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ABSTRACT

Everyone seems to have strong convictions about teacher education--about what teachers need to learn, about how they can be helped to learn those things, about the factors that affect professional growth and the improvement of teaching and learning. There is widespread consensus about some claims, but significant dissent about others. Reasonable as they may seem, do we really know these things? In many cases, the evidence on which particular claims rely is inadequate. The claims may be true. But they may also require qualification. Some are probably dead wrong. Some compete with others, equally popular. In this session, we will consider a set of claims about teacher learning and what it would take to deploy them as resources for developing a stronger knowledge base about professional education for teaching. This paper is not intended as a review of the literature, and is also not meant to suggest that we know nothing about teacher learning. Instead, it is meant to provoke a collective discussion of how inquiry and practice in teacher education might support its development and improvement. (Author)

WHAT DO WE BELIEVE ABOUT TEACHER LEARNING AND HOW CAN WE LEARN WITH AND FROM OUR BELIEFS?

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Everyone seems to have strong convictions about teacher education—about what teachers need to learn, about how they can be helped to learn those things, about the factors that affect professional growth and the improvement of teaching and learning. There is widespread consensus about some claims, but significant dissent about others. Reasonable as they may seem, do we really *know* these things? In many cases, the evidence on which particular claims rely is inadequate. The claims may be true. But they may also require qualification. Some are probably dead wrong. Some compete with others, equally popular. In this session, we will consider a set of claims about teacher learning and what it would take to deploy them as resources for developing a stronger knowledge base about professional education for teaching. This paper is not intended as a review of the literature, and is also not meant to suggest that we know nothing about teacher learning. Instead, it is meant to provoke a collective discussion of how inquiry and practice in teacher education might support its development and improvement.

The Value of Skepticism to the Development of Knowledge

One hot summer Sunday morning, my attention was captured by a provocative headline in the *New York Times*: "Science needs a healthy negative outlook" (Kolata, 2002). When scientific experiments are successful, noted the writer Gina Kolata, they are published, and that this is how we think knowledge grows. "But the sad truth about science is that most experiments fail and the hypotheses that seduced researchers turn out not to be true, or at least, the studies provide no evidence that they are true." Are such studies are any less important than those that we call "successful?" asks Kolata. Isn't it success to show that something we thought was true may not be, or that what we believed may need some revision?

I often make myself unpopular among my colleagues by asking, "Do we really know that?" about some popular idea or another. My intention is neither to suggest that we know nothing, nor to be unproductively cynical. But I am as prone as anyone to accord unwarranted weight to my assumptions and preferred ideas. The *New York Times* headline gives me courage to remind myself that being wrong is useful to learning. I know this already from my experience as a teacher. Children's errors can be exploited to make productive mathematical progress. Indeed, in mathematics, the failed proof may yield as much insight as the successful one (see, for example, Lakatos, 1976). Why should the progress of knowledge in teacher education be any different?

Perhaps it is the pressure—from funders, from the public, from our administrators and colleagues—to show that what we do works, or perhaps it is the natural internal need of teachers everywhere to believe that we are making a difference, and to think we are "right." We take firsthand, memorable experiences and generalize them; we develop beliefs and see them at play around us; we use our operating assumptions to explain events and outcomes. It is no easy task to push oneself to consider alternative explanations, to question the reliability or validity of evidence, to see the shadows as well as the foreground, to wonder and question. Yet the capacity for surprise is at the heart of learning, the possibility of refuting hypotheses the core of good science. Scheffler (1977/1991) captures this when he writes, "Receptive to surprise, we are capable of learning from experience—capable, that is, of acknowledging the inadequacies of our prior beliefs and recognizing the need for their improvement (p. 12). And much contemporary philosophy of science reveals the importance of the deliberate effort to refute operating assumptions, of the careful pursuit of counterexample and counterevidence (Kuhn, 1962; Popper, 1963).

Disciplined inquiry depends fundamentally on both faith—the formation of strong convictions and initiatives that seek to build on those—and doubt—the deliberate effort to be skeptical about those convictions. If hypotheses are not falsifiable, for example, then learning is hampered, because experience can do no more than confirm the premises. If the data gathered cannot offer evidence that calls those premises into question, then it does not support learning. If ideas are held as principles, and never unpacked and developed, their use for practice is likely to be negligible.

