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CHAPTER SIXTEEN

Multiples of Evidence, Time, and Perspective

Revising the Study of Teaching and Learning

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The activity of investigation is at the heart of many contemporary ideas about teaching and learning in classrooms. Whether students are studying temperature or democracy or poetry or probability, they are to learn from investigating phenomena and ideas. They are to learn from working on problems, talking with others about potential solutions, building on their own ways of thinking about concepts, and engaging with big disciplinary ideas. In mathematics lessons, for example, students are encouraged to investigate situations in which probabilistic events occur, construct ways of representing mathematical patterns, and debate the applicability of classic strategies for finding needed information. With literature, they are to consider texts closely, investigating and constructing alternative interpretations. Rather than simply assimilating conclusions, they are to engage in fundamental materials and ideas.

Two assumptions underlie this focus on investigation. One is that what there is to learn is more than conclusions—that the processes of knowing and figuring out are essential elements of knowledge of any field, in interplay with its core knowledge. Our thinking about this is related to the current literature on learning mathematics, or any other intellectual work, as being inducted into the culture of a "thinking practice." (See Lampert, 1998; O'Connor, 1998; Rogers Hall, Edward Silver, and other work by Magdalene Lampert.) Framing questions, deciding how to pursue them, being able to develop and evaluate reasonable interpretations and solutions—all of these both depend on and also generate knowledge. A second assumption is that investigation is itself a productive mode

of learning. Investigation as we imagine it is supported by both constructivist and situated theories of learning (Cobb, 1994; see additional references).

We have been exploring how these ideas about learning could apply even to the study of teaching itself. (We use the word *study* here to encompass both inquiry of a scholarly nature and inquiry conducted for the purpose of learning to do or change teaching.) For the past two decades both of us have been teaching elementary school mathematics. Ball has been an elementary school teacher, teaching all subjects. Lampert taught mathematics first at the high school and then at the elementary level (Lampert and Ball, 1998). We have been teachers deliberately seeking to develop our practice—to improve the ways in which we engage our students in mathematics. As we each gradually became involved in broader conversations about the development of practice, in communities of researchers, teachers, and policymakers, we brought to them our experience as teachers. We considered our work "experimental"—that is, we were taking a stance of deliberate inquiry around our practice (Dewey, 1933). We were not teaching for the purpose of testing a curriculum or testing instructional strategies that might be shown to work and then widely disseminated. With the publication of the NCTM (National Council of Teachers of Mathematics) Standards in curriculum and evaluation (NCTM, 1989, 1991), our teaching was frequently cited as demonstrating the NCTM vision for mathematics teaching. We argued, however, that our practice was not best understood as modeling the Standards. Although we had been trying to develop the kinds of teaching and learning that many scholars wanted to know about but had trouble envisioning in real school classrooms, we were not aiming to apply theory to practice, working out the finer details so that others could adopt what we were doing.

Instead, we argued that we were investigating, as teachers, what is entailed in *trying* to teach mathematics for understanding. We sought to engage our young pupils in serious mathematical inquiry, and we tried to create classrooms in which children's ideas were used and respected by the teacher and by their classmates. Because we were teaching in a public school, we were also responsible to meet district curriculum objectives and for our pupils' preparedness for standardized tests. As we encountered challenges and dilemmas (Lampert, 1985), we tried to identify and understand better what shapes them and how we might manage them. For example, we often found ourselves struggling with how much to follow students' novel ideas and how much to steer the class's work back to the main path of currently accepted mathematics and the established school curriculum (Ball, 1993). We worked hard on issues of representation: in the choices of tasks and tools, how different contexts, materials, and questions shape the mathematics that students explore, and what they might learn about mathematics (McDiarmid, Ball, and Anderson, 1989; Wilson, Shulman, and Richert, 1987).

Amid many kinds of discussion about teaching and learning, we realized how often such conversations never developed past exchanges of judgment and opinion. We noticed also how frequently people sought to reduce the complexity of teaching. Faced with problems, teachers and professional development leaders alike promoted solutions. Students are having trouble learning to subtract? Use manipulatives. Motivation difficult? Teach through games. Children having trouble retaining what they are learning? Increase practice. Grappling with teaching ourselves, we eschewed these flat remedies. We realized that the inherent complexity of practice was a central premise for us. We assumed that the main work of teaching was in the "swamp" of the messy challenges of helping all students learn, where the work was multidimensional. Our daily work was embedded in difficult problems of practice, and what helped was better and better understandings of its complexity, not efforts to eradicate that complexity.

Despite repeated reference to our teaching as exemplary of the NCTM Standards, we began to think about how to use our teaching instead to produce *examples* of practice that could be studied by ourselves and others. We would be in the following sense "exemplary": our work would offer examples of certain ideas about and aspirations for teaching. Given our premise about the complexity of teaching and learning, we sought a complex knowledge of teaching that expanded what any one of us could see or hear. We assumed that increased and more finely tuned ability to examine and interpret teaching and learning would improve practice. We wanted more, not fewer, questions with which to listen to our students. We wanted more, not fewer, perspectives from which to consider what to do next. Rather than quieting the pedagogical discord, we sought perversely to increase its cacophony. With multiple voices shaping what we could see, hear, and imagine, we would be better prepared to face the complexities of practice. It seemed reasonable that one way to develop these multiple voices was to engage many different kinds of people in the investigation of a common context of practice (see Wertsch, 1991, on voices; also Heaton and Lampert, 1992).

We realized that if we could represent practice, then the possibilities for investigating and communicating about teaching and learning—by different communities—would be enhanced. Although others wanted to highlight our practice, what we needed to draw on was our knowledge of *investigating practice*, not our own evolving knowledge of practice itself.

We understood this as a problem of representation and communication. How could the many complex layers of practice be represented? And how could practice be engaged and discussed by a wider range of people concerned with teaching and learning? By making it possible for others to gain access to our classrooms, we envisioned that we could develop a common experience of classroom events to ground a more analytic discourse of practice. We imagined the possibilities that

could ensue if more people were looking at the same classroom, bringing to bear different questions, experiences, and perspectives on the description, analysis, and appraisal of teaching and learning, and if, as part of that, the discourse of and about practice was shaped to center more on inquiry and analysis than on answers and evaluation.

The point was not to study Magdalene Lampert and Deborah Ball, or to study *our* teaching per se. Instead our vision was of using our classrooms as examples of a serious effort to teach elementary school mathematics for understanding and as a site for developing new ways to investigate teaching and learning. Viewed this way, what we envisioned can be seen as a special case of the genre of qualitative case studies. Like other case study research, this kind of work interweaves the empirical with the conceptual. Such case-based inquiry strives to illuminate broader issues, probe theoretical problems, and develop arguments and frameworks. A burden of proof rests with the investigator that something worthwhile can be learned from the close probing of a single instance. This raises the crucial question of what any "single instance" is an instance *of* (see Wilson and Gudmondsdottir, 1987; also Erlwanger, 1975). In our case, we sought to represent the teaching and learning in our classrooms as instances of elementary mathematics teaching and learning that aims at understanding.

