings to light. We begin with a brief overview of three conceptual themes that are central to the situative perspective—that cognition is (a) situated in particular physical and social contexts; (b) social in nature; and (c) distributed across the individual, other persons, and tools.

Cognition as Situated

Early cognitive theories typically treated knowing as the manipulation of symbols inside the mind of the individual, and learning as the acquisition of knowledge and skills

thought to be useful in a wide variety of settings (Greeno et al., 1996). Situative theorists challenge this assumption of a cognitive core independent of context and intention (Brown, Collins, & Duguid, 1989; Greeno & The Middle School Through Applications Project Group, 1998; Lave & Wenger, 1991). They posit, instead, that the physical and social contexts in which an activity takes place are an integral part of the activity, and that the activity is an integral part of the learning that takes place within it. How a person learns a particular set of knowledge and skills, and the situation in which a person learns, become a fundamental part of what is learned. Further, whereas traditional cognitive perspectives focus on the individual as the basic unit of analysis, situative perspectives focus on interactive systems that include individuals as participants, interacting with each other as well as materials and representational systems (Cobb & Bowers, 1999; Greeno, 1997).

A focus on the situated nature of cognition suggests the importance of *authentic activities* in classrooms. J. S. Brown and colleagues (1989) defined authentic activities as the "ordinary practices of a culture" (p. 34)—activities that are similar to what actual practitioners do. They claimed that "school activities," which do not share contextual features with related out-of-school tasks, typically fail to support transfer to these out-of-school settings. A. Brown and colleagues (1993) offered a different definition of authentic classroom activities—derived from the role of formal education in children's lives. If we consider the goal of education to be preparing students to be lifelong intentional learners, then activities are authentic if they serve that goal. Authentic activities foster the kinds of thinking and

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problem-solving skills that are important in out-of-school settings, whether or not the activities themselves mirror what practitioners do. Our discussion of authentic activities for teacher learning adopts a position similar to that of A. Brown and colleagues; that is, we consider the kinds of thinking and problem-solving skills fostered by an activity to be the key criterion for authenticity.

Cognition as Social

Dissatisfied with overly individualistic accounts of learning and knowing, psychologists and educators are recognizing that the role of others in the learning process goes beyond providing stimulation and encouragement for individual construction of knowledge (Resnick, 1991). Rather, interactions with the people in one's environment are major determinants of both what is learned and how learning takes place. This *sociocentric* view (Soltis, 1981) of knowledge and learning holds that what we take as knowledge and how we think and express ideas are the products of the interactions of groups of people over time. Individuals participate in numerous *discourse communities* (Fish, 1980; Michaels & O'Connor, 1990; Resnick, 1991), ranging from scholarly disciplines such as science or history, to groups of people sharing a common interest, to particular classrooms. These discourse communities provide the cognitive tools—ideas, theories, and concepts—that individuals appropriate as their own through their personal efforts to make sense of experiences. The process of learning, too, is social. Indeed, some scholars have conceptualized learning as coming to know how to participate in the discourse and practices of a particular community (e.g., Cobb, 1994; Lave & Wenger, 1991). From this perspective, learning is as much a matter of enculturation into a community's ways of thinking and dispositions as it is a result of explicit instruction in specific concepts, skills, and procedures (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Resnick, 1988; Schoenfeld, 1992). It is important to note that this learning is not a unidirectional phenomenon; the community, too, changes through the ideas and ways of thinking its new members bring to the discourse.

One important idea emerging from a social perspective is that a central goal of schooling is to enculturate students into various discourse communities, equipping them with competence in using the concepts and the forms of reasoning and argument that characterize those communities (Lampert, 1990; Michaels & O'Connor, 1990; Resnick, 1988). This perspective leads to the question of what kinds of discourse communities to establish in classrooms. In parallel to their position on authentic activities, some scholars argue that classroom communities should be modeled after disciplinary communities of mathematicians, scientists, historians, and so on (J. S. Brown et al., 1989). Others argue that—rather than preparing students to participate in the professional cultures of mathematicians and historians— "schools should be communities where students learn to learn" (A. Brown et al., 1993, p. 190). Their assumption is that by participating in activities designed to question and extend their own knowledge in various domains, students will become enculturated into ways of learning that will continue for the rest of their lives. In either case, the discourse communities being envisioned are significantly different from those traditionally found in public school classrooms.

Cognition as Distributed

Rather than considering cognition solely as a property of individuals, situative theorists posit that it is distributed or "stretched over" (Lave, 1988) the individual, other persons, and various artifacts such as physical and symbolic tools (Salomon, 1993a). For example, Hutchins (1990, 1991) described the navigation of a U.S. Navy ship, where the knowledge for successfully piloting the ship was distributed throughout the entire navigational system. Six people with three different job descriptions and using several sophisticated cognitive tools were involved in piloting the ship out of the harbor. The distribution of cognition across people and tools made it possible for the crew to accomplish cognitive tasks beyond the capabilities of any individual member (Hutchins, 1990).

School learning environments typically do not emphasize such sharing of learning and cognitive performance, focusing instead on the importance of individual competencies. But, as Resnick (1987) wrote, "as long as school focuses mainly on individual forms of competence, on tool-free performance, and on decontextualized skills, educating people to be good learners in school settings alone may not be sufficient to help them become strong out-of-school learners" (p. 18). Pea (1993) made a similar point: "Socially scaffolded and externally mediated, artifact-supported cognition is so predominant in out-of-school settings that its disavowal in the classroom is detrimental to the transfer of learning beyond the classroom" (p. 75). Admittedly there are disadvantages to incorporating tool-aided cognition and socially shared cognitive activities in classrooms; it seems clear, however, that to prepare students for successful participation in society, schools must achieve a better balance between activities that incorporate ideas of distributed cognition and those that stress only individual competence.

These three themes—learning and knowing as situated, social, and distributed—are fairly recent arrivals on the educational research scene in North America, although they have roots in the thinking of educators and psychologists as early as the late 19th century (e.g., Dewey, 1896; Vygotsky, 1934/1962). Greeno and colleagues (1996) wove these themes together in characterizing the situative perspective:

> Success in cognitive functions such as reasoning, remembering, and perceiving is understood as an achievement of a system, with contributions of the individuals who participate, along with tools and artifacts. This means that thinking is situated in a particular context of intentions, social partners, and tools. (p. 20)

As well as providing new perspectives on teaching and learning in K–12 classrooms, the situative approach has important implications for research on the learning of preservice and inservice teachers. In the remainder of this article, we consider these implications. We focus on three issues: (a) where to situate teachers' learning experiences, (b) the nature of discourse communities for teaching and teacher learning, and (c) the importance of tools in teachers' work. (For a more comprehensive discussion of the three themes and their implications for classroom practices and teacher education, see Putnam & Borko, 1997.)

Where Should Teachers' Learning Be Situated?

Teacher educators have long struggled with how to create learning experiences powerful enough to transform teach-

ers' classroom practice. Teachers, both experienced and novice, often complain that learning experiences outside the classroom are too removed from the day-to-day work of teaching to have a meaningful impact. At first glance, the idea that teachers' knowledge is situated in classroom practice lends support to this complaint, seeming to imply that most or all learning experiences for teachers should take place in actual classrooms. But the situative perspective holds that all knowledge is (by definition) situated. The question is not whether knowledge and learning are situated, but in what contexts they are situated. For some purposes, in fact, situating learning experiences for teachers outside of the classroom may be important—indeed essential—for powerful learning.

