PREPARING TEACHERS TO LEARN FROM TEACHING

James Hiebert
Anne K. Morris
Dawn Berk
Amanda Jansen
University of Delaware

The authors propose a framework for teacher preparation programs that aims to help prospective teachers learn how to teach from studying teaching. The framework is motivated by their interest in defining a set of competencies that provide a deliberate, systematic path to becoming an effective teacher over time. The framework is composed of four skills, rooted in the daily activity of teaching, that when deployed deliberately and systematically, constitute a process of creating and testing hypotheses about cause–effect relationships between teaching and learning during classroom lessons. In spite of the challenges of acquiring these skills, the authors argue that the framework outlines a more realistic and more promising set of beginning teacher competencies than those of traditional programs designed to produce graduates with expert teaching strategies.

Keywords: *analyzing teaching; learning to teach; teacher preparation*

How should teacher preparation programs be designed to ensure the graduates become expert teachers? A recently released volume by the American Educational Research Association (AERA) indicates that the question is not even close to being answered empirically (Cochran-Smith & Zeichner, 2005). This is not a new conclusion. The absence of research-based recommendations cited by authors of relevant chapters in the AERA volume (e.g., Floden & Meniketti, 2005; Zeichner & Conklin, 2005) reinforces similar conclusions reached in earlier reviews (Evertson, Hawley, & Zlotnick, 1985; Kennedy, 1999; Raths & McAninch, 1999).

The most common approach to teacher preparation—equipping prospective teachers with expert teaching strategies—has been convincingly critiqued on theoretical and practical grounds. Nemser (1983) argued that expecting prospective teachers to become expert classroom performers on graduation is unrealistic given the short time of preparation programs and the strong influences on teaching of prior experiences. Prior experiences, acquired during years in classrooms as students, heavily influence how prospective teachers interpret what they are learning and how they end up teaching (Borko & Putnam, 1996; Lortie, 1975). In addition, Berliner (1994) noted the long learning curve that characterizes expert teachers, a learning curve that cannot be traversed very far during a preparation program.

In the absence of empirical and theoretical support for traditional forms of teacher preparation, it is appropriate to consider alternatives. One alternative approach to teacher preparation

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that has a long but less noticed history in the literature is to design programs that prepare prospective teachers to learn from teaching when they enter the profession. Schaefer (1967) hinted at the possibilities of this approach when he outlined the advantages of structuring K-12 schools as places where teachers, not just students, could learn. Hawkins (1973) was more specific about the role of preparation programs in this long-term learning process:

> It may be possible to learn in two or three years the kind of practice which then leads to another twenty years of learning. Whether many of our colleges get many of their students onto that fascinating track . . . is another matter. (p. 7)

Nemser (1983) was even more explicit about the advantages of this alternative approach over conventional preparation programs:

> It would be far more realistic to think about preparing people to begin a new phase of learning to teach. That would orient formal preparation more toward developing *beginning* competence and laying the foundation for learning and teaching. (p. 157)

If a preparation program took seriously the goal of preparing teachers to learn from teaching, what would such a program look like? What knowledge, skills, and dispositions would teachers need to learn from teaching—not in an informal, haphazard way but in an intentional, systematic way?

The purpose of this article is to outline some of the specifics of a teacher preparation program that aims to help prospective teachers learn how to teach from studying teaching. We build on and extend the work of others (e.g., Hiebert, Morris, & Glass, 2003; Santagata, Zannoni, & Stigler, in press; van Es & Sherin, 2002) to propose a set of skills that will prepare prospective teachers to continue learning from their practice when they begin teaching. We draw our examples from mathematics; however, we believe the skills apply equally well to all school subjects.

We present our proposal as a hypothesis to be tested. It arises from our interpretation of the literature, from our analysis of teachers' everyday work, and from arguments about the process of improving complex, goal-oriented skills. Although we believe the proposal is sufficiently compelling to merit serious debate and empirical testing, we acknowledge that it is without direct empirical support. Later we review some indirect supportive evidence; however, we know of no research that has shown that teachers prepared in the way we propose perform more effectively than those prepared in more traditional programs. The absence of relevant data is due, in large part, to the fact that preparation programs of the kind we describe have not been operational with enough frequency and intensity to allow follow-up studies with graduates. So, the case we present rests on persuasive argument and is intended to generate discussion and empirical scrutiny.

LEARN TO ANALYZE TEACHING IN TERMS OF STUDENT LEARNING: THE CENTRAL CONSTRUCT

The goal of teaching is to support student learning. It is hard to imagine teachers becoming more effective over time without being able to analyze teaching in terms of its effects on student learning. What did students learn, and how and why did instruction influence such learning? How could lessons based on this information be revised to be more effective when teaching them next time? We propose that assessing whether students achieve clear learning goals and specifying how and why instruction did or did not affect this achievement lies at the heart of learning to teach from studying teaching. This kind of analysis is different than that which focuses on particular features of teaching or behaviors of teachers, such as asking higher order questions or managing discourse. We propose that focusing on students' learning and explaining such learning (or its absence) in terms of instructional episodes provides a targeted but comprehensive and systematic path to becoming an effective teacher over time.