We pondered what it would mean to make it possible for more people to have access to our classrooms as sites for investigating practice. What kinds of records would be needed to represent and communicate the complexity of these practices of teaching and learning? Whereas most researchers sample student and teacher work, discourse, and interaction, we engaged in a project to document classroom teaching and learning both extensively and intensively across an entire school year. During 1989–1990 we collected information about mathematics teaching and learning in our two classrooms. We collected video and audio records of small and large group work, copies of children's drawing and writing, quizzes, report cards, and our plans and notes. Over the past eight years we have been exploring the kinds of inquiry that access to this massive collection encourages and makes possible. Our inquiry into inquiry draws on our own efforts to study teaching and learning, as well as our observations of others' work with these materials (Schwab, 1961). To make still more fertile the terrain of inquiry, we have also been collecting and cataloguing annotations on the documents in the collection, building tools to analyze the records and annotations, and designing computer environments in which access to both records and analyses can be made available to both scholars and practitioners.

In this chapter we examine opportunities and problems in this approach to educational scholarship in which multimedia primary records of teaching and learning are made available to others. First we look more closely at what it might mean to investigate practice from multiple perspectives. Next we discuss

what is entailed in collecting information to represent and communicate the complexities of teaching and learning. Third, we speculate about the role of new technologies in the development of a discourse grounded in instances of practice. What can we say about a technology that is fragile, rapidly developing, and expensive as a necessary tool for doing this kind of work? Finally, we conclude with a discussion of issues raised by our investigations of the investigation of teaching and learning.

INVESTIGATING TEACHING AND LEARNING

One thing we have learned is that discussions about practice are often more fruitful when they are situated in reference to a common context. A conversation about the teacher's role in class discussions, for example, can proceed with more depth when it is grounded in a common and concretely available instance of class discussion. Without a common context, it is possible for people to talk about teaching and learning without knowing whether they are agreeing or disagreeing about the meaning of terms, principles, and ideas. They can advocate for "hands-on" learning, "class discussion," or "problem-based" instruction, and not realize how differently they conceive these. Hence, to ground *this* discussion, focused on the investigation of practice, we begin with an illustration from a by-now widely familiar lesson in Ball's third-grade class. Our intention is to situate our consideration in and around a particular instance of practice, and to use it as ground for an examination of the investigation of teaching and learning. First we briefly recount the lesson (see also Chapter Twelve for a discussion of "Sean numbers"). Then we examine observations and questions that ensue.

The Lesson

In the middle of January, when the third-grade class was studying even and odd numbers, Sean[1] raised his hand and said:

> I was just thinking about 6, that it's a . . . I'm just thinking. I'm just thinking it can be an odd number, too, 'cause there could be 2, 4, 6, and two, three 2s, that'd make 6. . . . And two 3s, that it could be an odd *and* an even number. *Both! Three* things to make it and there could be *two* things to make it [Class data, Jan. 19, 1990].

Listening to this, Ball understood that in a certain sense, Sean was wrong. Six is not "an even number and an odd number." Even and odd numbers are mutually exclusive categories. But she guessed that he was connecting this to something that another child had just said—that some even numbers are "made of two even numbers" (8 is "made of 4 + 4," for example). And she thought

[1]All names used here are pseudonyms.

that Sean and his classmates could straighten this out with reference to the working definitions they had developed.

When she asked others what they thought of his claim, several other students tried to show him he was wrong. Cassandra used the number line to show him the consequences of thinking of 6 as odd. Pointing alternately to the numbers beginning with 0, she labeled them, "Even, odd, even, odd, even, odd, even . . . " and explained that calling 6 odd would make 0 odd as well, which did not make sense. But Sean only reasserted his point that 6 could be both even *and* it could be odd.

Hearing this exchange made Ball think that what she needed to do was to clarify the class's working definitions of even and odd numbers, which the class then took a few moments to do. Ball thought this cleared things up.

Still Sean persisted with his idea. The class was becoming more agitated. "Prove it to us! Prove it to us that 6 can be odd!" demanded Tembe. Sean willingly walked up to the board and calmly drew six circles and divided them into three groups of two (see Figure 16.1).

Suddenly Mei seemed to see what Sean was saying: "I think what he is saying is that, it's almost, see, I think what he is saying is that you have three groups of two. And 3 is a *odd* number so 6 can be an odd number *and* a even number."

Sean agreed with her, nodding.

Mei, however, having clarified what Sean was saying, said she disagreed with that. She went up to the board, announcing emphatically, "It's not *according* to how many *groups* it is."

She stood at the board, thinking. Then, suddenly sure of herself, she drew ten circles on the board (see Figure 16.2.).

"Let's see. If you call 6 an odd number, why don't you call 10, uh, like . . . uh, an odd number and an even number, or why don't you call *other* numbers an odd number and an even number?"

Figure 16.1. Sean's representation of the number 6.

Figure 16.2. Mei's representation of the number 10.

Mei seemed to think that this would convince Sean to give up his idea. Instead he looked at it and said, "I didn't think of it that way. Thank you for bringing it up, *so*—I say it's—10 can be an odd and an even . . . "

Other children grew more excited, and hands waved in the air. Mei, with rising conviction, exclaimed, "But what about *other* numbers?! Like, if you keep on going on like that and you say that *other* numbers are odd and even, maybe we'll end it up with *all* numbers are odd and even. Then it won't make *sense* that all numbers should be odd and even, because if all numbers were odd and even, we wouldn't be even having this *discussion!*"

What Do People See in Practice?

This episode from Ball's class has been examined by many different people (among them Rodney McNair, Penelope Peterson, Ralph Putnam, and Lee Shulman). Groups of policymakers, for example, have viewed the segment on videotape and have discussed how this classroom differs from the mathematics classes that they remember. They have investigated what students might be learning from their participation in this discussion and have considered their views of what is important to learn. Some have become deeply focused on issues of classroom culture. "How did the class develop into a place where children are able to show respect for one another's ideas?" Others have wondered what is going on with students who are not speaking, assuming that those who are not speaking are also not engaged.

Experienced teachers have watched the tape and examined the teacher's journal and the students' written work. They have investigated questions such as, "What did the students seem to know about even numbers and odd numbers?" "What is going on with the students who are not speaking?" "Is this worth spending time on?" They have discussed issues of being patient with children, of waiting, and wondered about when and how teachers should intervene. "Does Ball ever finally tell the students that 6 is not both even and odd?" "What do the students take away from this? Do some become more confused about even and odd numbers?" "Where does Sean get this idea in the first place?"

Whereas experienced teachers often focus on the students and the pedagogical decisions, preservice teachers' questions are often more immediate. "Does Ball do this every day? How does she cover the curriculum if she does this?" They worry about Sean's feeling embarrassed and about Mei's "showing him up." They see Sean as confused and want to locate where Ball "clears things up" and how she does this. They notice the classroom culture, although they rarely call it this, and they ask: "How did Mei and Sean come to treat each other like this?" "Is Sean getting backed into a corner by his peers?" "Is Mei trying to put Sean and his idea down?"