The situative perspective thus focuses researchers' attention on how various settings for teachers' learning give rise to different kinds of knowing. We examine here some of the approaches that researchers and teacher educators have taken to help teachers learn and change in powerful ways, focusing on the kinds of knowing each approach addresses. We begin by considering professional development experiences for practicing teachers.

Learning Experiences for Practicing Teachers

One approach to staff development is to ground teachers' learning experiences in their own practice by conducting activities at school sites, with a large component taking place in individual teachers' classrooms. The University of Colorado Assessment Project (Borko, Mayfield, Marion, Flexer, & Cumbo, 1997; Shepard et al., 1996) provides an example of this approach. The project's purpose was to help teachers design and implement classroom-based performance assessments compatible with their instructional goals in mathematics and literacy. As one component, a member of the research/staff development team worked with children in the classrooms of some participating teachers, observed their mathematical activities, and then shared her insights about their mathematical understandings with the teachers. Teachers reported that these conversations helped them to understand what to look for when observing students and to incorporate classroom-based observations of student performances into their assessment practices (Borko et al., 1997).

Another approach is to have teachers bring experiences from their classrooms to staff development activities, for example through ongoing workshops focused on instructional practices. In the UC Assessment Project (Borko et al., 1997), one particularly effective approach to situating learning occurred when members of the staff development/research team introduced materials and activities in a workshop session, the teachers attempted to enact these ideas in their classrooms, and the group discussed their experiences in a subsequent workshop session. Richardson and Anders's (1994) practical argument approach to staff development provides another example. These researchers structured discussions with participating elementary teachers to examine their practical arguments—the rationales, empirical support, and situational contexts that served as the basis for their instructional actions—often using videotapes of the teachers' classrooms as springboards for discussion.

These approaches offer some obvious strengths when viewed from a situative perspective. The learning of teachers is intertwined with their ongoing practice, making it likely that what they learn will indeed influence and support their teaching practice in meaningful ways. But there are also some problems. One is the issue of scalability: Having researchers or staff developers spend significant amounts of time working alongside teachers is not practical on a widespread basis—at least not given the current social and economic structure of our schools. A second problem is that, even if it were possible in a practical sense to ground much of teachers' learning in their ongoing classroom practice, there are arguments for not always doing so. If the goal is to help teachers think in new ways, for example, it may be important to have them experience learning in different settings. The situative perspective helps us see that much of what we do and think is intertwined with the particular contexts in which we act. The classroom is a powerful environment for shaping and constraining how practicing teachers think and act. Many of their patterns of thought and action have become automatic—resistant to reflection or change. Engaging in learning experiences away from this setting may be necessary to help teachers "break set"—to experience things in new ways.

For example, pervading many current educational reform documents is the argument that "school" versions of mathematics, science, literature, and other subject matters are limited—that they overemphasize routine, rote aspects of the subject over the more powerful and generative aspects of the discipline. Students and teachers, reformers argue, need opportunities to think of mathematics or science or writing in new ways. It may be difficult, however, for teachers to experience these disciplines in new ways in the context of their own classrooms—the pull of the existing classroom environment and culture is simply too strong. Teachers may need the opportunity to experience these and other content domains in a new and different context.

Some professional development projects have addressed this concern by providing intensive learning experiences through summer workshops housed in sites other than school buildings. Such workshops free teachers from the constraints of their own classroom situations and afford them the luxury of exploring ideas without worrying about what they are going to do tomorrow. The SummerMath for Teachers program (Schifter & Fosnot, 1993; Simon & Schifter, 1991), for example, included a 2-week summer institute, during which teachers learned mathematics by participating in activities designed according to constructivist principles. A key goal of the institute was for teachers to experience the learning of mathematics in new ways. The Cognitively Guided Instruction (CGI) project (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989) also included a summer institute, during which teachers were introduced to research-based ideas about children's learning of addition and subtraction through a variety of experiences situated primarily in children's mathematics activities. In both projects, participants' beliefs and knowledge about teaching and learning mathematics shifted toward a perspective grounded in children's mathematical thinking.

Although settings away from the classroom can provide valuable opportunities for teachers to learn to think in new ways, the process of integrating ideas and practices learned outside the classroom into one's ongoing instructional program is rarely simple or straightforward. Thus we must consider whether and under what conditions teachers' out-of-classroom learning—however powerful—

will be incorporated into their classroom practice. There is some evidence that staff development programs can successfully address this issue by systematically incorporating multiple contexts for teacher learning.

One promising model for the use of multiple contexts combines summer workshops that introduce theoretical and research-based ideas with ongoing support during the year as teachers attempt to integrate these ideas into their instructional programs. The intensive 2-week summer institute in the SummerMath program, in addition to providing opportunities for teachers to participate in mathematics learning activities, engaged them in creating similar instructional sequences for their own students. Throughout the following school year, staff members provided feedback, demonstration teaching, and opportunities for reflection during weekly visits to the teachers' classrooms, as well as workshops for further exploring issues related to mathematics, learning, and teaching. This combination of experiences helped the teachers to develop different conceptions of mathematics and deeper understandings of mathematical learning and teaching, and to incorporate strategies such as group problem solving, use of manipulatives, and nonroutine problems into their mathematics instruction.

The CGI project provided a similar combination of experiences for some of its participants (Fennema et al., 1996; Franke, Carpenter, Fennema, Ansell, & Behrend, 1998). In addition to the summer workshops, these participants received support during the school year from a CGI staff member and a mentor teacher that included observing in the teacher's classroom and discussing the children's mathematical thinking, planning lessons together, and assessing children together. At the end of a 4-year period, most teachers had shifted from a view of teaching as demonstrating procedures and telling children how to think to one that stresses helping children develop their mathematical knowledge through creating learning environments, posing problems, questioning children about their problem solutions, and using children's thinking to guide instructional decisions. These two projects thus used a series of settings to introduce teachers to new ideas and practices and to support the integration of these learnings into classroom practice.

We have described in this section a variety of ways to situate experienced teachers' learning, ranging from staff developers working alongside teachers in their own classrooms; to teachers bringing problems, issues, and examples from their classrooms to group discussions; to summer workshops focused on the teachers' own learning of subject matter. Research on these projects suggests that the most appropriate staff development site depends on the specific goals for teachers' learning. For example, summer workshops appear to be particularly powerful settings for teachers to develop new relationships to subject matter and new insights about individual students' learning. Experiences situated in the teachers' own classrooms may be better suited to facilitating teachers' enactment of specific instructional practices. And, it may be that a combination of approaches, situated in a variety of contexts, holds the best promise for fostering powerful, multidimensional changes in teachers' thinking and practices. Further research is needed to better understand the complex dynamics of these multifaceted approaches to teacher learning.

Learning Experiences for Prospective Teachers

The argument for providing inservice teachers with multiple learning settings in and out of classrooms has its counterpart in preservice teacher education. In this case, the recommendation is to situate experiences in both the university and K–12 classrooms. Unlike experienced teachers, however, preservice teachers do not have their own classrooms in which to situate learning activities and have limited teaching experiences from which to draw in discussions of pedagogical issues. Traditionally, teacher educators have relied upon student teaching and field experiences in K–12 classrooms as sites for learning.