We propose that two quite different kinds of knowledge, skills, and dispositions—or competencies—contribute to analytic expertise required to study and improve teaching over time. A first kind of competence is subject matter knowledge for teaching. This is the kind of subject matter knowledge needed to unpack the content learning goals for students, to

understand students' thinking about the subject, to simplify the complex ideas of the subject in ways that sustain the integrity of the subject, to represent ideas in accessible ways for students, to pose key questions and problems, and so on. Shulman (1986) captured much of this kind of competence as "pedagogical content knowledge," and others have extended and refined these ideas, especially in mathematics (Ball, 1999; Ball & Bass, 2000; Ma, 1999; Sherin, 2002). Data are beginning to move beyond the vague (and often absent) correlations between subject matter knowledge and teacher effects (Floden & Meniketti, 2005) to show that mathematics knowledge for teaching influences how teachers teach and how well students learn (Borko et al., 1992; Hill & Ball, 2004; Hill, Rowan, & Ball, 2005; Sherin, 2002; Stein, Baxter, & Leinhardt, 1990). It is plausible that improvements in particular kinds of subject matter competence contribute to better analyses of practice which, in turn, yield improved teaching.

The second kind of competence that we believe contributes to a teacher's ability to analyze teaching is a collection of dispositions, knowledge, and reasoning skills that enable developing and testing hypotheses about cause–effect relationships between teaching and learning. For purposes of presentation, we capture these competencies as four skills: (a) setting learning goals for students, (b) assessing whether the goals are being achieved during the lesson, (c) specifying hypotheses for why the lesson did or did not work well, and (d) using the hypotheses to revise the lesson. The framework we describe foregrounds these skills, which have received less attention in the literature than subject matter expertise and which, we argue, merit further exploration.

Evidence from other domains indicates that this kind of analysis—specifying cause–effect hypotheses and testing them so that useful and defensible claims can be drawn from the evidence—is not commonly displayed and is challenging to develop (Moshman, 2005; Sandoval & Millwood, 2005; Smith & Osherson, 1995). Even though many teachers, including novices, probably engage in some kind of informal and intuitive reflection on the success of a lesson and on the factors that might be responsible, we expect that fostering intentional and systematic attention to cause–effect relationships will be a major challenge for the program we propose.

The challenges of developing analytic skills to study teaching mean that the teacher preparation we outline is not an easy substitute for traditional programs. For our proposed program to succeed, teacher educators will need to learn more than is currently known about the level of analytic competence possessed by prospective teachers when they enter preparation programs and about how to facilitate the development of this competence. As we argue later in the article, we believe that, in spite of these challenges, the proposed program is feasible.

We do not claim that analyzing teaching is the only competence that prospective teachers must have to begin a career path that leads to increasing effectiveness over time. They are likely to benefit from acquiring other pedagogical competencies, such as common performance routines—reviewing homework, introducing and summarizing the main point of a lesson, constructing and interpreting assessments, and so on (Berliner, 1994; Brown & Borko, 1992; Leinhardt, 1993). Perhaps the most effective preparation programs will be those that balance attention to developing pedagogical classroom skills and the analytic skills we describe. However, we emphasize the analytic skills, not only because they have received less attention but also because we believe the core of teaching—interacting with students about the content—is not learned well through automatizing routines or even through acquiring expert strategies during a teacher preparation program. Rather, it is learned through continual and systematic analysis of teaching.

A consequence of focusing on analytic skills is that the center of teaching expertise shifts from on-the-fly performance in the classroom to preparation and reflection outside the classroom. Although some researchers question whether preparation and real-time teaching can be meaningfully distinguished (see Brown & Borko, 1992, for a review), we believe it is useful to separate the kind of planning and reflection we have in mind from real-time teaching in the classroom. Teaching expertise, from our perspective, includes planning to learn from teaching (one's own teaching and the teaching of

others) and revising practice based on the data collected. This is quite different from models of teaching expertise that focus on the increasingly fluid and intuitive nature of classroom performance (Berliner, 1994).

That analytic activity can be engaged outside of the classroom and away from the press of real-time classroom performance suggests that it might be suited to teacher preparation programs. Numerous samples of teaching, captured in videos or transcripts of classroom lessons, can be slowed down, dissected, parsed into meaningful chunks, and recomposed. The skills can be scaled up either by addressing one skill at a time or soliciting all of them initially on a constrained and carefully selected teaching episode. In general, teaching can be analyzed deliberately and systematically. Teaching can be treated as an object of study. These features encourage us to agree with Hawkins (1973) and Nemser (1983) and propose that prospective teachers can be prepared during their training programs to learn from teaching.

A FRAMEWORK FOR ANALYZING TEACHING

The framework we propose consists of four skills drawn from the daily routines of ordinary classroom teachers as they plan, implement, and reflect on classroom lessons. As identified earlier, the skills are setting learning goals for students, assessing whether the goals are being achieved during the lesson, developing hypotheses about why the lesson did or did not work well, and revising the lesson on the basis of these hypotheses. In this section, we describe these skills and argue for elevating them to conscious, deliberate attention.