The Challenge of Combining Action and Inquiry

We find ourselves in a period where developments in professional education have perhaps never been more important. New professional standards, increased pressure for testing and results, new curriculum materials, and an ever-diversifying student population all imply the need for high levels of professional skill. But ours is not a highly selective profession like law or medicine. On a massive scale, we must prepare elementary and secondary teachers to begin teaching mathematics with reasonable proficiency. And, equally daunting, we need to build a culture, including structures and resources, for the ongoing professional learning that developing the complex practice of teaching mathematics requires. Rarely has the demand for teacher education and learning been as widely articulated, and rarely have as many opportunities and as much funding existed. It sometimes seems a bit frightening, for with all humility, we know that we do not know all that we need to know. Yet we must act. As teacher educators, leaders, and professional developers, we must design courses, programs, materials, and workshops. As teachers, we must choose opportunities for our own learning. This must all build on the best current knowledge, the best wisdom of practice, and on experience.

These conditions also present the field with unprecedented opportunities to develop knowledge about teacher learning and teacher education. Making clear our assumptions, beliefs, and current ideas to frame strategic working hypotheses can enable us to use practice itself as a medium for the development of such knowledge. Doing this means identifying the best of what we currently know, considering the basis for that knowledge, and actively cultivating skepticism. It means seeking disconfirming evidence, valuing negative results, and questioning the basis for our claims. Without this stance, teacher education runs the risk of being based on ideology more than wisdom. And without evidence for what we know, and the willingness to leave open that which we do not know, we have no better claim to what it would mean to create good professional development than anyone else. Our beliefs will compete, often ineffectively, with others'. And the quality of teachers' opportunities to learn will be based on caprice and personal bias rather than evidence.

Commonly Held—and Sometimes Competing—Beliefs About Mathematics Teacher Learning

I turn now to a small set of ideas that are often heard as claims about teacher learning. My purpose is to consider what does—or would—make these "knowledge," and what it would take to use these ideas as levers for developing reliable, valid, and useful knowledge about teacher education, and to avoid reinforcing ideology that limits the development of such knowledge. Grouped into a few important categories—what mathematics teachers need to know, for example, or the structure of effective professional development—some common beliefs compete with other, also commonly espoused, beliefs. The empirical bases for any of these claims vary widely. Some have been produced from studies of teacher learning and teacher education while some are part of a contemporary ideology in this country. Worth considering is how our ideas are both helpfully shaped and also limited by culture and experience. These ideas, then, have different origins, and possess uneven warrants. But, ubiquitous, they are widely held. And each makes sense, and is in some important ways, likely valid. But each also deserves to be questioned, for its basis, and likely validity. Put too simply: Where did each of these ideas come from? What about them do we know to be true? What is likely right about them? What are you suspicious about with each one? What would it take to unpack each one, to sort out its constituent ideas and assumptions, and use the results of this analysis deliberately to make progress in what we know about teacher learning?

1. The pedagogy and curriculum of mathematics courses for teachers
   Mathematics courses for teachers should be designed to model the ways that teachers should teach their own students.
2. The structure of professional learning opportunities for teachers
   (a) One-shot workshops are not effective.

(b) Teachers learn when they can work closely with colleagues.

(c) Lesson study is an effective form of professional development.

(d) Lesson study can work in a country like Japan, but would not work here.

3. The nature and scope of the mathematics that teachers need to know

   (a) Teachers need to know mathematics of the school curriculum in depth; courses that treat advanced mathematics are useless to teaching.

   Alternatively:

   (b) Teachers need to know more than they are responsible for teaching—advanced mathematics study is important to being able to have perspective and make good judgments.

4. The role of curriculum materials in mathematics teachers' practice

   (a) Highly detailed teachers' guides and curriculum materials limit teachers' professional autonomy. Teacher education should prepare teachers to work as professionals, using curriculum materials as a resource as needed.

   Alternatively:

   (b) Highly detailed teachers' guides and curriculum materials can make up for lacks in teacher knowledge and experience. Teacher education should help teachers learn to interpret, adapt, and use curriculum materials.

Before reading further, it might be useful to consider your own appraisal of each of these commonly heard beliefs about the professional education and learning of teachers. For which do you think there is substantial evidence? For which do you think the evidence is sparse? Which are you inclined to agree with, and why? And with which do you take issue? On what basis?