In some situations, these classroom experiences are carefully combined with university course experiences to provide coordinated opportunities for preservice teachers to learn new ideas and practices, as well as to reflect and receive feedback on their teaching. Wolf, for example, required preservice teachers enrolled in her children's literature course to conduct a "reader response case study" with a young child (Wolf, Carey, & Mieras, 1996; Wolf, Mieras, & Carey, 1996). Each teacher read with a child on a weekly basis, kept detailed field notes of the reading sessions, and wrote a final paper on the child's response to literature and her or his own growth as a teacher of children's literature. The preservice teachers' conceptions of literary response shifted toward an increased emphasis on interpretation over comprehension. They also came to hold higher expectations for children's capacity to interpret text and richer understandings of their roles as teachers of literature. Wolf and colleagues concluded that situating the preservice teachers' learning simultaneously in university and field-based experiences was crucial to the success of the course. As they explained,

> Much of the necessary work to guide and support preservice teachers' growing understandings of literary response can be accomplished in university class settings that emphasize subject matter knowledge. . . . Still, subject matter knowledge is only a part of the necessary training for preservice teachers. To arrive at a more complete understanding of children's literary response, preservice teachers must be involved with children—moving from the more distanced study of children in articles and books to the here and now of working with real children. . . . Thus, a university course infusion of new research ideas with multiple, though sometimes hypothetical, examples must be balanced with authentic, literary interaction with children, if we expect to see preservice teachers shift from limited comprehension-based expectations to broader interpretive possibilities for literary discussion. (Wolf et al., 1996, p. 134)

Thus, thoughtfully combining university- and field-based experiences can lead to learning that can be difficult to accomplish in either setting alone.

These approaches draw, at least implicitly, on an assumption of apprenticeship in an existing environment—that important learning to teach takes place as novices experience actual classrooms alongside experienced teachers. A concern, however, is that K–12 classrooms embodying the kinds of teaching advocated by university teacher education programs may not be available. Without such classrooms, the apprenticeship model breaks down. As Sykes and Bird (1992) cautioned,

Finally, the situated cognition perspective draws on the image of apprenticeship in a guild or a professional community as a powerful form of learning. But this image requires a stable, satisfactory practice that the novice can join. If the aim of teacher education is a reformed practice that is not readily available, and if there is no reinforcing culture to support such practice, then the basic imagery of apprenticeship seems to break down. Teachers' knowledge is situated, but this truism creates a puzzle for reform. Through what activities and situations do teachers learn new practices that may not be routinely reinforced in the work setting? (p. 501)

An important question facing researchers and teacher educators is whether experiences can be designed that maintain the situatedness of practica and student teaching while avoiding the "pull" of the traditional school culture. To address this question, we will need to understand better the influence of school-based experiences on prospective teachers' ideas and practices.

Case-Based Learning Experiences for Teachers

Teachers' learning experiences in university classrooms typically entail reading about and discussing ideas; their learning experiences in K–12 classrooms usually involve actually engaging in the activities of teaching. Case-based teaching provides another approach for creating meaningful settings for teacher learning (Doyle, 1990; Leinhardt, 1990; Merseth, 1996; Sykes & Bird, 1992). Rather than putting teachers *in* particular classroom settings, cases provide vicarious encounters with those settings. This experience *of* the setting may afford reflection and critical analysis that is not possible when acting in the setting.

Some proponents suggest that cases have several advantages over other activities used in preservice and inservice teacher education. As with actual classroom experiences, they allow teachers to explore the richness and complexity of genuine pedagogical problems. Cases, however, provide shared experiences for teachers to examine together, using multiple perspectives and frameworks (Feltovich, Spiro, & Coulson, 1997; Spiro, Coulson, Feltovich, & Anderson, 1988). They also afford the teacher educator more control over the situations and issues that teachers encounter, and the opportunity to prepare in advance for discussion and other activities in which the case materials are used (Sykes & Bird, 1992). For preservice programs, cases avoid the problem of placing prospective teachers in settings that do not embody the kinds of teaching advocated by university teacher educators.

Although all cases limit the information provided, they vary in the richness or complexity of classroom life portrayed. Some media, such as videotape, can convey more of the complexity of classroom events than written cases. Interactive multimedia cases and hypermedia environments have the potential to provide even richer sets of materials documenting classroom teaching and learning. Lampert and Ball (1998), for example, developed a hypermedia learning environment that combines videotapes of classroom mathematics lessons, instructional materials, teacher journals, student notebooks, students' work, and teacher and student interviews, as well as tools for browsing, annotating, and constructing arguments. The nonlinearity of such hypermedia systems, the ability to visit and revisit various sources of information quickly and easily, and the ability to build and store flexible and multiple links among various pieces of information, allow users to consider multiple perspectives on an event simultaneously (Feltovich et al., 1997; Spiro et al., 1988). Further, the extensiveness of the databases and ease of searching them enable teachers to define and explore problems of their own choosing (Merseth & Lacey, 1993). Like traditional cases, these multimedia and hypermedia materials provide a shared context for the exploration of pedagogical problems. They can come much closer, however, to mirroring the complexity of the problem space in which teachers work.

Despite vocal advocates and an increased use of cases in recent years there is much to learn about their effectiveness as instructional tools. Commenting on this "imbalance between promise and empirical data," Merseth (1996) noted, "the myriad claims for the use of cases and case methods far exceed the volume and quality of research specific to cases and case methods in teacher education" (p. 738). Questions for research include differences in what is learned from the rich and open-ended experiences provided by hypermedia cases versus more structured and focused written and videotaped cases, as well as comparisons of cases and case methods with other instructional materials and approaches. In addressing these questions, it will be important to understand and take into account the variety of purposes and uses of case-based pedagogy. We may learn, for example, that considerable limiting of complexity is desirable for some purposes, such as illustrating particular teaching concepts or strategies. For other purposes, such as reflecting the confluence of the many constraints on a teachers' problem solving, complex open-ended case materials may be important.

Discourse Communities for Teachers

Just as a situative perspective shifts our attention to establishing and participating in discourse communities in K–12 classrooms, so too it draws attention to the discourse communities in which teachers work and learn. These discourse communities play central roles in shaping the way teachers view their world and go about their work. Indeed, patterns of classroom teaching and learning have historically been resistant to fundamental change, in part because schools have served as powerful discourse communities that enculturate participants (students, teachers, administrators) into traditional school activities and ways of thinking (Cohen, 1989; Sarason, 1990). In this section, we explore existing research and unresolved issues concerning the role of discourse communities in supporting teachers learning to teach in new ways.

Discourse Communities for Experienced Teachers

A number of educational reformers have argued that for teachers to be successful in constructing new roles they need opportunities to participate "in a professional community that discusses new teacher materials and strategies and that supports the risk taking and struggle entailed in transforming practice" (McLaughlin & Talbert, 1993, p. 15). Further, the notion of distributed cognition suggests that when diverse groups of teachers with different types of knowledge and expertise come together in discourse communities, community members can draw upon and incorporate each other's expertise to create rich conversations and new insights into teaching and learning. The existing cultures and discourse communities in many schools, however, do not value or support critical and reflective examination of teaching practice.