Although these skills are rooted in the daily activity of teaching, they take on the nature of research or inquiry skills when they are deployed deliberately and systematically (Dewey, 1929). The compatibility of teaching and researching has been drawn numerous times in the literature, perhaps most frequently by those promoting or examining the idea of teacher as researcher (Burnaford, Fischer, & Hobson, 1996; Cochran-Smith & Lytle, 1993, 1999). Our framework shares some features with teacher as researcher in its attention to collecting concrete evidence to inform decisions about teaching; however, there are important differences as well. Our framework does not include the development of research skills needed to conduct a range of research studies in the classroom. Rather, "research" is invoked in our descriptions to convey a critical and empirical disposition toward planning and reflecting on teaching. In this sense, our framework outlines a research process of intentional learning from carefully planned experiences as part of the daily routine of teaching. Indeed, it equates teaching expertise, at least in part, with the research-like skills needed to analyze and improve teaching.

In its inquiry stance, with an emphasis on gathering data on students' thinking, the framework we propose also shares a central orientation with some of the literature on reflective practice (Osterman & Kottkamp, 2004). The framework is especially aligned with interpretations like those of Cruickshank and Applegate (1980) who described reflective practice as a process that helps teachers think about what happened during a classroom lesson, why it happened, and what could be done next time to make it happen more successfully. As will be seen, our framework focuses reflective practice squarely on the relationships between instructional practices and students' achievement of the intentional learning goals.

Skill 1: Specify the Learning Goal(s) for the Instructional Episode (What Are Students Supposed to Learn?)

Analyses of teaching involve assessing the effects of an instructional episode against precisely defined learning goals. An episode might be a task or activity that constitutes part of a daily lesson, a full daily lesson, or a sequence of lessons. By defining the learning goals for an episode precisely and explicitly, it is possible to investigate whether and how instruction facilitated or inhibited students' achievement of the goals.

Specifying learning goals is the first skill in the proposed framework because until learning goals are expressed clearly, further analyses

are impossible. Without explicit learning goals, it is difficult to know what counts as evidence of students' learning, how students' learning can be linked to particular instructional activities, and how to revise instruction to facilitate students' learning more effectively in future lessons. Formulating clear, explicit learning goals sets the stage for everything else.

Describing learning goals precisely requires unpacking them into component goals or subgoals. The more specifically learning goals are described, the more detailed and useful the subsequent analysis of teaching. Consider a common learning goal in a sixth-grade mathematics class: "Students will understand the concept of a decimal fraction." Leaving the goal at this level of generality provides little guidance for subsequent analyses. What counts as evidence that students "understand the concept?" Specifying the goal further—"Students should recognize that the value of a digit is determined by its place in the numeral, that the values of the adjacent places are more (or less) than each other by a factor of 10, and that powers of 10 can include negative exponents"—provides better guidance for studying the relationships between teaching and learning during the lesson.

Unpacking learning goals is one site in the framework where subject matter competence is sure to make a difference. In fact, the skillful specification of learning goals could be used to help define the kind of subject matter knowledge for teaching that prospective teachers need to acquire. What does one need to know to take apart larger goals into related, component goals and to connect component goals to create larger goals (Ma, 1999)? Although little empirical data have addressed the way in which subject matter knowledge influences teaching at this level of detail, we suspect that this first skill in analyzing teaching provides a critical mechanism through which subject matter knowledge affects teaching.

Two caveats conclude our description of the first skill in the framework. Unintended learning, not captured by the learning goals, is likely to occur during an instructional episode. In this article we focus on learning intended by the teacher, learning aligned with explicit learning goals. Although unintended learning might be important, intended learning is the kind of learning teachers can plan for and get better at facilitating. By definition, accidental or unintentional learning is unplanned and, consequently, beyond the reach of systematic study. Because we are proposing a preparation program for teachers, we focus on skills that can be improved by intentional, systematic study.

A second caveat is that the skill of specifying learning goals takes different forms depending on whether one is analyzing someone else's teaching or one's own teaching. Learning goals are easier to specify if you are the teacher. Assuming that prospective teachers also analyze the teaching of others, say from a videotaped lesson, they probably will need supplementary resources to identify learning goals. Goals are not always made explicit by the teacher during the lesson. Written lesson plans, textbook pages and teacher handouts, commentaries by the teacher about the lesson, and, ideally, interviews with the teacher can help to specify the learning goals so that the analysis process can proceed.

How can the development of prospective teachers' skill in specifying learning goals be measured? Two criteria emerge from the previous discussion. First, goal descriptions are more useful when they are more specific, when they include subgoals and primary or general goals. Second, goal descriptions are more useful when they use the language of the subject. A goal of "80% correct by each student on the quiz at the end of the lesson" is not as useful as a goal of "students should construct relationships between the value of a decimal fraction, the sum of the values of each of its digits, and increasing (and decreasing) powers of 10." Goal descriptions that meet these criteria are useful because they set the stage for what will count as evidence that students are achieving them. This leads to the second skill.

Skill 2: Conduct Empirical Observations of Teaching and Learning (What Did Students Learn?)