The Pedagogy and Curriculum of Mathematics Courses for Teachers

Frequently it is claimed that teachers need to learn mathematics in the same ways that their students should experience that mathematics. An alternative formulation of this idea is that mathematics courses for teachers should "model" the pedagogy and curriculum that teachers would learn to enact with students. An under-elaborated idea, it is not clear what is included in the notion of "modeling. " Somehow, however, it is thought that instructors or professional developers would work with teachers as they learn mathematics in ways similar to what those teachers should do with their own students.

The idea of "modeling" good practice is intuitively appealing. In fact, it would seem difficult to argue that the teaching should not exemplify good practice. It seems obvious that the better the teaching, the more effective the course or workshop will be. And, most important, this "good teaching" can not only help teachers learn mathematics, but it will also help them learn about teaching mathematics. However, what would it mean for this to be something we could say we *know*, as opposed to an idea to which we are attracted?

First, it would help to unpack the idea of "modeling," and decide what the elements are that might be modeled. A second question would be what it means for an approach to be "similar." Without this sort of clarity in the core ideas of the claim, it is difficult to investigate it.

Second, it would be useful to consider what might make this a valid claim, and what might militate against it. On the face of it, we suspect that how ideas are taught and experienced shapes what is learned. If the point is for teachers to develop the sort of knowledge they will need when they work with students, then they may need to encounter it in similar ways. Moreover, teachers may learn about teaching from the ways in which they are taught mathematics, and so "modeling" teaching may deliberately take advantage of this to make it possible for teachers to learn about teaching mathematics even while they are learning the mathematics itself.

This leads to a sub-claim about what is learned from "models." What do we mean when we speak of "modeling"? What do teachers actually learn from watching their instructors teach mathematics to them? How is their learning from modeling affected by whether or not the instructor narrates what he or she is doing? How is their learning affected by their opportunities to analyze the instruction?

Stepping back from the question about what constitutes modeling and what is learned from models, some observations suggest that, for all the intuitive appeal of the idea, it might not always make sense to teach mathematics to teachers as one might teach mathematics to students. After all, teachers are not eight-year-olds, and they have already been taught the mathematics that comprises much of what they encounter in teacher education. They have been taught to divide fractions, multiply decimals, to identify polygons and quadrilaterals. They have solved countless puzzles and problems. The challenge for some teachers, documented in many studies of teachers' mathematical knowledge, is that they have learned these ideas with little meaning or connective tissue. They know the forms, but not the ideas. Sometimes they have not even really learned the forms. All of this suggests however, that as teachers approach learning mathematics, they bring different resources and foundations than do their students. So, for example, problems that are fruitful for children may not be so for their teachers. And vice versa. Take, for example, the well-known problem of constructing a story problem for 1 3/4 ÷ 1/2 (Ball, 1988; 1990; Ma, 1999):

(a) Calculate the answer to 1 3/4 ÷ 1/2. What do you get? What method did you use to get the answer?

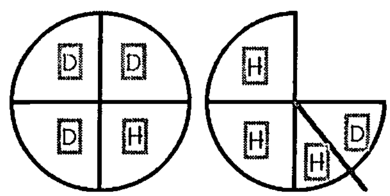
(b) Write a story problem, or describe a situation, for which 1 3/4 ÷ 1/2 is the mathematical formulation. What do you get? How does it fit with the answer you got when you calculated?

While most preservice and practicing teachers remember the procedure of "invert and multiply" and can get 3 1/2 for the calculated answer, most cannot produce a story problem that correctly maps to this expression. Instead, most stories involve dividing by 2 rather than 1/2. A typical story is:

I had two pizzas. My roommate ate 1/4 of one of them, and then I had 1 3/4 pizzas left.

I shared the remaining pizza with one of my friends. How much pizza did we each get?

Automatically assuming the pizzas to be divided into fourths, many imagine the following:



This representation results in each of two people getting 3 1/2 pieces. What people do not often notice is that this solution changes the unit from halves to quarters. Each person in the pizza story is getting 3 1/2 *quarter-pizzas*, not 3 1/2 *half-pizzas*. (Worth noting is that this common "solution" to the problem of generating an appropriate story problem is produced by most adults—not just teachers—to whom the question is posed.) What is important for the present discussion is that this problem, posed to a group of teacher education students or practicing teachers, can be fruitfully used to develop a number of significant mathematical ideas, including interpretations of division, the importance of the unit, and what is involved in building a mathematical correspondence between a model and a mathematical expression. That this is a fruitful workspace seems related to the fact that the arithmetic territory is not new to them, that the work is engaging them in a disequilibrating encounter with something they already know. This would *not* make a good problem for sixth graders first learning to divide fractions. They would not be able to calculate with such ease, nor use the algorithm of "invert and multiply" to produce the initial answer. The discrepancy between the calculated answer and the story problem would not emerge, and there would not arise the surprise factor that animates adults' learning in this problem.