Mathematicians have viewed the episode with an eye toward the mathematics underlying the exchanges. At a recent conference, over one hundred mathematicians viewed the full lesson segment and investigated Sean's understandings.

They viewed the tape, examined the lesson transcript, and discussed their interpretations of the child's thinking. Asserting with great certainty what Sean knew or was doing, they were soon stunned to discover how differently they saw Sean. Heretofore content to assume that professional mathematical training could provide the intellectual tools to "hear" students, they confronted the interpretive nature of the work of understanding children's mathematics. And they contemplated the ambiguities and uncertainties inherent in this process. Whereas one mathematician was sure that Sean and the class were encountering modular arithmetic, specifically numbers congruent to 2 mod 4, another asserted equally definitively that Sean was operating on the desire to make the odd numbers closed under addition—that is, that an odd plus an odd ought also to be odd. Still another believed Sean was quite clearly confused as a result of the imprecise definitional language that the teacher had given the class. The "working definition" seen in the lesson is: *Even numbers are numbers that you can split evenly in half without having to use halves.* This definition was not necessarily given by the teacher, but the mathematician assumed that.

Education researchers also have viewed this episode. Their observations and questions, too, are shaped by their concerns and perspectives. On one occasion we showed this episode at a meeting focused on the study of classroom communication. A group of prominent researchers who study classroom teaching and learning watched the seven-minute film clip and began discussing the interactions among the children and between Ball and the children. One researcher asserted that Ball had a clear agenda and was doing all the talking, thus restricting children's opportunities to articulate their ideas. Another emphatically disagreed, arguing that Ball had all but abdicated her role in orchestrating or steering the discussion. The children, according to the researcher, were being allowed to meander, with little pedagogical guidance. Still another saw the lesson primarily in terms of patterns in who was talking, types of turns, and what this might reveal about status within the class. Another examined patterns of interaction by gender. Whereas the mathematicians attended closely to the content of the lesson, the educational researchers attended to interaction, classroom norms, and students.

STUDYING TEACHING AND LEARNING FROM MULTIPLE PERSPECTIVES

Across settings, communities, and individuals we have seen how differently people see and interpret the video segment and the accompanying texts: children's work and the teacher's journal. Just as we expected, they bring their own training and perspectives to bear. Sociologists often notice patterns of interaction by groups. Psychologists comment on the children's development. Parents notice the children's

interest level. Further, because classrooms are multidimensional, people do not confine themselves to those issues central to their own areas of experience. They are drawn, quite naturally and individually, into the complex tangle of practice. For example, mathematicians do not comment only about the mathematical issues, but also make claims about what children are learning, or they comment on the pedagogy. Policymakers become engaged in the mathematics of the children's talk. Psychologists examine the classroom culture. People do not see or hear the same things. What they see or hear is interpreted through the filters of their own knowledge and experience, both professional and informal (see Ball, forthcoming; Kelly and Lesh, forthcoming; and Lampert, 1998).

On one hand, then, we see the amazing array of perspectives that can be fruitfully brought to bear on practice from the outside. But what of the perspectives available from the inside? What we see and ask in examining the materials from our classrooms is from a viewpoint of insiders to the setting and the practice. We identify and ask about things that outsiders may not see. Having listened to dozens, even hundreds, of eight-year-olds, and knowing these particular eight-year-olds, means that we conjecture meanings in their talk that others may not. Deliberating on alternatives, we are aware of decisions we face that are invisible to observers. We can feel rhythms of timing that shape the motion of class. We are aware of the many cues we read off students' faces, words, and posture-composing our impressions of student engagement, boredom, understanding, confusion (Ball, forthcoming).

We return to the episode with Sean and the number 6. At the time, Ball remembers feeling conflicted and having many questions. She was pleased to see him so engaged, because he was not always so. But what was he really saying? Was he serious about thinking that 6 could be odd? Where were the other children on this? Was this discussion confusing them? Ball could see some possibilities around Sean's "discovery," but, she wondered, Is this worth spending more time on right now? The children had been engrossed in exploring conjectures about even and odd numbers, such as "even plus even equals even" and "odd plus even equals odd." They were working in small groups, seeking to figure out if these conjectures would be true for all even or odd numbers. This work, on the brink of early experience with formal proof, was exciting to the children, and to Ball as well. Was it worthwhile to divert this work to attend to Sean's idea about 6? Ball noted with pleasure how Mei and Sean were treating each other—with respect and seriousness, it seemed to her. Still, she wondered how Sean was feeling. Ball wondered whether and how best to exploit Sean's idea while also making sure the children got clearer about the definitions for even and odd numbers. Continuing the discussion for a while, a pattern was identified for other numbers like Sean's 6: 10, 14, 18, 22, 26, and so on. (Each of these numbers, like 6, has an odd number of factors of two.) They even discovered that 2 fit the pattern, for it has *one* group of two, and 1 is an odd number. Ball felt torn: she could see that the children had

wended their way into some interesting mathematical territory. But she also could see the third-grade curricular schedule before her eyes, and she continued to question what this exploration, however mathematically intriguing, was doing for all the students.

Just as disciplinary perspectives—mathematical, sociological, philosophical, and so on—can illuminate aspects of practice not otherwise focal, perspectives drawn from inside the practice of teaching also expand our collective understandings not only of the practice but also *of what there is to investigate about practice*. Lampert's work on dilemma management, for example (Lampert, 1985), emerged from her own experience of facing mutually incompatible goals and concerns as a fifth-grade teacher and yet having to maintain attention to them in her moves and decisions. Facing the multiple aims and considerations was not a matter of choice, she argued. Her analyses and those of others who drew on her conceptualization of "dilemmas of teaching" have since opened a perspective on the challenges of practice that broke with the ways in which others had written about dilemmas in teaching (see, for example, Berlak and Berlak, 1981). Heaton's (1994) work on the experience of an accomplished teacher who seeks to learn to teach for understanding by teaching fourth-grade mathematics illuminates the confusions and insecurities that a teacher in such a position might face—confusions and insecurities that would be difficult for an outsider to recognize. Ball's examination of the episode with Sean highlights the endemic tension in honoring both students and subject matter (Ball, 1993).

These and many other questions like them, articulated from inside practice, are both multidisciplinary and extradisciplinary in nature. Their pursuit entails empirical, conceptual, and philosophical considerations. Many of these questions, central as they are, are also fundamentally unknowable. There is no single or conclusive answer to whether pursuing Sean's idea is mathematically worthwhile, or to what the other children are getting from this discussion. The complexity of practice makes it a terrain of uncertainty rather than conclusiveness. Infrequently are the central questions matters for which definite answers can be found: despite the fact that "What is Sean thinking?" is a question at the heart of practice, it is not one that can be definitively answered. Yet investigation and careful analysis can finely map an issue in such a way that it can be seen and considered from more perspectives. Although this does not lead to answers, it does lead to improved understanding of the multiple constituents and interactions within any particular slice of teaching and learning.