When learning goals are specified, evidence can be collected about whether, and to what extent, each student is achieving the goals. Conducting appropriate empirical observations

to collect the evidence involves (a) appreciating that evidence about students' learning is essential for assessing the effects (and effectiveness) of teaching—indeed, no other information will suffice; (b) recognizing what counts as evidence that students are achieving the learning goals—distinguishing students' responses that are relevant from those that are irrelevant; and (c) knowing how to collect evidence—identifying key moments in a lesson where evidence of students' learning should be apparent and planning ways to collect it from each student. In summary, conducting useful empirical observations requires knowing *that*, knowing *what*, and knowing *how*.

Knowing that evidence on students' learning is needed to assess the effectiveness of teaching is not as obvious as it might sound. It is tempting to assess teaching effectiveness based on what the teacher does rather than on how the students respond (Morris, in press; Santagata et al., in press). The presence of teaching features that align with current reform recommendations, for example, can be and often are interpreted as a sign of effectiveness regardless of student learning (Hiebert & Stigler, 2000; Spillane & Jennings, 1997). And teachers often analyze their practice in terms of a smooth implementation of activities rather than an anticipated change in students' thinking (McCutcheon, 1980; Zahorik, 1970). The shift from focusing on the teacher to focusing on the students represents, by itself, a significant development of this second skill.

It is likely that prospective teachers will struggle to make this shift—to focus on their students as learners rather than on themselves as teachers. Beginning teachers are likely to be especially conscious of their own performance. In addition, attending to students is motivated by concern about the effectiveness of a teaching episode, and prospective teachers have not yet encountered experiences that would prompt them to question their own effectiveness. Teachers' self-efficacy doubts might support closer attention to their students' learning because the disequilibrium teachers experience from questioning their effectiveness can promote changes in their perspectives (Wheatley, 2002). Knowing that evidence on students' learning provides critical information for improving teaching provides a useful tool when prospective teachers encounter doubts about their own effectiveness.

Knowing what counts as evidence of students' learning means distinguishing students' responses that reveal how well they are achieving the learning goal from responses that are relevant to the learning goal but uninformative (e.g., students nodding their heads in agreement in response to a relevant question from the teacher) and from responses that are informative but not relevant to the learning goal (e.g., a student's description of how to generate repeating decimals on the calculator when the goal is to relate the value of a decimal number with the value of its digits). In general, the most useful data are students' responses that use specific language of the subject and align with the learning goals. These responses could be verbal statements by students during class or written work completed by students during or after class.

Knowing what counts as evidence means deciding not only what kind of student work to collect but knowing what about this work reveals students' achievement of the learning goal. This requires a set of competencies or skills that draw directly on subject matter knowledge combined with knowledge of student thinking. First, a teacher must be ready to observe (and eventually predict) the kinds of strategies that students will use to solve a problem or the kinds of responses they will give to a question. Without preparing to hear or read the range of possible responses, it is easy to overlook a response that counts as evidence. Second, a teacher must know what a particular response implies about the student's thinking. What would the student have to know to give this response? Without engaging in this analysis, it is impossible to know what responses count as evidence of students' learning relevant to the goal.

Obviously, the development of these skills does not occur overnight. However, teachers can become increasingly skillful at collecting and studying students' work and using it to inform their own practice (Kazemi & Franke, 2004). One practical strategy for focusing attention on what counts as evidence is to study an intended lesson plan and predict how students will respond during the lesson, asking, beforehand, whether these responses would count as

evidence and, if not, what kinds of responses would count as evidence.

Knowing how to collect revealing and relevant evidence builds directly on knowing what counts as evidence. Knowing what evidence to collect helps teachers know where to look for it. This means planning to collect evidence during key parts of the lesson and then collecting it from every student as the lesson plays out. Planning to collect evidence involves identifying key moments during the instructional episode that could, and perhaps should, reveal students' achievement of the learning goals. Parsing the lesson or episode in this way is facilitated by clear specifications of subgoals because it is by zeroing in on where these subgoals will be addressed that specific potential learning moments can be identified beforehand. Collecting evidence during the lesson involves looking for revealing student evidence as planned and, at the same time, being open to unanticipated key moments and unexpected student evidence. Revealing evidence is likely to include a variety of responses from individual students signaling that different students are at different places in their achievement of the learning goal. Of course, careful listening and gathering targeted written work will be rewarded only if the instructional episode affords students the opportunity to reveal what they know.

Consider again the sixth graders who are learning about decimal fractions. The lesson plan indicated that the teacher intended to focus students' attention on the relative size of adjacent positions by asking students to represent 2.36 with base-10 blocks (blocks of four sizes beginning with a small cube, a long [10 cubes glued together], a flat [10 longs], and a large cube [10 flats]). When showing decimal numbers with the blocks, students had used only the large cube to represent 1. After students showed 2.36 with the blocks, the teacher planned to ask them to represent the same number with blocks but this time to use the flat to stand for 1. The teacher expected that changing the unit—which block represents 1—would be a key learning moment because students would need to mentally detach a particular block from a particular value, or from a particular position in a number's written form. This, the teacher expected, would increase the chances that students would focus on the 10-times-bigger relationship that is an important subgoal (identified earlier). Consequently, the teacher assumed that evidence of students' thinking might be revealed by observing how they solved this second problem.