Developing the concept of division and extending it to fractions, as one would do with sixth graders is a different pedagogical undertaking than challenging complacent procedural knowledge of adults. That teachers already know a great deal of mathematics, albeit often without deep knowledge of the fundamental ideas, makes productive mathematics learning experiences often different for the two groups. Hence, the simple adage that teachers should be taught as they would teach students, is likely *too* simple. The mathematics *problems* that afford appropriate intellectual space for students' learning are often different from those that afford learning spaces for teachers. Teachers would not necessarily profit from problems designed for student learning. And problems that are designed to be fruitful for teachers may not set up students' learning as well.

Treating as a working hypothesis this reasonable idea that professional development should "model" the mathematics teaching that teachers should use with students would involve examining the sorts of mathematical tasks that seem to afford productive learning for teachers, and for students. It might also involve close analyses of the interactive dynamics of mathematics discussions among teachers, compared with those of children. Just as there may be some distinctive features of problems that are fruitful for teachers' learning, there may also be particular possibilities or challenges in helping teachers work—independently and with others—on mathematics. Their histories, identities, and understanding are all likely different in some important ways from those of students, and good pedagogy is about building bridges between learners and the mathematics to be learned. Engaging this principle as a hypothesis rather than mandate would likely uncover interesting areas of overlap between the teaching and learning of children and the teaching and learning of teachers. Doing so would require careful unpacking of the constituent elements of the claim, and scrutiny of their validity in a variety of contexts and under different conditions. Are the issues different for beginning versus experienced teachers? For elementary versus middle or high school teachers? Does it matter what the mathematical content is? For example, does it make a difference if the mathematics to be learned is *new* to teachers—that is, not content that they are revisiting, but content they have never explored before? Does it matter if the purpose of their work is to prepare them to work on it with students versus to develop some broader sense of the territory, some sensibilities or peripheral vision? And throughout, what we need is a thoughtful development of what "modeling" might involve, and what it would take for it to be educative.

There are also important teacher learning questions involved in this set of ideas. What might it mean to approach an opportunity to learn mathematics as a teacher rather than as a student? And are there versions of such a stance that would make more mathematics courses and workshops into useful sites for developing mathematical knowledge, with less reliance on the instructor's ability to model a particular pedagogy? For example, a limiting version of such a stance might mean that a teacher would see as irrelevant forays into mathematical ideas and issues not directly related to the curriculum. But generative versions of such a stance might mean that a teacher would actively take note of others' mathematical ideas in the session as a window into how others might solve a particular problem or understand a specific idea. Or, a teacher, aware of the sort of depth and flexibility of understanding needed in teaching, might not settle for getting right answers, and be more demanding of himself or her-self, and of the instructor to reach for a stronger sense of the ideas. While the notion of "modeling" may include some important claims worth unpacking about what instructors can do, there may be some parallel ideas about what it means to learn mathematics as a teacher that may be worth uncovering and exploring as well.

The Structure of Professional Learning Opportunities for Teachers

Many hold strong beliefs about what constitute productive structures for teachers' learning. Widely believed is that "one-shot workshops"—that is, single session professional learning opportunities, without follow-up—are not useful. And many believe that when teachers work with colleagues, the time spent is worthwhile. Reactions to the newer phenomenon that is referred to as "lesson study" are similarly impassioned, often also related to structure of the work, and the professional and social features of the learning opportunities. Although likely important in combination with other more "curricular" aspects of professional development, *what* teachers work on—the curriculum of the professional learning—seems likely to be as big a factor as the *structure* of the opportunity. Notably relevant is that organizational features of students' learning of mathematics have not been shown to have effects on their learning of mathematics on their own. This should give pause to strong claims about the effects of structure on teachers' learning.