CREATING A REPRESENTATION OF TEACHING AND LEARNING

Because we were convinced that a kind of investigation of practice was needed that was at once built from the inside and developed with multiple perspectives

from the outside, we set out to represent the terrain of practice. Despite our conviction, we had many questions: Are there ways to record and represent practice that would enable us to interrogate its complexities more effectively? Can tools be designed that would support multilayered investigations of practice, not just by us but by others? What might such materials and tools make possible? What problems and issues might emerge?

We chose to document closely a year of teaching and learning in our own classrooms because we were willing to be recorded day after day, to have our students' work scrutinized, and to keep careful records of our own plans and reflections. Committed to the idea that teaching practice could not be captured in a few model lessons, we were willing to have documentation occur no matter what was happening in the room. We wanted to learn about what it might take to crisscross the terrain of practice, to learn about teaching from the inside of the practice itself. A problem we faced was how to represent the teaching and learning in our classrooms in ways that would make it possible to investigate practice.

Teaching and learning are seamless activities that occur in the streams of human experience and interaction. One does not start teaching when the morning bell rings or stop learning when it is time for recess. The events we would call "teaching" and "learning" do not have neat boundaries around them. Although they are interactive, they do not occur only when teacher and students are face to face. Any particular event is connected in multiple and complex ways to the events that preceded it. From the inside, it seemed to us that the problem of capturing a year-long record of everything we did as mathematics teachers and everything our students did as mathematics learners was similar to the problem faced by the mapmakers in Borges's imaginary kingdom, who thought the best map should represent exactly in one-to-one scale everything in the kingdom. Even if it were possible to run several video cameras from the start of the 1989 school year to its end, we reasoned, we would have an inadequate record, because the stream of events so recorded could be understood only in the context of past experience, suggesting the even more absurd idea that if we really wanted to document teaching and learning, we should have been videotaping everything in the lives of the players since their births. We would have to choose to collect a limited set of records. That was clear. But how would we choose? We could have decided on a "story line" at the outset like "the development of students' capacities to represent their ideas in multiple formats" or "the establishment of a classroom culture that supports mathematical discourse" or "the teacher's and students' roles in determining lesson content" and collected the records we would need to tell that story. But many such "stories" could be told about any class over a one-year period, and we wanted to make a collection that would make it possible to assemble numerous stories after the fact. With this goal in mind, we made our decisions about the structure of the collection as a

whole and about what should be collected on any given day and periodically throughout the year. We were guided throughout by the idea of producing multiple representations of the phenomena under study. We began in September 1989 with the idea that we would record an entire year's worth of teaching and learning. (This work was funded by the National Science Foundation under grants TPE 89–54724.)

The idea that what we were producing would be a representation of practice meant that we wanted to collect multiple records of what was happening. (We recognize that all records are in some sense interpretations and that records and interpretations exist along a continuum of documentation of experience. Hence, no data are "raw"—that is, complete and unbiased.) To make records, we wanted to add to our capacities to perceive and remember what was happening and produce multiple images of events for others to look at and listen to. Such a multiplicity of images would enable post hoc triangulation and description.

Ordinary Artifacts of the Practices of Teaching and Learning

In this category are the records that we would routinely keep for the purposes of planning and reflecting on our teaching and student assessment: daily teaching journals and student class work, tests, and homework, as well as reports to students and their parents on students' work. These artifacts serve as both records of what occurred and as representations of what one *does* in the course of doing the kind of teaching and learning we wanted to study.

As teachers we had been keeping journals as a matter of course for more than ten years. Except for the rule that we would write something every day, entries in these journals were not standardized. We generally wrote for an hour for each hour of teaching time and variously included notes on lesson preparation and evaluation, including long- and short-term plans, observations on individual students, design of mathematical problems for each class session, and comments on general pedagogical problems. We did not alter this practice during 1989–1990, nor did we make any changes to the form of our journal entries. Because teacher thinking is a central component of teaching practice, we reasoned that those who wanted to study teaching and learning in our classrooms would need access to these notes in order to get some insight into our insights, perspectives, reactions, plans.

As we wrote in our journals across the year, in bound notebooks, with pens, our writing and drawing was transferred to electronic text and graphics so that it would be possible to do word searches on the text to find information about particular students, issues, and problems.

We had also developed as a regular part of our practice routines for students to record their work on mathematics in and out of the classroom in a bound notebook. At the fifth-grade level, students wrote down the "problem of the day," recorded their experiments with aspects of the problem, stated their conjecture

about a solution, and composed a reasoned argument for why their solution "made sense." In the third grade students also copied the day's problem and worked on it, first individually and often with a partner as well. During the class discussion of the problem, they continued to write and record ideas and representations. Students in both classes used their notebooks to illustrate ideas they were trying to explain to other students. In addition to being a running record of what students did during the mathematics class besides think and talk, the notebooks document something about the content of the lessons for each student. Because of the way lessons were structured, students differed in their experiences of and interpretations of the curriculum, so it would not have been enough simply to record each day's assignment. For any particular day, we wanted a record of what mathematics students were working on. The notebook as a whole could offer perspectives on each student's experience on a given day and over time.

These notebooks were collected and reviewed regularly by each teacher. Lampert wrote comments on the students' work for them to read and respond to; Ball took notes in her teaching journal and also spoke with the children individually about what she saw in their notebooks. We collected and catalogued homework assignments in order to demonstrate the nature and role of homework in relation to classwork and show the teacher's decisions about what students can profitably do at home. We continued this practice during 1989–1990. The student notebooks were collected weekly and photocopied. Once the notebooks were photocopied, page numbers were added to each page, and they were filed by date and student. We also photographed the notebooks on occasion to record the sense of the whole.

In addition to the daily notebooks, we collected all homework, quizzes, and reports to parents in order to have a complete record of all existing written information about students' work and learning.

Records Collected: Videotapes and Audiotapes, Transcripts, Observers' Notes as Records of Lessons

Beyond the collection of materials generated in the course of routine practice in our classrooms, we also collected records that would make more available the multiple events and levels of experience. We used videotape and audiotape to record lessons and other conversations with the children outside of class. Structured field notes on every lesson were also written during class by observers. (We are indebted to Fred Erickson and Jan Wilson, 1982, esp. pp. 39–47, for guidelines for collecting multimedia records in classrooms derived from the standards set in ethnographic.)

We collected extensive video and audio documentation of both classes. Although the people who did the taping did not have professional videography skills, they brought school-sensitive tact, knowledge, and insight to the task that technical assistants might have lacked.

We began taping each day as students came in the door for recess and continued taping for a few minutes after each lesson was over to get a more complete class period. We wanted to portray the fact that teaching and learning go on outside the conventional lesson boundaries imposed by bells or the teacher's announcements. Students often do or say things as they come in the room or as they are packing up their books that are highly connected to what goes on during a lesson. In both classrooms, the formal lesson period had roughly three parts: a short beginning segment in which the teacher communicated the "problem of the day," about a half-hour during which students worked in groups of four to six on the problem, and another half-hour of teacher-led discussion of some aspect of the mathematics in the problem.