Ball (1994) characterized the discussions in many staff development sessions as "style shows" that provide few opportunities for meaningful reflection and growth:

> The common view that "each teacher has to find his or her own style" is a direct result of working within a discourse of practice that maintains the individualism and isolation of teaching. This individualism not only makes it difficult to develop any sense of common standards, it also makes it difficult to *disagree*. Masking disagreements hides the individual struggles to practice wisely, and so removes an opportunity for learning. Politely refraining from critique and challenge, teachers have no forum for debating and improving their understandings. To the extent that teaching remains a smorgasbord of alternatives with no real sense of community, there is no basis for comparing or choosing from among alternatives, no basis for real and helpful debate. This lack impedes the capacity to grow. (p. 16)

Several recent professional development programs provide existence proofs for the kind of critical, reflective discourse community envisioned by Ball (1994) and by McLaughlin and Talbert (1993). In the Community of Learners project (Wineburg & Grossman, 1998; Thomas, Wineburg, Grossman, Myhre, & Woolworth, 1998) high-school teachers of English and history gathered with university-based educators to read books, discuss teaching and learning, and design an interdisciplinary humanities curriculum. Central to this work was the idea that each participant brings unique knowledge and beliefs to a professional learning community:

> The individual teachers . . . bring with them very different areas of expertise; some are extremely knowledgeable about the subject matter, whereas others bring specialized knowledge of students, including linguistic minority students and students enrolled in special education programs. Teachers also bring different pedagogical understandings and expertise to the group discussions. By drawing on each individual's private understandings, which represent these different degrees of pedagogical and disciplinary expertise, the collective understanding of the group is thus advanced. (Thomas et al., 1998, p. 23)

Preliminary findings indicate that an intellectual community for teachers developed within the high school, collegiality among faculty within and across departments was enhanced, and the curriculum of the school was affected. Members of the university team gained new insights about the time, effort, and trust required to reform the professional culture of teaching (Thomas et al., 1998).

In another project, Goldenberg and colleagues (Goldenberg & Gallimore, 1991; Saunders, Goldenberg, & Hamann, 1992) worked with a group of teachers to elaborate the concept of instructional conversation—a mode of instruction that emphasizes active student involvement in goal and meaning-oriented discussions. Together, participants developed principles of instructional conversations for elementary classrooms as they engaged in instructional conversations themselves. Goldenberg played a critical role in guiding instructional conversations with teachers, while the teachers brought intimate knowledge of their own classrooms and teaching practices to the conversations (Saunders et al., 1992).

Richardson and Anders's (1994) practical argument approach to staff development (see previous discussion) also used new forms of discourse among teachers as a professional development tool. Their staff development team brought research-based ideas about learning and instructional practices to the task of developing and examining practical arguments. Teachers provided knowledge about their students, the particular settings in which they taught, and their own teaching practice.

Although these three projects differed in their goals, they all illustrate the bringing together of teachers and university-based researchers or staff developers into new forms of discourse communities focused on teaching and learning. University participants can bring to these communities the critical and reflective stance and modes of discourse that are important norms within the academic community. In addition, they bring research-based knowledge, including "conceptual inventions, clarifications, and critiques" (Shulman, 1986, p. 27) that can contribute to the improvement of teaching. Teachers, in turn, can bring to such discourse communities craft knowledge about pedagogical practices, their own students, and the cultural and instructional contexts of their classrooms. Together, these two groups of participants can learn new ways of thinking about their practices and simultaneously create new forms of discourse about teaching.

New kinds of discourse communities for teachers, while potentially powerful tools for improving pedagogical practice, also may introduce new tensions into the professional development experience. For example, the university teams in all three projects struggled with the question of how much guidance and structure to bring to the conversations, seeking an appropriate balance between presenting information and facilitating teachers' construction of new practices. In considering these issues of balance, we are reminded of what Richardson (1992) labeled the *agenda-setting dilemma*: The staff developer wants to see teachers' practice change in particular directions while empowering the teachers themselves to be meaningfully involved in determining the changes. This dilemma is analogous to one faced by the classroom teacher who wants to empower children to build upon their own thinking while simultaneously ensuring that they learn expected subject-matter content. Staff developers, like teachers, must negotiate their way between the learners' current thinking and the subject matter or content to be learned. In the case of staff development, the "learners" are teachers and the "content" is typically new teaching practices and forms of pedagogical thinking.

The university teams in all three projects addressed these issues of balance by avoiding the extremes of either viewing teachers as merely implementing someone else's pedagogical approach or attempting to empower them without introducing new pedagogical ideas. Instead, they drew upon the unique sets of knowledge and skills offered by researchers and teachers. As a result, the ideas that emerged in the discourse communities created within the projects were "joint productions" that furthered the understanding of all participants. Researchers, as well as teachers, came away with new insights about teaching and learning.

Discourse Communities for Preservice Teachers

Traditionally, preservice teacher education programs have focused more on the development of individual knowledge and competencies thought to be important for teaching than on the establishment of discourse communities for prospective teachers. But the view of knowledge as socially constructed makes it clear that an important part of learning to teach is becoming enculturated into the teaching commu-

nity—learning to think, talk, and act as a teacher. As we pointed out earlier, however, such enculturation can be problematic when existing professional communities do not represent the kinds of reformed teaching advocated by university teacher education programs (Sykes & Bird, 1992), or when they embody norms and expectations that do not support the experimentation, risk taking, and reflection required to transform practice (McLaughlin & Talbert, 1993).

Thus, important tasks facing teacher education researchers include identifying key characteristics of field-based experiences that can foster new ways of teaching, and determining whether and how these experiences can be created within existing school cultures. Professional development schools may offer one possibility for creating such experiences (Holmes Group, 1990; Stallings & Kowalski, 1990). Most professional development schools have as a central component the establishment of new learning communities where inquiry, critique, and reflection are the norms. We know little, however, about the impact of these communities on experienced teachers' knowledge, beliefs, and practices. And we know even less about whether and how professional development schools can be organized to meet the learning needs of both experienced and novice teachers.

Another important feature of prospective teachers' learning during field-based experiences is the mentoring they receive from more knowledgeable others—the teacher educators and experienced teachers with whom they work. These people form a type of "mini discourse community" within which the preservice teacher is enculturated into the teaching profession. Although the view of the cooperating teacher as a mentor or coach to the novice is a common one, little systematic inquiry has been conducted on the nature of this mentoring role. Feiman-Nemser and Beasley (1997) explored mentoring in their case study of a cooperating teacher (Beasley) working with a teacher intern to plan a lesson for the second/third-grade class they taught. While the teachers together learned about the new content to be taught, Beasley's scaffolding played a critical role in guiding the intern's pedagogical thinking.

As we continue to explore various approaches to the mentoring of preservice teachers and seek to identify characteristics of successful mentoring, we should simultaneously investigate the relationship between these mini discourse communities and the larger communities within which mentoring takes place. It would be useful to know, for example, how professional development schools support and constrain mentoring relationships like the one Beasley created with her teacher intern. Another important issue is how novices can work effectively with multiple mentors who hold varied conceptions of teaching and learning—some from the university and some from the school.

The Importance of Tools

In the world outside of school, intelligent activities often depend upon resources beyond the individuals themselves such as physical tools and notational systems (Pea, 1993). Many of these tools do not merely enhance cognition, they transform it; distributing cognition across persons and tools expands a system's capacity for innovation and invention. For example, productivity tools such as word processors, spreadsheets, and database management systems have fundamentally changed many tasks of the business world. Numerous writers have argued that computers and other new technologies have the potential to transform teaching and learning in schools as well (Means, 1994; Office of Technology Assessment, 1995). Most research on the use of technology by teachers, however, has focused on availability of new technologies, frequency of use, and attitudes toward computers. The situative perspective provides lenses for examining more thoughtfully the potential of new technologies for supporting and transforming teachers' work and learning.