Why might we believe such claims? Let's take the "one-shot workshop" first. One reason to disparage such formats is that most of us, whether teachers or teacher educators, have seen or participated in shoddy one-shot teacher "inservice" sessions. We have had strong reactions to the waste of time, to the lack of engagement or useful knowledge, to the often-poor pedagogy or dramatic style of such sessions. Yet many school districts continue to provide such opportunities, and many of us have ourselves offered such sessions. We may even think that some of what we do in such sessions has value, and may also hear from participants that they found them useful. Reflecting further, many of us may have also had important insights in the context of a single session—a lecture, a workshop, a meeting—that turned out to be significantly generative for our learning. Taken together, there may be more to ponder than at first meets the critical eye. If in fact, districts are likely to continue sponsoring such sessions, there are good reasons to investigate the sorts of experiences, content, and ways of working that *can* be productively packaged into single sessions.

Moreover, and equally important are the teacher learning questions involved. Teachers, like most professionals, have many opportunities to learn and to develop their knowledge, skill, and practice. What does it take to be a good user of professional learning opportunities—to combine different kinds of learning, to use sessions and people as resources in an ongoing learning program of one's own? In other words, what would it mean to be a discriminating and constructive user of multiple forms of professional development, across sessions, workshops, courses, meetings—with one's own needs for learning and one's own practice as the drivers? Viewed from the perspective of the teacher as a learner, a series of one-shot workshops that the teacher coordinates in his or her own learning may have more coherence and value than can be seen by the outside observer.

The current enthusiasm for and concomitant skepticism about "lesson study" is no more than a specific case of the claims often made about forms of teacher education. Made visible through the popular book, *The Teaching Gap* (Stigler & Hiebert, 1999), and actively developed in research and development programs such as those led by Catherine Lewis (Lewis, 2000) and Clea Fernandez (Fernandez, Chokshi, Cannon, & Yoshida, in press) and their colleagues, "lesson study" is a term given to describe a kind of professional work in which Japanese teachers engage to develop their teaching. Probing the surfaces of the practices involved in lesson study suggests that there are important aspects of this work that offer promise for teachers to learn in and from practice, in the company of other professionals. Teachers work closely on a particular mathematical idea, examining its elements and connections, probing ways it might be represented to students, and investigating difficulties children might have in learning it. They collaborate to design and teach the topic to students, testing their design ideas in practice, analyzing how they work, and revising and reteaching the lesson.

This cycle of study and development in practice offers some important opportunities for teachers' learning. It also shares family resemblances with other forms of professional learning being explored in the United States and in other countries—the use of cases, for example, or the study of videotapes or other records of practice. Learning from experience is difficult. It is also both essential and inescapable. What these different forms of professional development share is the attempt to "harness" practice to make it a productive site for professional learning. Closer analysis of the underlying ideas and the ways in which they are enacted would afford important possibilities to gain knowledge about how teachers can learn in, from, and for practice (Ball & Cohen, 1999).

Yet some of the current attention to lesson study does not yet probe its fundamental conceptual structure as an opportunity for teacher learning. Ironically, both its proponents and its skeptics can at times remain focused on its external structure and form. People ask questions such as: How much time do teachers spend? How often do they meet? How many lessons do they work on in a year? While its forms matter, what is significant about lesson study is probably not merely those forms. Most likely what is significant is not mainly that teachers work with one another. It is more likely that what matters is the unusual ways in which it engages teachers in learning mathematics in ways connected to practice. Also important may be the work on lesson design that organically connects attention to student thinking and to the integrity of the mathematical ideas. If the structures used in Japan do not fit the common organization of teachers' work in the U.S., this provides fodder for discussion. But if these structures are taken as the dominant feature, then the possibilities of learning about the interplay of structure and what teachers work on, and in what ways, are limited.

Lesson study is no more than an instance of a larger challenge we face in developing knowledge about teacher learning and teacher education. Surely the structures of teachers' opportunities to learn do matter. But to develop what we know beyond claims about surface features of professional education, we will need to unpack the dynamics of form and content—of what teachers do, in what forms, and what sorts of professional learning by teachers occur across different permutations of these.