As the lesson unfolded, the teacher observed that most of the students showed the correct collections of blocks for 2.36 using the flat as the unit but, when asked to explain why they chose their set, their responses varied. Some students said that when they were told the flat block should represent 1, they knew they needed a block 10 times smaller for the tenths. Other students offered a variation of this explanation by saying they used the long for the tenths because 10 longs make 1 flat. However, some students simply said they "lined up the blocks in order." Apparently some students shifted their focus, as intended, from the size of the blocks to the 10-for-1 relationship between the blocks; however, some students just followed the pattern "pick the next smallest block for the next digit" and did not think about the 10-for-1 relationship.

This example illustrates an appreciation for students' responses that provide evidence of teaching effectiveness, a beginning notion of what counts as evidence, and a plan for when and how to collect evidence (around a key learning moment). The next step (Skill 3) is to develop a hypothesis that might account for these findings in terms of the instructional events that preceded them.

As with the first skill, criteria that can be used to measure growth of conducting empirical observations of learning (Skill 2) are suggested in the previous discussion. One criterion is crucial: The evidence should reveal clearly whether the learning goals were achieved. This criterion is more likely to be satisfied when the evidence is more detailed and specific, especially when the specificity connects the evidence with particular subgoals. In addition, the evidence is more useful when it captures students' thinking that lies beneath surface behaviors and responses. Finally, the evidence is most useful when it represents the range of thinking in the classroom rather than the selected thinking of the most vocal students.

Skill 3: Construct Hypotheses About the Effects of Teaching on Students' Learning (How Did Teaching Help (or Not) Students Learn?)

Developing hypotheses that link teaching with learning requires forming conjectures about how a particular instance of teaching (task, question, activity, etc.) facilitated or inhibited a particular kind of learning. Whereas Skill 2 focuses on students' responses, Skill 3 shifts to the instructional events that facilitated these responses. The hypotheses are tentative claims about how the instructional event influenced the intended learning. The hypotheses specify questions that merit further examination in future instructional episodes. Hypotheses about cause–effect relationships can be made at different levels of localness. Hypotheses might specify connections between teaching and learning at particular key moments of a lesson that focus on a specific subgoal, or they might be framed at more general levels such as students' learning at the end of a lesson connected with a series of teaching activities that occurred during the lesson. Regardless of the level of localness, hypotheses must be stated with enough detail and specificity that they can be tested in subsequent instructional episodes.

How are hypotheses produced? Evidence that students did or did not advance toward the learning goal at a critical point in the lesson provides important information about the learning end of the hypothesis. However, how does one generate ideas that specify the kinds of instructional events that might have contributed to such learning or whose absence might account for the lack of learning? An expert might imagine many alternative hypotheses. However, how are these hypotheses generated, especially by novices, and how are selections made among them?

A set of principles of learning and teaching can guide the formulation and selection of useful hypotheses that connect instruction with student learning. Such principles often describe the instructional conditions under which particular kinds of learning are likely to occur. Suppose intended learning did not occur. Principles that specify the conditions most likely to support learning of that kind offer explanations for why the learning did not occur and point to instructional tasks, explanations, questions, and so on that might have promoted such learning.

In our work with prospective teachers, learning goals for school students often involve conceptual understanding of mathematics. Drawing from theoretical and empirical work, two principles that link teaching with achievement of these goals are (a) the explicit discussion and/or examination of the critical mathematical relationships and (b) the opportunity for students to wrestle or struggle with key mathematical ideas (Brownell, 1935; Fennema & Romberg, 1999; Hiebert & Grouws, 2007; National Research Council, 2001).

If the learning goals are something other than conceptual understanding, then other principles might apply. For example, rapidly paced instruction, frequent feedback, and smooth transitions from teacher modeling to student practice have been shown to facilitate quick and accurate execution of procedures as measured on standardized tests (Brophy & Good, 1986; Hiebert & Grouws, 2007).

Principles like those associated with conceptual understanding or efficient execution of procedures provide lenses through which (prospective) teachers can view instructional episodes and generate hypotheses for why instruction might have, or might not have, helped students achieve particular learning goals. In doing so, the principles provide a pathway along which empirically supported knowledge of learning enters the framework for studying and improving teaching.

Apparent from this discussion is that Skill 3 necessarily invokes more general knowledge of learning and teaching, not embedded directly in the instructional episode, to formulate useful cause–effect hypotheses about the episode. Skill 3 builds on, but moves beyond, Skill 2 by appealing to principles of learning and teaching. Skill 3 is an empirical process (like Skill 2) because it requires careful, structured observations of the key lesson events (with one eye on the teacher) and an inferential process because it requires evaluating the potential of these events, in light of appropriate principles, for students' learning. This places Skill 3 as a bridge between Skills 2

and 4, a bridge between analysis of teaching and improvement of teaching.