In discussing the use of computers in education, Salomon (1993b) made a distinction between *performance tools*, which enhance or change how a task is accomplished (e.g., a calculator or a word processor), and *pedagogical tools*, which focus primarily on changing the user's competencies (e.g., a simulation designed to change a learner's understanding of a mathematical concept). Although this distinction oversimplifies the complex interweaving of performance and pedagogical functions, it is useful for organizing our discussion. We first consider tools that can support, enhance, or transform teachers' work and then focus on those explicitly designed to support teachers' learning.

Performance Tools to Enhance and Transform the Work of Teaching

Despite claims about the power of new technologies to transform education, the actual use of computers in schools has been rather limited (Becker, 1993; Peck & Dorricot, 1994). The most widely adopted tools are those that fit easily within the existing conceptual and social organization of classrooms—drill and practice programs that can be used by individual students without interfering with whole-class activity, word-processing tools for preparing instructional materials, presentation tools that can replace overhead projectors, and tools for keeping attendance and grades. Such tools can support teachers in doing what they already do, but have little potential for transforming the work of teachers or the nature of teaching and learning in classrooms (Marx, Blumenfeld, Krajcik, & Soloway, 1998; Means, 1994).

More recently, however, researchers and teacher educators have developed computer-based technologies with considerable potential for supporting and transforming teachers' work. One example is the Project Integration Visualization Tool (PIViT; Marx et al., 1998), a productivity tool designed to aid teacher planning. Using PIViT, teachers can create, elaborate, and revise "project designs"—graphical representations of projects that include central questions, curricular objectives, concepts, student investigations, teacher activities, and artifacts. This tool was developed to be consistent with how teachers actually plan, while helping them think about curriculum and instruction in new ways. Teachers who used PIViT to develop and adapt curriculum for their classrooms were able to create multiple representations of their project designs that would not have been possible had they used linear planning.

In theory, teachers should be able to use computer-based planning tools such as PIViT to design projects for any grade level or subject area. Marx and colleagues have revised PIViT based on studies of how teachers use it and the supports they need, and have shown it to be applicable to multiple areas of science (Marx et al., 1998). Additional research is needed to determine what adjustments are required to ensure its applicability to other subject areas. Future research

might also explore the possibility, suggested by Marx and colleagues, that planning tools such as PIViT can be used to create communities of practice in which teachers learn from each other by sharing common templates and models of instructional innovations.

Computers and new communication technologies also have the potential to transform teaching and learning in classrooms and the work of teachers by providing new avenues to access distributed expertise. As Marx and colleagues (1998) noted, teachers' access to the expertise of others has traditionally been limited primarily to printed materials and face-to-face interactions (e.g., through inservice activities, workshops, and conferences). Electronic mail, users groups, and other on-line forums, however, open up myriad possibilities for interacting with colleagues and experts in various fields. Information systems such as the World-Wide Web provide access to digital libraries and vast amounts of information in print, visual, and video form.

At the same time, these new communication opportunities raise a number of questions and concerns. For example, just as Ball (1994) noted the lack of critical reflection in many teacher discourse communities, there is some evidence that teachers' network-based communication may not be particularly substantive (DiMarco & Muscella , 1995; McMahon, 1996). Given our understanding of discourse communities, informed in part by the situative perspective, this should come as no surprise. As Cuban (1986) observed, it is tempting to assume that simply introducing new technologies into schools will transform educational practice. But just as the existing norms and practices of teachers' discourse communities shape their face-to-face interactions, they will shape and limit teachers' electronic interactions. Simply providing new media and access to communication with a much wider circle of colleagues and experts is, in itself, unlikely to change the nature or form of teachers' professional interactions.

Further complexity is added to the picture because conversations over e-mail and listserve forums typically take place over time, with participants reading what has come before and adding their contributions. Such *asynchronous* communication may afford a different sort of reflection and analysis than face-to-face discourse, but also requires the establishment of new norms and strategies for interacting.

Given these features of communication technologies, it is not surprising that teachers need guidance and support to engage in productive technology-based discourse about teaching and learning (Ruopp, Gal, Drayton, & Pfister, 1993; Watts & Castle, 1992). Additional research is needed to determine how such guidance should be designed and made available, to maximize its potential for fostering educationally worthwhile conversations among teachers. Further, we need to better understand the impact of virtual communities of practice and on-line conversations on teachers' relationships with their colleagues. Do virtual professional communities detract from school-based communities? Do teachers shift to participating in on-line conversations at the expense of face-to-face conversations with other teachers in their buildings?

Pedagogical Tools to Support Teachers' Learning

In addition to transforming the tasks of teaching, new computer technologies can support the learning of novice and experienced teachers in ways that build on assumptions about the social, situated, and distributed nature of knowledge and learning. As we discussed earlier, multimedia systems, with their new and flexible ways of representing and connecting information, can enable teachers to explore unfamiliar pedagogical practices and various problems of pedagogy.

The Student Learning Environment (SLE; Lampert & Ball, 1998), described briefly in our discussion of case-based teacher education, provides one image of the possible (Shulman, 1983). Within this environment teachers investigate pedagogical problems that arise as they view and read about Ball's teaching of mathematics in a third-grade classroom and Lampert's in a fifth-grade classroom, simultaneously becoming familiar with new technological tools and exploring new ideas about teaching and learning. Lampert and Ball examined 68 investigations conducted by teacher education students and identified several patterns. Most students saw teaching and learning through pedagogical and psychological lenses, exploring features of the classrooms such as teacher-student relationships, instructional strategies, classroom management, and student participation, rather than mathematical content or curriculum. The students' investigations in this multimedia environment sometimes pushed their thinking beyond where it was when they started. For example, after carefully examining the empirical evidence, some students changed their minds about particular features of classroom life, such as whether boys were being called on more than girls, or whether students were understanding fractions. In contrast, the investigations sometimes reinforced beliefs that the students brought with them into the teacher education program. The initial questions these teacher education students posed when conducting their investigations were typically based on strong normative assumptions such as their notions about a "good" classroom environment or "helpful" teacher. These assumptions framed the students' inquiry and were rarely challenged by doing the investigations. Rather, the collection and interpretation of records of practice simply reinforced the students' entering assumptions.

Marx, Krajcik, Blumenfeld, and colleagues also created a technology-based tool that can support teacher learning and professional development efforts (Krajcik, Blumenfeld, & Starr, 1993; Marx et al., 1998; Urdan, Blumenfeld, Soloway, & Brade, 1992). CaPPs (Casebook of Project Practices) is a collection of multimedia cases, each of which tells a story about how a particular teacher resolved a challenge associated with enacting Project Based Science. Like the SLE, CaPPs can be used by teachers to explore new visions of teaching. CaPPs, however, presents teachers with an organized set of selected video clips depicting particular teaching issues, whereas the SLE presents teachers with a large corpus of information from which they develop and explore their own questions. Based on teachers' experiences with CaPPs, Marx and colleagues suggested that multimedia cases are good vehicles for presenting teachers with visions of what innovative teaching might look like.