The Nature and Scope of the Mathematics that Teachers Need to Know

Many strong views exist about what teachers need to know. Few, however, are based on more than anecdotal or small-scale evidence about how teachers' knowledge of mathematics affects their effectiveness with students. Yet because mathematical knowledge for teaching is a domain that also lends itself to logical analysis, countervailing claims permeate the discussion, each with reasonable bases. Professional opinion provides the foundation for many claims in this arena. However, few disciplined means exist for sorting out these competing claims. It makes sense to claim, for example, that what teachers most need is to understand the mathematics for which they are responsible. In order to teach multiplication of decimals well, for instance, there is much to understand about number and operations, about models for each, and about algorithms and place value, about the distributive and commutative properties. Yet closer scrutiny may also reveal that mathematical issues can arise as teachers work with their students, issues for which more advanced mathematical knowledge might be useful (see, for example, Lampert, 2001, for an up-close view of the mathematical complexity of elementary teachers' daily work). When students propose alternative approaches, teachers need ways to size up their mathematical validity and value in order to make sound decisions about what to take up and what to deal with individually (Ball & Bass, 2000). Seeing connections between these elementary arithmetic procedures, such as multi-digit multiplication, and ideas and work with polynomials can also offer teachers a sense of the mathematical horizons, of the trajectories along which their students are traveling. Ma's (1999) notion of "knowledge packages" offers one way to conceptualize the structure of usable mathematical knowledge, emphasizing the importance of core ideas and their connections and development over time. A close focus on the curriculum, narrowly interpreted as what teachers teach, can limit teachers' peripheral vision and lead to a kind of myopia in teaching decisions. However, it is also easy to overlook the complexity and richness important to unpack and learn right in the immediate mathematical territory. A commitment to extending teachers' mathematical reach can inadvertently shortchange what there is to learn about the ideas within the student curriculum.

So far, we see that competing claims about the extent of teachers' knowledge are viable, based on reasoned argument. However, significant problems exist that limit our progress on this important set of issues. First, we lack specificity about what it might mean to learn "the mathematics of the curriculum" or to engage with "advanced ideas." We need ways to make these notions more concrete and be able to develop indicators or measures of each, and of other conceptions of teacher knowledge. And we need to be able to track and analyze how different kinds of mathematical knowledge bear on practice. How, for example, do teachers with different kinds of mathematical understanding appraise and use curriculum materials? How do they size up the mathematical quality of alternative materials, perceive and compensate for distortions, transform weak presentations, learn from unfamiliar but promising representations or approaches? Evidence on these and other such questions about practice would help to mediate these different claims. It is even possible that the more closely tied to practice the discussion becomes, the closer, too, will grow the different claims. And remaining to study, most important, is how teachers' mathematical knowledge affects what their students learn. Progress on this question depends on developing the sort of more nuanced conceptions of what might be meant by "knowing mathematics for teaching," for the past efforts to use proxies for teachers' mathematical knowledge (e.g., courses taken, degrees held) have generally been too imprecise to detect effects.

It may also be too imprecise to view all mathematical knowledge similarly. Perhaps the nature of knowledge for teaching depends on the ideas themselves. For example, maybe knowing geometry for teaching is qualitatively different from the knowledge needed to teach number and operations. What about elements of mathematical knowledge that are less topical—knowledge about the nature and role of mathematical definitions, for instance, or mathematical reasoning? It may also be that some mathematical ideas and skills have high leverage for teachers' mathematical proficiency in teaching. Possibly certain elements of mathematics not easily considered "knowledge" have significant power in teaching. Examples might include sensibilities about what makes a mathematical solution elegant, fascination with symmetries and correspondences, appreciation of particular representations, sense of a good problem. Might it be that these mathematical qualities and orientations bear in important ways on teachers' decisions and capacities? Investigating these and other questions about the mathematical resources that matter for teaching requires moving beyond the sort of blunt (e.g., numbers of courses) or vague (e.g., descriptors such as "deep" or "flexible") claims about what teachers need to know. It requires a closer probing of mathematics itself and what there is to know and appreciate about the domain. It requires also an equally closer probing of the mathematical demands of teaching, and improving our working hypotheses in ways that will allow us to test and develop our claims.