Return, for a moment, to the sixth-grade lesson on decimal fractions. The teacher had observed that asking students to show the decimal number 2.36 using the flat block as the unit yielded at least two different ways of thinking—one focused on the 10-for-1 relationship as intended, the other focused on the decreasing size of blocks that allowed students to evade the key relationship. It now became clear to the teacher that changing the unit did not, by itself, require explicit attention to the 10-for-1 relationship. The blocks, by themselves, were not enough. Changing the unit from the large block to the flat did not pose the dilemma, at least for some students, which the teacher had envisioned. The teacher now hypothesized that the 10-for-1 relationship is not simply seen in the blocks but rather constructed by students when they face some kind of dilemma that cannot be resolved simply by lining up the blocks in order of size. What kinds of questions or tasks would pose a dilemma for the students that could be resolved only by thinking directly about the 10-for-1 relationship? As the teacher considered promising revisions, the teacher's hypothesis guided the review and selection of revisions most likely to help all students achieve the goal.

Constructing hypotheses about causal connections between teaching and learning requires an appropriate level of skepticism. Teaching is exceedingly complex, and the connections between teaching and learning, regardless of how well supported by evidence, are only partially understood. The effects of teaching occur through numerous interactions, only some of which will be captured by any single hypothesis. In addition, all teaching is likely to be partially effective rather than completely effective or ineffective, and it is likely to be more effective for some students than others. These complicating factors mean that causal hypotheses should be treated as questions to be examined further rather than as conclusions assumed to be true.

It should be obvious that subject matter knowledge of a special kind is needed to formulate appropriate hypotheses. Understanding the demands that students' responses make on different kinds of knowledge and what instructional cues might have triggered particular kinds of thinking require knowing the subject deeply. However, it is a kind of knowledge that must be tightly integrated with knowing how people think about the subject.

Criteria that can be used to evaluate the quality of the hypotheses that prospective teachers make about the effects of teaching can be summarized as follows: Hypotheses are more likely to lead to improvements in students' learning when (a) they are made about students' achievement of the learning goals (rather than about learning other topics), (b) they specify the teaching and learning with enough detail to clarify and justify the hypothesized connections between them and with enough detail to invite testing and refinement, (c) they appeal to well-supported principles appropriate for the particular learning goals, and (d) they are expressed with appropriate nuance and recognition of the complexity of teaching–learning relationships.

Skill 4: Use Analysis to Propose Improvements in Teaching (How Could Teaching More Effectively Help Students Learn?)

The purpose of applying the previous three skills is to provide the information needed to make evidence-based decisions about how to improve an instructional episode. To summarize, the skills aim to clarify the learning goals, gather information about whether students are achieving the goals, and generate hypotheses about how instruction is (or is not) facilitating students' learning. Making revisions to improve the instructional episode is then a matter of following the implicit recommendations contained in the hypotheses.

A final visit to the sixth-grade lesson on decimal fractions illustrates the process of using what is gleaned from applying the first three skills to improve teaching. After the teacher constructed a hypothesis about why the activity of representing decimal numbers with base-10 blocks prompted the intentional learning for some students but not others, promising revisions to the lesson could be imagined. The challenge for the teacher was to revise the tasks or modify the sequence of tasks to ensure that

students confronted, explicitly, the 10-for-1 relationship between adjacent positions of the digits in decimal numbers. One possible revision would be to assign the long block the value of 1. The small cube, the smallest block, would then have a value of 1/10 or 0.1. To represent 2.36 with blocks, students would need to invent the hundredth block—to verbally describe or draw a picture of the block needed to represent 1 hundredth. This would require students to describe explicitly the relative values of the blocks rather than just lining them up in decreasing order of size. Another possible revision, that might have a similar effect, would be to ask students to use a different representation than base-10 blocks, say letting 20 circles represent 1. This would mean that 2 circles would represent 0.1, and students would need to divide 2 circles into 10 equal pieces to represent 0.01.

Cause–effect hypotheses formed by applying Skill 3 usually point the way to the revisions developed by applying Skill 4. It is difficult to imagine a carefully developed revision not preceded by a hypothesis that linked a (deficient) instructional event with incomplete learning. Indeed, it is this hypothesis that provides the rationale for the proposed revision. Evaluating the quality of proposed lesson revisions necessarily involves a different process than outlined for the first three skills. In the end, the quality of a revision depends on whether the revised episode helps all students achieve the learning goal(s) more effectively. This criterion can be difficult to apply in a teacher preparation program because prospective teachers cannot always test revisions in real classrooms. We can, however, suggest two proximate measures. First, the proposed revisions can be interpreted in light of principles for learning and teaching as described earlier. Second, it is possible to assess the revision's potential by judging the quality of the argument that can be offered by the prospective teacher to support the recommendation (the relationships among the data, the hypothesized cause–effect connection, the principles that support the hypothesis, and the proposed revision). Like the first proximate measure, this does not substitute for evidence of students' learning during implementation; however, it does reveal the soundness of the prospective teacher's reasoning in using the information derived from applying the first three skills.