Considering possible types of shooting and editing, we chose neither conventional documentary procedures in which we would collect shots varying greatly in scope and piece them together in an order different from the original sequence in which they were shot, nor the opposite extreme of "locking on" the camera to one perspective and letting it run for the duration of the lesson. Instead, we filmed long takes, with the camera zooming in and out and the camera person moving around focusing on salient details. This allowed us to acquire a continuous record of events while at the same time doing some situated interpretation (see Feld and Williams, 1975, for an argument supporting this approach).

During all of the time we taped, there were many different kinds of activities going on simultaneously. When watching earlier tapes we had made, viewers often asked, "What is the teacher doing when . . . ?" or "What is the rest of the class doing while . . . ?" Although we could not realistically capture everything viewers might want to see, we decided to have two cameras running simultaneously during all times—one that would follow the teacher and one that would roam off the tripod during small group activity. Although keeping the camera on a tripod was less distracting for students, we knew we wanted close-ups of student work while it was in production, as well as documentation of students' talk and body language as they tried to communicate their mathematical ideas to their peers.

We decided each day which children to focus the cameras on to vary who was being recorded and take advantage of the variety of activity available to record. Much of the time, the cameras captured several small groups seriatim as they worked on the problem.

We audiotaped all lessons in order to generate a complete record of whole group interchanges. We also decided to audiotape conversations in small groups in order to expand the regions of the classroom that were recorded. The daily audiotapes also made it easier to produce "first-pass" transcripts of each lesson. These transcripts were then corrected, and the detail added "enhanced" by a member of the research team who could recognize individual students' speech patterns since they

had made extensive observations in the classroom. We anticipated that transcripts would be invaluable to users unfamiliar with the classroom and its discourse, even if the sound on the videotapes was of good technical quality.

We decided to supplement the audio and video records of the classes by having observers write summaries of each lesson describing mathematical content, pedagogical representations, problems that arise from the perspective of the students, activities of five focal students in each class, incidents of potential interest to teacher educators and teacher preparation students, and comments on the overall agenda. These standardized semianalytic field notes would provide a complex index of lessons that would make possible searches of various kinds. We rotated the preparation of notes among observers with mathematical background, teaching experience, and teacher education experience to vary the perspective of the notes and avoid a singular focus.

ACCESSING, LINKING, AND ANNOTATING THE RECORDS: USING NEW TECHNOLOGIES TO CREATE A MULTILAYERED DISCOURSE OF PRACTICE

In 1989 we made a request to Apple Computer for some equipment to start experimenting with building tools that would give us and other investigators access to all of these records and the capacity to record and browse multiple interpretations of teaching and learning events. We argued:

> Given access to a rich collection of documents in multiple media, users should be able to form their own hypotheses about teaching and learning and to test those hypotheses against a wealth of data from the two classrooms. . . . In the hands of a user who seeks to learn about teaching, the system would enable and encourage exploration and investigation. . . . In the system we propose to design, users will have the capacity to do research on their own questions about how teaching and learning proceed in classrooms where a different kind of mathematics is being taught. They will have access to tools which enable them to move through material (audio, video, written transcripts, voice/written annotated notes by the instructor or other students), to construct their own interpretations [Lampert and Ball, 1998].

The technical capacities of hypermedia were just beginning to be realized in 1989 with the commercially available but simplified software produced by Apple called Hypercard and in more sophisticated environments like that created in Brown University's Intermedia. The tools for investigation produced by Intermedia were impressive: in biology, history, and English literature, faculty members and students were able to browse many kinds of documents in a nonlinear

fashion, creating their own links among ideas and evidence and making annotations on varieties of text and graphics. But Intermedia depended on a whole laboratory full of developer-programmers and hardware designers—as well as very expensive UNIX computers for each student workstation (Yankelovitch, Han, Meyrowitz, and Drucker, 1988). And although Intermedia made it possible to link and annotate text and graphics, it did not include video or audio as sources of information. At the same time that Intermedia was presenting a hypertext "proof of concept," Apple was beginning to market Hypercard and had even produced a booklet for university instructors on how to design and market multimedia course materials and some demonstration videos of projects under development (Apple, 1988). The company suggested that not only text and graphics but video and audio could be linked and annotated. We saw in hypermedia the technical capacity to make records of teaching available to multiple investigators. We imagined that with Hypercard, we could build interactive multimedia tools that would run on personal computers (see Ambron and Hooper, 1988, for several case studies of development projects in the education sector).

At the MIT Media Lab in the 1980s, researchers were beginning to explore the use of video in documenting multiple perspectives on classroom teaching and learning and experimenting with Hypercard as a program for editing, linking, and annotating that record (Goldman-Segall, 1990; Harel, 1990). These researchers argued that hypermedia could provide multiple perspectives on classroom activity, since records of the learner's work, the teacher's work, the results of that work, and interpretations of it could all be linked and made available to anyone who was interested in seeing what went on. They deliberately rejected the "documentary" genre of videography as representative of a single (the editor's) point of view on classrooms and chose instead to build systems that would enable users to make their own "documentaries," to be able to view the documentaries of others, and to have the flexibility to remake the story over and over.

Coincidentally, while we were engaged in the study of education practices and thinking about hypermedia as a tool for communication about those practices, a team of researchers at the University of Illinois, led by Rand Spiro, was studying medical practice with similar problems in mind. They wanted to be able to represent diagnostic practice in order to communicate better with medical students about how doctors used knowledge. They went beyond the classical case-based instruction then popular in medical schools, claiming that real-world cases had a multifaceted complexity and thus needed to be represented in lots of different ways to bring out those multiple facets. They criticized written cases for being unilateral and for representing their author's perspective. The metaphor that Spiro and his colleagues used for their hypermedia development work was drawn from Wittgenstein's ideas about knowledge as a terrain to be explored by multiple journeys through it, none of which

would entirely capture the terrain in its entirety. This metaphor seemed powerful to us, given what we wanted to represent about teaching. When Wittgenstein set out to summarize his thoughts about the nature of knowledge into a coherent whole "with a natural order and without breaks," he instead produced *Philosophical Investigations* (1963), a series of remarks representing different journeys across the intellectual terrain that relates meaning, understanding, logic, consciousness, and other things. He says of this work in the Introduction:

> After several unsuccessful attempts to weld my results together into such a whole, I realized I should never succeed. . . . My thoughts were soon crippled if I tried to force them on in any single direction against their natural inclination.—And this was, of course, connected to the very nature of the investigation. For this compels us to travel over a wide field of thought crisscross in every direction.—The philosophical remarks in this book are, as it were, a number of sketches of landscapes which were made in the course of these long and involved journeyings [Wittgenstein, 1963/1968].

Wittgenstein's frustrations felt familiar. His notion of knowledge as a terrain has persisted in our thinking about teaching and learning as a domain of study.