The Role of Curriculum Materials in Mathematics Teachers' Practice

Do curriculum materials hamper or enable teachers? Strong views run in different directions on these questions, complicated by equally strong views about the quality of any particular textbook. Some are sure that textbooks determine the curriculum; others are convinced that teachers are a bigger determinant than the materials they use. Perhaps it is because teaching is a mass profession, or perhaps because of the importance of design and development in learning, curriculum materials do play a visible and important role in instruction. Much evidence suggests that despite an ideology that suggests that teachers who "make" their own curriculum are more "professional," commercially published curriculum materials dominate teaching practice in the U.S. (Goodlad, 1984). This role may be greater in mathematics teaching even than in other subjects. Textbooks provide a structure and organization for the ideas and skills, and order the development of content over time. With both assignments for students and guidance for teachers, curriculum materials are a relatively elaborated resource for teaching. Unlike frameworks, objectives, assessments and other mechanisms that seek to guide curriculum, instructional materials are concrete and daily. They are the stuff of lessons and units, of what teachers and students do. That centrality affords curricular materials a uniquely intimate connection to teaching. An important question, then, is how teachers use them, and how much and what aspects of curriculum developers' visions are enacted in classroom lessons.

Because of this close connection to the daily work of teachers, the design and spread of curriculum material is one of the oldest strategies for attempting to influence classroom instruction. Reformers have often used instructional materials as a means to shape what students learn (Bruner, 1960; Dow, 1991) and some developers have operated as though curriculum materials could operate nearly independently on students (Dow, 1991). Recent strong efforts in states such as California and Texas reflect policymakers' assumption that controlling textbook adoption will determine the curriculum. Critics argue that this strategy "de-skills" the professional work of teaching and severely limits local discretion over curriculum (Apple, 1990). Many of the recent debates in mathematics education have centered on this set of issues: on arguments about curriculum materials, their endorsement and adoption, their evaluation and effects.

However, too little is known about how teachers use textbooks, or more, what they learn from them. Long-term research on teachers' content decisions by Porter and his colleagues (e.g., Schwille, Porter, et al., 1983) suggest that teachers' mediate curriculum developers' designs and intentions. And many researchers claim that teachers include and omit lessons, follow and modify teachers' guides, as a function of their own knowledge and beliefs about mathematics, learning, students, and goals (Fennema & Franke, 1992). Still, while some argue for highly elaborated materials with detailed teachers' guides, others claim that such curriculum materials deny teachers professional discretion. Here, as in other areas, ideology and evidence co-mingle. Imagine another profession where the essential tools of the trade were as contested as textbooks are in teaching. The notion of a "professional" creating his or her own tools de novo is not only impractical; it is both risky and foolish. None of us would prefer surgeons who departed from detailed protocols for particular procedures or who defined professionalism as the right to be creative and find one's own style. A recent essay in the *New Yorker* illustrates just how complex is the learning to use and carry out such procedures effectively, and how long is the "learning curve" in doing so (Gawande, 2002). To complicate matters further, as in teaching, professional practice changes across a surgeon's career, making it necessary to continue learning new procedures, approaches, and ideas.

Yet even to agree that curriculum materials provide important tools for instruction does not answer major questions about what makes curriculum materials usable, what makes them resources with and from which teachers can learn, and what might constitute the needed guidance for the necessarily particular nature of helping children learn mathematics. Turning our beliefs and worries about the role of curriculum materials in teachers' learning and in their practice demands a closer examination of what might be meant by "guidance" and ways to distinguish among different kinds of detail in materials. Are some forms of detail prescriptive and inflexible, while others provide specifics that are usable and adaptable? How do teachers read and use different kinds of material, and what factors seem to influence differences in teachers' uses? Do some materials make it possible for even relatively inexperienced teachers, or teachers with weaker mathematics backgrounds, to teach well, while others are most useful to very skilled teachers?

Learning more about how curriculum materials might function in practice requires setting aside worries and ideologies, and turns assumptions about teachers and teaching into questions that can be investigated in relation to teacher education and learning over time. Although this set of ideas pertains to instruction rather than to teacher education, it is important because of the centrality of curriculum materials in mathematics teaching. A recent study (Cohen & Hill, 2001) suggests that professional development may be more effective when teachers' opportunities to learn mathematics, and to learn about how to help students learn that mathematics, are connected with the materials they use. What we understand about the interplay of curriculum and teachers in teaching can contribute significantly to our ideas about teacher learning and teacher education. What do teachers need to learn to appraise, interpret, and use curriculum materials wisely? How might professional education and curriculum be designed to work together more effectively in improving the quality of mathematics instruction and in helping teachers develop their practice?