The research teams that developed SLE and CaPPs identified a number of unanswered questions about what and how users learn from these realistic and complex depictions of innovative classroom practice. For example, Marx and colleagues (1998) called for research to determine the structures and scaffolds that are necessary to support teacher learning (e.g., work spaces for writing, written commentary

by other teachers). Lampert and Ball (1998) noted the need for further examination of prospective teachers' reasoning as they explore teaching and learning within the SLE. They wondered whether and when teacher education students learned from one another, and "what conclusions or questions really found their way into their thinking" (p. 160). Determining the answers to questions such as these is an important challenge for ongoing research on teacher learning and teacher education. As Marx and colleagues suggested, "careful analysis of how teachers learn from multimedia and how they incorporate their learning into their daily practices will enable designers to create systems tailored to different teacher learning needs" (p. 41).

Conclusion

In this article we set out to consider what the situative perspective on cognition—that knowing and learning are situated in physical and social contexts, social in nature, and distributed across persons and tool—might offer those of us seeking to understand and improve teacher learning. As we pointed out earlier, these ideas are not entirely new. The fundamental issues about what it means to know and learn addressed by the situative perspective have engaged scholars for a long time. Almost a century ago, Thorndike and Dewey debated the nature of transfer and the connections between what people learn in school and their lives outside of school. These issues, in various forms, have continued to occupy the attention of psychologists and educational psychologists ever since (Greeno et al., 1996).

Labaree (1998) argued in a recent *ER* article that this sort of continual revisiting of fundamental issues is endemic to the field of education. Unlike the *hard* sciences, whose hallmark is replicable, agreed-upon knowledge, education and other *soft* knowledge fields deal with the inherent unpredictability of human action and values. As a result, the quest for knowledge about education and learning leaves scholars

> feeling as though they are perpetually struggling to move ahead but getting nowhere. If Sisyphus were a scholar, his field would be education. At the end of long and distinguished careers, senior educational researchers are likely to find that they are still working on the same questions that confronted them at the beginning. And the new generation of researchers they have trained will be taking up these questions as well, reconstructing the very foundations of the field over which their mentors labored during their entire careers. (p. 9)

Questions about the nature of knowing and the processes of learning have not been matters only for academic debate. Teacher educators have long struggled to define what teachers should know (e.g., Carter, 1990; Holmes Group, 1986; National Board for Professional Teaching Standards, 1991) and to create environments that support meaningful teacher learning (e.g., Howey & Zimpher, 1996; Sykes & Bird, 1992). These struggles have played out in ongoing attempts to teach preservice teachers important principles of learning, teaching, and curriculum in ways that connect to and inform their work in classrooms. They have resulted in solutions as varied as teaching carefully specified behavioral competencies believed to be central to effective teaching (e.g., Rosenshine & Stevens, 1986) to building teacher education

programs around immersion in public school classrooms (e.g., Holmes Group, 1990; Stallings & Kowalski, 1990).

Given the enduring nature of these questions and the debates surrounding them, what is to be gained by considering teacher knowledge and teacher learning from a situative perspective? Can this perspective help us think about teaching and teacher learning more productively? We believe it can—that the language and conceptual tools of social, situated, and distributed cognition provide powerful lenses for examining teaching, teacher learning, and the practices of teacher education (both preservice and inservice) in new ways.

For example, these ideas about cognition have helped us, in our own work, to see more clearly the strengths and limitations of various practices and settings for teacher learning. But this clarity comes only when we look closely at these concepts and their nuances. By starting with the assumption that all knowledge is situated in contexts, we were able to provide support for the general argument that teachers' learning should be grounded in some aspect of their teaching practice. Only by pushing beyond this general idea, however, to examine more closely the question of where to situate teachers' learning, were we able to identify specific advantages and limitations of the various contexts within which teachers' learning might be meaningfully situated: their own classrooms, group settings where participants' teaching is the focus of discussion, and settings emphasizing teachers' learning of subject matter. Similarly, ideas about the social and distributed nature of cognition help us think in new ways about the role of technological tools in creating new types of discourse communities for teachers, including unresolved issues regarding the guidance and support needed to ensure that conversations within these communities are educationally meaningful and worthwhile.

We close with two issues that warrant further consideration. First, it is important to recognize that the situative perspective entails a fundamental redefinition of learning and knowing. It is easy to misinterpret scholars in the situative camp as arguing that transfer is impossible—that meaningful learning takes place only in the very contexts in which the new ideas will be used (e.g., Anderson et al., 1996; Reder & Klatzky, 1994). The situative perspective is not an argument *against* transfer, however, but an attempt to recast the relationship between what people know and the settings in which they know—between the knower and the known (Greeno, 1997). The educational community (and our society at large) has typically considered knowledge to be something that persons *have* and can take from one setting to another. When a person demonstrates some knowledge or skill in one setting but not another (e.g., successfully introducing a concept such as negative numbers to one's peers in a micro-teaching situation, but having difficulty teaching the same concept to children in a classroom mathematics lesson) a common view is that the person *has* the appropriate knowledge but is not able to *access* that knowledge in the new setting. This view is consistent with the educational approach—prevalent in teacher education as well as K–12 classrooms—of teaching general knowledge, often in abstract forms, and then teaching students to *apply* that knowledge in multiple settings. Ball (1997), in contrast, has written about the impossibility of teachers determining what their students really know (and the imperative to try in spite of

this impossibility). An insight demonstrated by a student during a small-group discussion "disappears" when the student tries to explain it to the whole class. A student "demonstrates mastery" of odd and even numbers on a standardized test yet is unable to give a convincing explanation of the difference between even and odd. Based on this "now you see it, now you don't" pattern, Ball argued that the contexts in which students learn and in which we assess what they know are inextricable aspects of their knowledge. In other words, learning and knowing are situated.

A parallel argument can be made for teacher learning. As teacher educators we have tended to think about how to facilitate teachers' learning of general principles, and then how to help them apply this knowledge in the classroom. From the situative perspective, what appear to be general principles are actually intertwined collections of more specific patterns that hold across a variety of situations. In this vein, some scholars have argued that some, if not most, of teachers' knowledge is situated within the contexts of classrooms and teaching (Carter, 1990; Carter & Doyle, 1989; Leinhardt, 1988). Carter and Doyle, for example, suggested that much of expert teachers' knowledge is *event-structured* or *episodic*. This professional knowledge is developed in context, stored together with characteristic features of the classrooms and activities, organized around the tasks that teachers accomplish in classroom settings, and accessed for use in similar situations.

It is this sort of thinking in new ways about what and how teachers know that the situative perspective affords. Rather than negating the idea of transfer, the situative perspective helps us redefine it.

These ideas about the relationships among knowing, learning, and settings lead to the second issue—the role that researchers play in the process of learning to teach. As researchers we inherently become a part of, and help to shape, the settings in which we study teachers' learning. In examining her own work with children, Ball (1997) found it was impossible to determine how, and the extent to which, the understandings and insights expressed by children during interactions with her were supported by her implicit (unconscious) guiding and structuring. She argued that teachers' sincere desire to help students and to believe that students have learned may lead them to "ask leading questions, fill in where students leave space, and hear more than what is being said because they so hope for student learning" (p. 800). Ball suggested that this unavoidable influence means we must recast the question of what children "really know," asking instead what they can do and how they think in particular contexts. Further, in addressing these questions, teachers must consider how their interactions affect their assessments of what students know.