Although we did not have access to tools that would make it possible for us to collect records of teaching and learning in digital form, we did want to collect them in a form that could later be digitized and stored in a computer. We gambled on the fact that the tools for digitizing would become cheaper and more widely available in the near term, making the idea of computer storage and software-driven access realistic. We used hi−8 video cameras, audio recorders, and still photographs. We used black pens on white paper for all material that was to be photocopied and later scanned. Software for making these records digital was in its infancy, and we tried a variety of graphics and word processing programs simultaneously, producing filing cabinets full of tapes and paper versions of transcripts, students' work, observers' notes, and teachers' notes.

We had set out on our quest to collect a rich set of records of practice. What we wound up with was a multifaceted archive produced using various computer applications that had very quickly outdistanced HyperCard's capacity for filing and linking. Database software that would make a system of even simple cross-referencing available was growing and changing quickly, but at the time we needed it, none was available for use on standard personal computer hardware that could cope with the many different kinds of information we were collecting. None could make links between, for example, the seating chart for a given day and the work of the students sitting in a particular group. Only recently have databases been able to deal in any way with more complicated data such as complex text, and multimedia and most databases provide only the limited ability of storing all such complex data as an indistinct unit that can be saved and retrieved, but not searched or manipulated.

The archive of classroom records we collected is very complex in terms of its structure and the way that one piece relates to others. It encompasses a large number of different types of objects. Database programs typically track a limited number of things (like an inventory system, where there are many different objects that are tracked, but technically each object is treated as the same) and treat complex objects as uniform and undifferentiated. Storing, accessing, and manipulating data of the type we have collected by several simultaneous users is still on the leading edge of computer science research. Making a user interface that clearly communicates what is there and how to get to it complicates the problem even further. (See Moody, 1996, for the story of the software development team that worked on a children's multimedia encyclopedia for a year.)

INVESTIGATIONS IN PRACTICE

We grappled with what was involved in representing teaching and learning with more complexity. We worked to create an accessible and flexibly manipulable terrain of representation that could be crisscrossed by investigators seeking to learn about teaching and learning. Throughout, we have been actively engaged in experimenting with what happens when such materials, even in less than full format and without the most sophisticated tools, are engaged and explored by others. Our core aim is to examine what happens and what might be learned when investigators seek to learn about practice through close examination of artifacts of teaching and learning. In the last section of this chapter, we return to the episode about Sean and the number 6 and discuss what we have been learning from our forays.

What Stands Out About Others' Inquiry into Practice?

What stands out about what is entailed in understanding teaching and learning from the many times we have shown materials from this class to individuals and groups? What we have usually made available for these investigations includes a videotape of twenty-one minutes of class—although we usually show only approximately eight minutes—copies of children's writing from their notebooks from that day, and the teacher's journal entries for that day and several days thereafter.

Number and Scope of Questions. One thing that has repeatedly struck us is the range and variety of questions that are provoked from one segment of a classroom lesson. Additionally striking is the many domains from which these questions emerge and in which their pursuit heads. Some questions bore down into the data at hand. Who is talking, and what kinds of turns do they take? What is Ball saying, and what do her moves seem to do? Other questions

require more interpretation: What is the mathematical essence of what Sean is saying? Is he confused or onto something mathematically profound? These questions seek to understand and explain the episode itself.

Other questions extend beyond the boundaries of the seven minutes of tape. Asking what students take from this episode and whether they become confused as a result is a question that requires examining evidence beyond that lesson. Asking how the classroom culture developed by January to make this episode possible requires looking at data from the beginning of the school year. It also requires examining what are consistent features of this classroom's culture. These questions examine this classroom more broadly. Both these and the previous questions are about the particulars of this episode and this classroom. Making the connection from particulars to more general questions or issues of teaching and learning is far from automatic.

Still other questions jump off the episode, and even off the data, into a host of crucial normative issues. Is Sean's idea worth discussing, or should the teacher simply tell him and his classmates that even and odd numbers are mutually exclusive sets and review the definitions of each? Should the teacher let a couple of children talk in front of the class, or should she put them in small groups so that everyone gets a chance to talk? These questions, and others like them, raise issues of value and norms, prompted by but not confined to the particular episode.

The Relations of Observations and the Observer. Noting the range of questions that emerge repeatedly reminds us of the deeply theoretical nature of observation. What people see and inquire about is shaped by what they know, believe, and assume (see Latour and Woolgar, 1979, on how scientists use theory in their observations). Events, relations, ideas, and patterns are not "in the data," to be apprehended by viewers. Quite obvious is the fact that an experienced elementary teacher will see things on the tape that will be invisible to a policymaker—the structures of the pedagogical moves, for instance. A mathematician will see things not likely to be noticed by an educational researcher, and vice versa. Take as an example an excerpt from the commentary produced by the mathematician Hyman Bass (1997):

> Ball and the other children have implicitly taken as understood that a number cannot be both even and odd. While Sean consistently (with one small exception) speaks of 6 being even *and* odd, letting these qualities comfortably coexist in his mind, Ball often paraphrases Sean as proposing that 6 is even *or* odd, suggesting that it is ambiguously one or the other, rather than both at the same time, as Sean wishes to allow. Ball's use of "or" conveys a source of the conflict that we witness, and which Sean's "and" did not intend. Ball at one moment thinks that Sean, in saying that 6 is odd, is saying therefore that 6 is *not* even, and [concludes that] Sean must be confused about the definition of even numbers.

Taking note of the difference in meaning between "6 could be both even and odd" and "6 could be even or it could be odd" is a subtle but critical observation, linked to significant differences in the mathematical conjecture. In his written commentary on this lesson, Bass frequently notes mathematical moves and uses of language that highlight for him, as a mathematician, what is going on mathematically among the children and their teacher. For example, he points out that Sean's idea is confined to the number 6. It is only when Mei offers 10, presumably as a challenge to the implication of Sean's idea, that his idea begins to be generalized, setting the stage for the students' later discovery that 14, 18, and 22 are all also examples of his idea. Bass's comments often point to issues of knowledge invisible to others whose experience and training point them to other salient elements of the lesson which are, in turn, obscure to Bass and his colleagues.

The Inherent Incompleteness of Any Representation of Practice. A third, and related, issue is what constitutes the "data" for investigating teaching and learning. No data comprise all there is to "see" or to inquire about (see Erickson and Wilson, 1982). Despite the vastness of our database and despite our attention to collecting extensive daily video and written information about these classes across an entire school year, the information is nonetheless necessarily incomplete. The camera takes aim and makes choices the investigator may rue. What is the small group sitting at the front right of the class doing at the beginning of the small group work time? This question is out of bounds unless that region of the classroom was in the camera's eye at that moment. The children's written work is a cognitive archaeology that defies the desire to examine the layers and their temporal development. Did Ofala make that picture of even numbers before or after Nathan said his idea? When did Riba cross out her written definition? Was Daniel looking at Harooun's notebook, or vice versa, or did they work together, recording as they went? Answers to these critical questions of practice are impossible from the temporally compressed records we have collected. What was the teacher's intention in asking a particular question, and how did the students interpret it? Our claim here is not that any other practice is somehow more possible to document completely. Instead we seek to highlight the crucial elements of incompleteness in records of teaching and learning.