Although students' learning is the primary criterion for judging the effectiveness of lesson revisions, a quite different secondary criterion also can be applied: Does the revision increase the teacher's opportunities to observe whether students are achieving the learning goals? If the analysis process we have described facilitates improvements in teaching, then lessons that enable more insightful and informative analyses are (at least, short-term) improvements. So, an additional criterion to evaluate lesson revisions is an increase in the access teachers will have to students' thinking and learning at key moments during the lesson.

WHY THIS FRAMEWORK?

Of the range of skills or competencies that prospective teachers might need to become effective teachers, over the long run, why did we select these four skills? A first reason is that the skills are drawn from the (implicit) practice of classroom teachers. Although we doubt that most U.S. classroom teachers engage in these skills with the deliberateness we describe, the skills are not alien to them. This gives the skills a kind of face validity and, in addition, suggests the skills might be sustainable, in some form, as part of teachers' daily and weekly practice.

A second reason for selecting these skills is their similarity to the components of disciplined inquiry (Dewey, 1929). This similarity indicates that teachers who apply these skills will be engaged in a disciplined inquiry into teaching—the precise goal of the framework. The melding of teaching and research is a promising response to the stubborn gap between research and practice, between the archives of researchers and the practice of classroom teachers (Hiebert, Gallimore, & Stigler, 2002). It offers teachers the opportunity to accumulate knowledge for improving their own teaching (and that of others) over time. These kinds of research-oriented teaching skills, that enable teachers to participate in the process of gathering knowledge to inform their practice, can engender a healthy and productive professional identity (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998; Malara & Zan, 2002).

A third reason for selecting the four skills is that they create a framework that allows space for the influence of subject matter knowledge. Subject matter knowledge clearly influences how and how well teachers teach (Borko et al., 1992; Borko, Livingston, McCaleb, & Mauro, 1988; Carlsen, 1993, 1997; Hill et al., 2005; Leinhardt & Greeno, 1986; Stein et al., 1990; Stodolsky, 1988); however, the mechanisms through which such knowledge enters teachers' thinking and practice are not well understood. The framework we propose identifies sites where subject matter knowledge could influence teachers' work, especially as they prepare to implement and then reflect on classroom lessons.

A fourth reason for selecting these skills is that preliminary data suggest they work; that is, applying skills like those we describe leads to improvements in teaching over time. Although very little data currently exist to inform frameworks like the one we propose, the existing data are encouraging. Goldenberg, Saunders, and Gallimore (2004) and Saunders and Goldenberg (in press) reported considerable success with schoolwide efforts to improve students' learning that emphasize teachers' analysis of practice. In the weekly teacher meetings that occurred in these schools, teachers set learning goals for students, brought student work to examine, and used the findings of their analysis to revise classroom teaching. One teacher described the process this way:

> First we evaluate the student work and as we evaluate the student work we look at strengths and weaknesses. Then we decide on what kind of instruction we're gonna try in the classroom. And we try the instruction in the classroom and then we go back and reassess to see if the instruction is working. If it's not working we just, we try to take a different approach until we meet those goals and those standards and objectives. (Saunders & Goldenberg, in press, pp. 19-20)

Kazemi and Franke (2004) also described the ways in which teachers can reflect on and improve their practice by collecting and studying students' written responses to tasks designed with particular learning goals in mind.

Cross-cultural research has uncovered analysis of teaching practices that form the core of professional development activities in several Asian countries (Lewis & Tsuchida, 1997; Ma, 1999; Marton & Tsui, 2004; Paine & Ma, 1994; Stigler & Hiebert, 1999; Yoshida, 1999). Although many factors account for the apparent success of continued teacher learning in these countries, the relentless focus on analyzing classroom practice and testing hypothesized improvements, using skills like those we described earlier, clearly support the growth of expertise among these teachers. That many U.S. teachers think of teaching in terms of implementing activities rather than analyzing effects of instruction on students' learning might be a consequence of the general lack of attention in this country to the skills that compose our framework (Fernandez & Cannon, 2005).

A fifth reason for choosing this framework lies in its potential for helping teachers move toward more equitable instruction. With its focus on student thinking and on collecting concrete evidence of students' achievement of the learning goals, the framework encourages teachers to make instructional decisions based on each student's learning rather than on their (sometimes biased) perceptions and expectations. Collecting revealing evidence of students' thinking is facilitated by knowing one's students, knowing what ideas they bring to the classroom, and appreciating why individual students might differ in their thinking. Using students' thinking to revise instruction places teachers in a better position to help each student achieve the learning goals. We recognize, of course, that equitable instruction involves additional work by the teacher; however, we believe the emphasis on gathering evidence of each student's achievement of the learning goals and revising instruction based on this evidence is a first step toward greater equity. Ways in which the framework can further support equitable instruction will need to be elaborated as the framework is developed and refined.

A final reason why this framework has promise is that the four skills can be applied to improve learning with respect to all types of learning goals. During their teaching careers, prospective teachers are likely to be asked to help their students achieve a variety of learning goals. Earlier, we identified goals associated

with conceptual understanding and goals associated with procedural efficiency, goals that are common in school mathematics. Other subject areas also pose a range of learning goals for students. There is an advantage, we think, in acquiring skills for improving teaching that can be applied to all goals rather than to a limited set of goals.