Similarly, as researchers trying to understand what teachers know and how they learn, we must be particularly attentive to the support and guidance that we provide. In the heyday of behaviorist perspectives, process-product researchers worked hard to avoid this issue by making their observations of teachers' behaviors as objective as possible; the goal of the observer was to be a "fly on the wall," recording what transpired but not influencing it. With the shift to cognitive perspectives, many of the efforts to study teachers' thinking and decision making maintained this goal of detached objectivity. Researchers working within the interpretive tradition and, more recently, those who hold a situative perspective, remind us that we are inevitably part of the contexts in which we seek to understand teachers' knowing and learning. Rather than pretending to be objective observers, we must be careful to consider our role in influencing and shaping the phenomena we study. This issue is obvious when individuals take on multiple roles of researchers, teachers, and teachers of teachers; it is equally important, though often more subtle, for projects in which researchers assume a nonparticipatory role.

As Labaree suggested, we will not resolve these issues concerning the relationships between knowing and context and between researcher and research context once and for all. Like Sisyphus, we will push these boulders up the hill again and again. But for now, the situative perspective can provide important conceptual tools for exploring these complex relationships, and for taking them into consideration as we design, enact, and study programs to facilitate teacher learning.

Note

References

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher, 25*(4), 5–11.

Anderson, J. R., Reder, L. M., & Simon, H. A. (1997). Situative versus cognitive perspectives: Form versus substance. *Educational Researcher, 26*(1), 18–21.

Ball, D. L. (1994, November). *Developing mathematics reform: What don't we know about teacher learning—but would make good working hypotheses?* Paper presented at Conference on Teacher Enhancement in Mathematics K–6, Arlington, VA.

Ball, D. L. (1997). What do students know? Facing challenges of distance, context, and desire in trying to hear children. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers and teaching* (Vol. II, pp. 769–818). Dordrecht: Kluwer.

Becker, H. J. (1993). Instructional computer use: Findings from a national survey of school and teacher practices. *The Computing Teacher, 20*(1), 6–7.

Borko, H., Mayfield, V., Marion, S., Flexer, R., & Cumbo, K. (1997). Teachers' developing ideas and practices about mathematics performance assessment: Successes, stumbling blocks, and implications for professional development. *Teaching and Teacher Education, 13,* 259–278.

Brown, A., Ash, D., Rutherford, M., Nakagawa, K., Gordon, A., & Campione, J. C. (1993). Distributed expertise in the classroom. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 188–228). Cambridge: Cambridge University Press.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C., & Loef, M. (1989). Using knowledge of children's mathematical thinking in classroom teaching: An experimental study. *American Educational Research Journal, 26,* 499–532.

Carter, K. (1990). Teachers' knowledge and learning to teach. In W. R. Houston, M. Haberman, & J. Silkula (Eds.), *Handbook of research on teacher education* (pp. 291–310). New York: Macmillan.

Carter, K., & Doyle, W. (1989). Classroom research as a resource for the graduate preparation of teachers. In A. Woolfolk (Ed.), *Research perspectives on the graduate preparation of teachers* (pp. 51–68). Englewood Cliffs, NJ: Prentice Hall.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23*(7), 13–19.

Cobb, P., & Bowers, J. S. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher, 28*(2), 4–15.

Cohen, D. K. (1989). Teaching practice: Plus ça change . . . In P. W. Jackson (Ed.), *Contributing to educational change: Perspectives on research and practice* (pp. 27–84). Berkeley: McCutchan.

Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920.* New York: Teachers College Press.

Dewey, J. (1896). The reflex arc concept in psychology. *Psychological Review, 3,* 356–370.

DiMarco, V., & Muscella, D. (1995, October). *Talking about science: The case of an electronic conversation.* Paper presented at the Computer Supported Collaborative Learning '95 conference, Indianapolis, IN.

Doyle, W. (1990). Case methods in teacher education. *Teacher Education Quarterly, 17*(1), 7–15.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*(7), 5–12.

Feiman-Nemser, S., & Beasley, K. (1997). Mentoring as assisted performance: A case of co-planning. In V. Richardson (Ed.), *Constructivist teacher education* (pp. 108–126). London: Falmer Press.

Feltovich, P. J., Spiro, R. J., & Coulson, R. L. (1997). Issues of expert flexibility in contexts characterized by complexity and change. In P. J. Feltovich, K. M. Ford, & R. R. Hoffman (Eds.), *Expertise in context: Human and machine* (pp. 125–146). Cambridge, MA: AAAI/MIT Press.

Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education, 27,* 403–434.

Fish, S. (1980). *Is there a text in this class? The authority of interpretive communities.* Cambridge, MA: Harvard University Press.

Franke, M. L., Carpenter, T., Fennema, E., Ansell, E., & Behrend, J. (1998). Understanding teachers' self-sustaining, generative change in the context of professional development. *Teaching and Teacher Education, 14,* 67–80.

Goldenberg, C., & Gallimore, R. (1991). Changing teaching takes more than a one-shot workshop. *Educational Leadership, 49*(3), 69–72.

Greeno, J. G. (1997). On claims that answer the wrong questions. *Educational Researcher, 26*(1), 5–17.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 15–46). New York: Macmillan.

Greeno, J. G., & the Middle School Through Applications Project Group. (1998). The situativity of knowing, learning, and research. *American Psychologist, 53,* 5–26.

Holmes Group. (1986). *Tomorrow's teachers.* East Lansing, MI: Author.

Holmes Group. (1990). *Tomorrow's schools: Principles for the design of professional development.* East Lansing, MI: Author.

Howey, K. R., & Zimpher, N. L. (1996). Patterns in prospective teachers: Guides for designing preservice programs. In F. B. Murray (Ed.), *The teacher educator's handbook: Building a knowledge base for the preparation of teachers* (pp. 465–505). San Francisco: Jossey-Bass.

Hutchins, E. (1990). The technology of team navigation. In J. Galegher, R. E. Kraut, & C. Egido (Eds.), *Intellectual teamwork: Social and technological foundations of cooperative work* (pp. 191–220). Hillsdale, NJ: Erlbaum.

Hutchins, E. (1991). The social organization of distributed cognition. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 283–307). Washington, DC: American Psychological Association.

Krajcik, J. S., Blumenfeld, P. C., & Starr, M. L. (1993). Integrating knowledge bases: An upper elementary teacher preparation program emphasizing the teaching of science. In P. A. Rubba, L. M. Campbell, & T. M. Dana (Eds.), *Excellence in educating teachers of science* (pp. 37–54). Colombus, OH: ERIC Clearinghouse.

Labaree, D. F. (1998). Educational researchers: Living with a lesser form of knowledge. *Educational Researcher, 27*(8), 4–12.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal, 27,* 29–63.

Lampert, M., & Ball, D. L. (1998). *Teaching, multimedia, and mathematics: Investigations of real practice.* New York: Teachers College Press.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life.* Cambridge: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Leinhardt, G. (1988). Situated knowledge and expertise in teaching. In J. Calderhead (Ed.), *Teachers' professional learning* (pp. 146–168). London: Falmer.

Leinhardt, G. (1990). Capturing craft knowledge in teaching. *Educational Researcher, 19*(2), 18–25.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1998). New technologies for teacher professional development. *Teaching and Teacher Education, 14,* 33–52.