The Relations of Question and Terrain for Inquiry. A fourth issue we have grappled with is what constitutes an appropriate or adequate terrain for a question—for example, the question of what the children take from the discussion of Sean's idea that 6 is both even and odd. One place to look for an answer is in their notebooks, to see what they wrote at the end of this lesson. Another is their subsequent quiz on even and odd numbers. But another is how they use and interact in class discussions in the future. Yet another is their reference to and use of even and odd numbers in subsequent class work.

Each path offers the possibility of a different insight into the question of what children are taking from the lesson. No one is any more complete than another, nor do they sum to the truth. Still, the possibility of looking from multiple perspectives offers a kind of insight less likely to be attained in other ways (see Schwab, 1961, on polyfocal conspectus).

Considering where to look to investigate issues of teaching and learning is a matter almost without bound. Like the rational number line, the information at a given moment in time is infinitely dense. And like the number line, the places to look extend infinitely in either direction—the past, present, and future.

The Interdisciplinary Nature and Scope of Useful Materials for Inquiry into Practice. Beyond the records of classroom interactions, teacher notes, and children's written work, other resources play a role in examining teaching and learning. For example, determining whether Sean's notion about 6 is worth spending time on is not merely a matter for idiosyncratic contemplation. More than a matter of personal opinion, this question might be informed by access to third-grade curriculum guidelines: What is expected that children should learn at this level? But it might also be informed by reference to a longer view of curricular expectations: What are students to learn over time in school mathematics, and how does an unexpected student idea such as Sean's fit on this longer trajectory of mathematics learning? Still, decisions about worth are more than matters of mapping against the extant mathematics curriculum. They may be referenced to disciplinary knowledge apart from its current school translation.

Because teaching and learning are webs of theory and practice, their investigation is inherently multidisciplinary. For example, embedded in the episode with Sean are philosophical issues to be examined about the aims of education and about alternative perspectives on the nature of knowledge: What are the issues about what is worth knowing? Is it about even and odd numbers? About the construction of knowledge in mathematics? How do ideas about democratic participation, and about the moral aspects of teaching, illuminate the episode?

And there are issues about mathematics. Is Sean misunderstanding, or is he doing something fundamentally mathematical in identifying a new class of objects? What should a mathematical definition do? How do alternative mathematical definitions of even numbers offered by the students map against one another? How are the teacher's and different students' moves in the conversation seen from a mathematical perspective?

Perspectives derived from psychology, sociology, and political science all can highlight elements of the episode otherwise left unexamined. The list extends indefinitely. And such disciplinary perspectives interact in practice. Empirical questions about what the children learn, for example, entail psychological theory, philosophical considerations of what counts as knowledge, and mathematical perspectives on what to pay attention to in the students' talk and

writing. Investigating teaching and learning in ways that afford deeper understandings of practice depends on tools built from fields far from the buzzing life of third-grade mathematics.

But the materials useful in shaping and conducting inquiry into practice are broader yet than the disciplines. We still have a lot to learn about the range of ideas and materials that offer perspectives on practice.

The Underdeveloped Nature of Discourse About Practice. The multidisciplinary nature of practice and its investigation raises important questions about the discourse of knowing teaching. First, different groups of people know and seek to make claims about teaching. They come from different communities with different norms for what counts as knowing and for expressing and giving evidence for knowledge claims. The culture of professional mathematics, for instance, socializes mathematicians toward a more certain view of knowledge than is customary among social scientists. The mathematicians who have investigated our materials have consistently made much more definitive assertions and reached final conclusions. When knowing is seen as more interpretive, knowledge claims are made more tentatively. Sean is seen as *possibly* confused or *possibly* seeing the pattern of 2 mod 4; evidence can be marshaled for both interpretations. Less easily claimed would be the assertion that Sean does not understand what an even number is at all. In contrast to mathematicians, we may ask, How do teachers or policymakers treat knowledge claims about teaching and learning? How various are their views within these communities? What are the pressures in practice that might lead to greater certainty or tentativeness in knowing? The point is that across communities, different patterns exist for knowing and communicating about knowing (how consistent these are, how much is formed through professional socialization and enculturation into ways of knowing, and how much is personal and idiosyncratic—questions about which we yet know too little).

Related to this is a lack of standards for what counts as evidence, or adequate evidence, for making claims about teaching and learning. Investigators of this material differ widely in what they seem to count as adequate warrants for an assertion. One person will say, "Only a small number of children are following this discussion," and refer to how children appear on the videotape—that is, many are looking down or writing in their notebooks. Another will examine the children's notebooks and see many of them filled with the very material that is being discussed by Mei and Sean at the board and use this to claim that these children are engaged in the discussion and are learning. Someone else will argue that whether children are writing in their notebooks or not does not adequately answer the question of what it means to be "engaged" in a discussion when you are not one of the principal speakers. Knowing whether children are "engaged" in a classroom lesson, and what would count as adequate basis for knowing, is in fact a question of compelling importance to teachers and

researchers alike. Hence, issues about standards of evidence are critical across communities of those who seek to learn about practice.

A third element that complicates discourse about teaching is the sparseness and unevenness of language for describing teaching. Describing the nature of the teacher's moves in the course of the class, for example, is complicated by the few terms we have for discriminating and labeling different kinds of questions or responses. A question like, "Are you saying all numbers are odd and even?" is very different from the question, "Sean is saying that some numbers, like 6, could be both even and odd. What do other people think about this?" And both of these are different from, "Who can think of a number to test Ofala's conjecture about odd numbers?" or "Who can tell Sean why 6 is not odd?"

Asking, "Are you saying all numbers are odd and even?" can be seen as a mathematical move, seeking to engage the children in the mathematically important question of the scope of the discovery one has made. It is a question that presses on the central mathematical aim of generalization. Pressing children to generalize is not necessarily germane to discussions of poetry or historical events. It is an example of a pedagogical move deeply rooted in the specific subject matter. In contrast, asking, "Sean is saying that some numbers, like 6, could be both even and odd. What do other people think about this?" is a generic pedagogical move useful across subjects. A teacher might ask this when she is unsure whether other students are following a classmate's claim or in order to invite more students into the conversation. It underscores and revoices a student's idea (see O'Connor, 1998), seeking to make it focal for more of the class. One might imagine such a question in any class. Asking, "Who can tell Sean why 6 is not odd?" is a common move made by teachers that at once signals to everyone that something is wrong and also demands that the other children search their knowledge. It is a different move from simply explaining to Sean that 6 is not odd and reminding him of why. But as a question, it is also different from the two previous ones.