Readers might have noticed that the framework does not adopt a particular stance on preferred theories of learning and teaching (e.g., constructivism, behaviorism). In our view, the role for theories of learning and teaching is to provide principles that can generate hypotheses that link instructional activities with students' achievement of particular kinds of learning goals. They suggest predictions that streamline what otherwise would be a lengthy and chaotic trial-and-error process of blindly producing and testing hypotheses about more effective instructional activities.

A related issue that we have not yet addressed is what theories, or principles, of learning and teaching underlie our efforts to help prospective teachers acquire the four skills. Just as teachers need to invoke principles of learning and teaching to analyze teaching and improve their students' learning, teacher educators must apply principles of learning and teaching to help prospective teachers achieve the program learning goals. Put simply, we see the acquisition of the four skills in our framework as conceptual learning. Using the four skills effectively requires understanding the relationships among elements within the skills and among the skills. Consequently, our analyses of our own instruction and our hypotheses driving continuing revisions in our courses draw heavily on the two principles identified earlier: making the critical relationships explicit and encouraging prospective teachers to wrestle with the key ideas contained in these skills.

CAN PROSPECTIVE TEACHERS DEVELOP THESE SKILLS?

Is the framework we have sketched feasible as a set of learning goals for prospective teachers? Can they acquire the four skills we described during their preparation program? As we indicated earlier, there are no data that test the success of this kind of program directly. However, the relevant data that exist are encouraging.

Van Es and Sherin (2002), using a somewhat different framework and with beginning, rather than prospective, teachers found that teachers could engage in analyzing videos of classroom lessons and, over time, move from descriptive responses to analytic responses. Of particular interest is that with practice and discussion, teachers' analytic responses gradually acquired the characteristics that would have yielded high ratings on the criteria we suggested for measuring the growth of each skill. With a sample of prospective teachers, albeit in Italy rather than the United States, Santagata et al. (in press) found that attention to teaching analysis skills of the kind we propose resulted in significant growth, over a few months, in participants' analysis performance. Finally, some evidence suggests that U.S. prospective elementary teachers have acquired components of some of these skills before entering their preparation programs; however, they access and apply the skills only under certain conditions (Morris, in press). This suggests that prospective teachers bring some analytic competencies with them when they enter the program and that appropriate conditions might enhance and even accelerate the acquisition of intended skills. Furthermore, the prospective teachers in the current study who did display good analytic skills generated recommendations for revising the lesson that were judged to improve students' learning opportunities. Although the data are too scarce to confirm that prospective teachers can acquire the skills to analyze teaching, the early results argue for continued exploration and testing.

Complicating the assessment of the framework's feasibility is the fact that the skills we propose constitute a new curriculum for teacher preparation programs. Little knowledge for how to implement such a curriculum currently exists. If one adopts the framework we propose, the learning goals for prospective teachers are the four skills that compose the framework. If one further accepts the view that meaningful acquisition of the skills is a conceptual task, then appropriate principles that guide instruction of

prospective teachers can be suggested. However, teacher educators still face the same challenge as classroom teachers—to engage in the difficult, ongoing work of improving teaching by helping students (prospective teachers) more effectively achieve the learning goals.

A first step in this work is suggested by the framework itself—to specify the learning goals more precisely. Only by defining learning goals precisely and explicitly will it be possible collect the relevant data—to assess whether and how the preparation program facilitated prospective teachers' achievement of the goals. This means unpacking the four skills into more detailed and precise component skills and examining how the component skills can be developed and recomposed. Clearly, there is much work to do; however, in the spirit of improving teaching through the deliberate and systematic study of teaching, we believe that the framework we propose provides a path toward improvement for teacher educators and classroom teachers.

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James Hiebert *is the Robert J. Barkley Professor of Education at the University of Delaware, where he teaches in programs of teacher preparation, professional development, and doctoral studies. His professional interests focus on mathematics teaching and learning in classrooms. He has coauthored* Making Sense: Teaching and Learning Mathematics with Understanding *(1997) and* The Teaching Gap *(1999). He recently served as the director of the mathematics portion of the TIMSS-R Video Study and currently is a primary investigator on the National Science Foundation–funded Mid-Atlantic Center for Teaching and Learning Mathematics.*

Anne K. Morris *is an associate professor in the School of Education at the University of Delaware, where she teaches mathematics content courses for prospective elementary and middle school mathematics teachers and doctoral courses in mathematics education. Her professional interests focus on preservice teachers' analysis of teaching skills, and K-16 students' understanding of mathematical proof.*

Dawn Berk *is an assistant professor in the School of Education at the University of Delaware, where she teaches mathematics content courses for prospective elementary and middle school mathematics teachers and doctoral courses in mathematics education. Her professional interests focus on the relationship between preservice teachers' mathematics content knowledge and pedagogical skills.*

Amanda Jansen *is an assistant professor in the School of Education at the University of Delaware, where she teaches mathematics content and methods courses for prospective elementary and middle school mathematics teachers as well as doctoral courses in mathematics education. Her professional interests focus on motivational processes among students and teachers in mathematics classrooms.*