Means, B. (Ed.). (1994). *Technology and education reform: The reality behind the promise.* San Francisco: Jossey-Bass.

McLaughlin, M., & Talbert, J. E. (1993). *Contexts that matter for teaching and learning: Strategic opportunities for meeting the nation's educational goals.* Stanford, CA: Center for Research on the Context of Secondary School Teaching, Stanford University.

McMahon, T. A. (1996). *From isolation to interaction? Computer-mediated communications and teacher professional development.* Unpublished doctoral dissertation, Indiana University.

Merseth, K. K. (1996). Cases and case methods in teacher education. In J. Sikula (Ed.), *Handbook of research on teacher education* (2nd ed.; pp. 722–744) New York: Macmillan.

Merseth, K. K., & Lacey, C. A. (1993). Weaving stronger fabric: The pedagogical promise of hypermedia and case methods in teacher education. *Teaching and Teacher Education, 9,* 283–299.

Michaels, S., & O'Connor, M. C. (1990). *Literacy as reasoning within multiple discourses: Implications for policy and educational reform.* Paper presented at the Council of Chief State School Officers 1990 Summer Institute: "Restructuring Learning," Literacies Institute, Educational Development Center, Newton, MA.

National Board for Professional Teaching Standards. (1991). *Toward high and rigorous standards for the teaching profession.* Washington, DC: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Education Goals Panel. (1991). *The national education goals report: Building a nation of learners.* Washington, DC: Author.

National Research Council. (1993). National science education standards: An enhanced sampler. A working paper of the National Committee on Science Education Standards and Assessment. Washington, DC: Author.

Office of Technology Assessment. (1995). *Teachers and technology: Making the connection.* Washington, DC: Author.

Pea, R. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 47–87). New York: Cambridge University Press.

Peck, K. L., & Dorricot, D. (1994). Why we use technology? *Educational Leadership, 51*(7), 11–14.

Putnam, R. T., & Borko, H. (1997). Teacher learning: Implications of new views of cognition. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers & teaching* (Vol. II, pp. 1223–1296). Dordrecht: Kluwer.

Reder, L. M., & Klatzky, R. (1994). Transfer: Training for performance. In D. Druckman & R. A. Bjork (Eds.), *Learning, remembering, believing: Enhancing team and individual performance* (pp. 25–56). Washington, DC: National Academy Press.

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13–20.

Resnick, L. B. (1988). Treating mathematics as an ill-structured discipline. In R. I. Charles & E. A. Silver (Eds.), *Research agenda for mathematics education: Vol. 3. The teaching and assessing of mathematical problem solving* (pp. 32–60). Hillsdale, NJ: Erlbaum.

Resnick, L. B. (1991). Shared cognition: Thinking as social practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 1–20). Washington, DC: American Psychological Association.

Richardson, V. (1992). The agenda-setting dilemma in a constructivist staff development process. *Teaching & Teacher Education, 8,* 287–300.

Richardson, V., & Anders, P. (1994). The study of teacher change. In V. Richardson (Ed.), *A theory of teacher change and the practice of staff development: A case in reading instruction* (pp. 159–180). New York: Teachers College Press.

Rosenshine, B., & Stevens, R. (1986). Teaching functions. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 376–391). New York: Macmillan.

Ruopp, R., Gal, S., Drayton, B., & Pfister, M. (Eds.). (1993). *LabNet: Toward a community of practice.* Hillsdale, NJ: Erlbaum.

Salomon, G. (Ed.). (1993a). *Distributed cognitions: Psychological and educational considerations*. Cambridge: Cambridge University Press.

Salomon, G. (1993b). On the nature of pedagogic computer tools: The case of the Writing Partner. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as cognitive tools* (pp. 179–196). Hillsdale, NJ: Erlbaum.

Sarason, S. (1990). *The predictable failure of educational reform: Can we change course before it's too late?* San Francisco: Jossey-Bass.

Saunders, W., Goldenberg, C., & Hamann, J. (1992). Instructional conversations beget instructional conversations. *Teaching & Teacher Education, 8*, 199–218.

Schifter, D., & Fosnot, C. T. (1993). *Reconstructing mathematics education: Stories of teachers meeting the challenges of reform*. New York: Teachers College Press.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning* (pp. 334–370). New York: Macmillan.

Shepard, L. A., Flexer, R. J., Hiebert, E. H., Marion, S. F., Mayfield, V., & Weston, T. J. (1996). Effects of introducing classroom performance assessments on student learning. *Educational Measurement: Issues and Practice, 15*(3), 7–18.

Shuell, T. J. (1986). Cognitive conceptions of learning. *Review of Educational Research, 56*, 411–436.

Shulman, L. S. (1983). Autonomy and obligation: The remote control of teaching. In L. S. Shulman & G. Sykes (Eds.), *Handbook of teaching and policy* (pp. 484–504). New York: Longman.

Shulman, L. S. (1986). Paradigms and research programs in the study of teaching: A contemporary perspective. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 3–36). New York: Macmillan.

Simon, M. A., & Schifter, D. (1991). Towards a constructivist perspective: An intervention study of mathematics teacher development. *Educational Studies in Mathematics, 22*, 309–331.

Soltis, J. F. (1981). Education and the concept of knowledge. In J. F. Soltis (Ed.), *Philosophy and education* (pp. 95–113). Chicago: National Society for the Study of Education.

Spiro, R. J., Coulson, R. L., Feltovich, P. J., & Anderson, D. K. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. In *Tenth Annual Conference of the Cognitive Science Society* (pp. 375–383). Hillsdale, NJ: Erlbaum.

Stallings, J. A., & Kowalski, T. (1990). Research on professional development schools. In W. R. Houston, M. Haberman, & J. Silkula (Eds.), *Handbook of research on teacher education* (pp. 251–263). New York: Macmillan.

Sykes, G., & Bird, T. (1992). Teacher education and the case idea. *Review of Research in Education, 18*, 457–521.

Thomas, G., Wineburg, S., Grossman, P., Myhre, O., & Woolworth, S. (1998). In the company of colleagues: An interim report on the development of a community of teacher learners. *Teaching and Teacher Education, 14*, 21–32.

Urdan, T., Blumenfeld, P., Soloway, E., & Brade, K. (1992). IbyD: Computer support for developing unit plans: A first study. In S. Dijkstra, H. P. M. Krammer, & J. J. G. v. Merriënboer (Eds.), *Instructional models in computer based learning environments* (pp. 323–348). Secaucus, NJ: Springer-Verlag.

Vygotsky, L. S. (1962). *Thought and Language* (Eugenia Hanfmann & Gertrude Vakar, Ed. & Trans.). Cambridge, MA: MIT Press. (Original work published in Russian in 1934)

Watts, G. D., & Castle, S. (1992). Electronic networking and the construction of professional knowledge. *Phi Delta Kappan, 73*, 684–689.

Wineburg, S., & Grossman, P. (1998). Creating a community of learners among high school teachers. *Phi Delta Kappan, 79*, 350–353.

Wolf, S. A., Carey, A. A., & Mieras, E. L. (1996). What is this literachurch stuff anyway? Preservice teachers' growth in understanding children's literary response. *Reading Research Quarterly, 31*(2), 130–157.

Wolf, S. A., Mieras, E. L., & Carey, A. A. (1996). What's after "what's that?": Preservice teachers learning to ask literary questions. *Journal of Literacy Research, 28*, 459–497.