The purpose of this slightly extended foray into the territory of teachers' questions in the course of conducting content-based class discussions is to illustrate the vast uncharted terrain of practice. We lack maps, location, and names for many parts of the terrain. This observation highlights the exciting expanse of investigation that lies ahead for those who seek to learn about teaching and learning and who do so in the context of much richer records of practice. The sparseness of maps and language, however, also highlights the complexities of exploration and communication that lie ahead.

Investigations in Practice: Multiples of Time, Evidence, and Perspective

Across our investigation of the study of practice, in our own work, and in the work of others who have investigated our materials, we have been struck with multiplicity along three dimensions. First is multiplicity of time. Two aspects

stand out. Our practice-based decision to use the school year as the case means that investigators seeking to understand what the third graders took away from the discussion of "numbers that could be both even and odd" face complex judgments about when to look. Does one answer this question by what the students say, do, and write on this particular day during class? Through the ensuing days of work on even and odd numbers? Later in the year? Multiplicity of time is in part the opening up of teaching and learning, acknowledging and grappling with its unboundedness, both before and after any given episode. A second facet is the capacity within this kind of inquiry to examine and reexamine practice. That the materials capture and hold still the sweep of time passing in classrooms allows investigators to delve deeply into phenomena that in real time are much less apprehensible.

A second dimension of multiplicity is that of evidence. The variety of materials comprising this representation of practice means that investigators have access to a wide variety of information pertinent to any particular question. On one hand, this allows a richer exploration of a question. Seeking to learn what other children in the class were taking from the discussion of Sean's idea might involve examination of the written transcript, the children's written work, or the video. Each of these offers different information. On the other hand, these kinds of information do not necessarily converge. Quite often interpretations grounded in one piece of information seem to conflict with what is gleaned from another. Confronting and considering this multiplicity of evidence is both an affordance for the study of practice and a phenomenon of practice with which teachers—and others—must contend and not ignore.

A third dimension of multiplicity is the rich potential inherent in convening interpretations around a common context, and learning through and about the diverse perspectives that different investigators and communities of investigators bring to their inquiries. The webs of complex insight and interpretation produced by literally hundreds of diverse traversals of the episode about Sean offer remarkable insights and enhance subsequent investigations. Important work lies ahead in investigating what is seen within and across multiple perspectives and what is entailed in crossing the boundaries across such perspectives. How does experience with multiple interpretations of a common phenomenon shape investigators' intellectual dispositions and habits? How do we make sense of the multiple, and often conflicting, interpretations? What do we "know" from across these?

CONCLUSION

New ideas about the nature of practice and what it means to know it are combining with new technologies to make possible the accrual of a discourse about teaching that begins in the study of teaching and learning. Having access to

shared records of practice, and to multiple interpretations of those records, can shape one's own internal discourse and the discourse within one's own community. It may also make possible a transcending of community boundaries and, hence, views of teaching and learning, what it means to know, and what is possible to know or appreciate about practice.

Fundamental questions concern what is entailed in "knowing" about teaching and learning and how what we are doing fits with other traditions of scholarly and practical inquiry about teaching. In a sense, we are pressing on some elements of qualitative research, blurring the boundaries of insider-outsider, and throwing questions of knowledge open to question. That more people can have access to the same data also means that data can lend themselves to more interpretations. How might we think about what would count as standards for good work of this kind, and how would such conversations proceed, across time, perspective, and the purposes of different communities? Who are the communities that might contribute to the development of a discourse about practice, and how might the availability of common materials of teaching and learning affect the traditional chasms among such communities? As in the investigation of practice, these questions central to the investigation of the study of practice are themselves multidisciplinary and will be honed and informed through perspectives on inquiry and knowledge in other domains.

Toward that end, we have strived in our work to bring multiple external voices to the study of teaching and learning. There is obvious value in illuminating different perspectives and questions about practice. New points of view highlight heretofore invisible elements of teaching and learning. But to what do these all sum? There is no algorithm for combining multiple perspectives to produce interpretations and understandings that are somehow "better" because of their variety. Multiplicity does not necessarily yield more refined views of practice.

Moreover, not only is there no formula for combining different points of view; we have also seen that perspectives from these different realms do not even "talk" to each other. It usually takes translations, and people who are border crossers, to lend authority and comprehensibility to these perspectives. We and others have worked as ambassadors or border crossers, visiting—and even inhabiting—these different worlds. We have spoken of practice with policymakers and researchers. We have engaged them in problems of practice. As teachers we have carried ideas from outside into the realm of practice.

What we are contending with is the challenge of developing practices of knowing and norms of discourse that can facilitate communication about teaching and learning within and across communities and that are centrally concerned with fashioning a distinctive vocabulary, syntax, and rhetoric of practice. A discourse and epistemology of practice will, in part, borrow profitably from the disciplines from which teaching and learning draw. In the academic world, we assume that these multiple perspectives, in conversation and in interaction

with one another, could support the construction of better understandings of practice. In the world of practice, we assume that being able to access and support internal and joint arguments among the many voices that bear on practice could enhance teachers' capacities to see, hear, deliberate about, and know in practice.

Some elements of the discourse that we need for the investigation of practice, however, transcend particular disciplinary tools, language, structures, and syntax. The study of practice requires more than intercultural or interdisciplinary discourse. We ask, How might a "borderland" (Delgado-Gaitan, 1997; Anzaldua, 1987) be created in which a disciplined and multivocal discourse of practice might be developed? What would an epistemology of practice look like that could involve people from different worlds and perspectives but would also provide language for a focus on practice, grounded in its particular structures?

What would such an epistemology of practice entail? It would embody a respect for the complexity of practice. It would seek to illuminate, not solve, its intricacies. Knowledge in and of practice would be seen as inherently interpretative rather than certain and real. Norms would be created for distinguishing and mediating among various kinds of claims. Empirical questions ("Does the teacher always let students shape the agenda of class so strongly?") are different from normative ones ("How can seriously exploring a confused student's idea be justified?"). Some claims are logical or analytic ("The press to symbolic representation of mathematical relationships and ideas is in tension with situated theories of knowing and learning"), and others are matters of pedagogical appreciation or taste ("The teacher does not support the children's risk taking"). A discourse of practice needs discussable standards for validating different kinds of claims and for distinguishing better from less well-grounded assertions. Finally, and perhaps most complex, the study of practice requires methods for mediating across multiple claims. If "polyfocal conspectus" (Schwab, 1961) on teaching is to yield the richness of understanding it promises, then mechanisms are needed for reconciling or holding in interpretative complement different interpretations of teaching and learning.

We are left, as usual, with more questions. We need more systematic opportunities to examine the kinds of inquiry conducted across our forays with this material. We need to examine the relations between investigations conducted within the particular contexts of our classrooms and the construction of more general hypotheses, questions, and knowledge about teaching and learning. We are reminded of Mei, the young girl in Deborah's class, who presses Sean about his wonderment over the number 6. If these questions about what it would take to combine multiples of time, evidence, and perspective were less central to improving what we know about practice and how we know it, then "we wouldn't even be having this discussion."

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