On Knowing What We Know

The domains briefly explored above are riddled with beliefs. Firsthand experience, anecdotes, and commitments can lead to strong views about good professional development, what mathematics teachers need to know, or how textbooks shape instruction. But in each of these areas—as in any others we might explore—opposing views compete without grounding to mediate their claims. Our arguments are based as often on firsthand perspectives and personal experience or anecdote as on more rigorous evidence. Even where we do have better evidence, that evidence is often currently limited in a variety of ways that matter for our claims to "knowledge." Our evidence in some cases does help to support our ideas, but there is more to ask, and to investigate. For example, we have not put in the foreground the "who" of teacher learning as often as we might. We tend to know only of teachers who stay *in* professional development, or who *do* participate in programs, workshops, or who pilot materials. What might be learned by following those who leave professional development, who work more on their own, who do not work closely with university educators? What about preservice teachers who are less visible or less enthused about their education classes or their mathematics courses, who are more or less engaged? There are also important questions about generalizability. What of teachers in contexts where less research has been done on teacher learning, where fewer interventions are tried, where resource conditions and the contexts of practice are different? What about beginning teachers versus teachers with many years of experience? Or teachers with substantial depth in mathematics for teaching compared to those without? Does who the teacher is, or where he or she works, shape the usefulness of different ideas, programs, or approaches?

There are questions based on *how* we work, as well as with whom. For example, many opportunities for teachers' learning are designed based on one view or another, without the possibility of scrutinizing the validity of any particular claim. For example, mathematics courses are offered for teachers that engage them in advanced study, while others aim to probe the intricacies of the mathematics of the school curriculum. In some cases, deliberate effort is made to model the pedagogy teachers should use with students, in others not. Some professional development is strategically tied to specific curriculum materials while other programs offer supplementary material and ideas, unconnected to any particular textbook series. In general, opportunities for teachers' learning are designed based on the views held by those who develop and run any particular experience. Only rarely are these assumptions articulated as such, and even less often are they systematically tested. If more such deliberate articulation, design, and delivery could be designed, and then followed, we might be able to engage in various forms of comparative analysis. Doing this would engage us in a useful discussion about evidence.

Wilson and Berne (1999), surveying the practice of professional development, and our beliefs about it, note that the qualities of high-quality teacher professional development can be found in lists sprinkled through our literature. These lists are highly consistent, and, they note, perfectly reasonable. "Yet we know as little about what teachers learn in these kinds of forums (conforming to the principles which we embrace) as we do about what teachers learn in traditional staff development and inservice. Our readiness to embrace these new principles may, in fact, be rooted in a desire to escape collective bad memories of drab professional development workshops rather than sound empirical work. Replacing our old conceptions of professional development with new only makes sense if the new ideas are held up for rigorous discussion and evaluation. New isn't always right." (Wilson & Berne, 1999, p.176) In their review of four thoughtful intensive professional development programs, each focused on subject matter instruction in a particular area, Wilson and Berne (1999) acknowledge the complexity of the work, but prod: Too often, examination of program effects was based on teachers' reflections on what was useful and helpful, comments about what they used, and reports of what they learned. While participants' reactions are obviously important in seeking to understand how teachers experience particular learning opportunities, imagine if we relied on children's reports of what was helpful for our examination of the effectiveness of particular instructional approaches. Wilson and Berne push for more developed methods of studying what teachers actually learn, and how, and for how what they learn affects their effectiveness with students. They note that the progress of the field depends on more systematic ways of studying what teachers learn and how this affects what they do, and more careful examination of how teachers learn inside of particular approaches and experiences.

Our charge, then, is to take our fond beliefs and current ideas, and turn them into explicit working hypotheses that can be tested, compared, and falsified in a variety of settings, and with different kinds of teachers. If all we do is create programs for professional learning based on what we currently believe and then generate illustrations of how these ideas play out in practice, we do not push our ideas nor test them. We do not make progress as a field, and we condemn ourselves to a morass of endless irreconcilable arguments about the quality and effects of professional development.

So, for instance, we need to articulate more clearly what it means to "model" good teaching in professional development, and what, specifically, it would mean to teach teachers as they should teach students. We need to track closely how this might be done, and examine critically what teachers attend to, how they interpret what they experience, see, and discuss, and what impact this has on what they know and believe and what they do. And we need to compare different ways of enacting the principle of "modeling" good instruction. Only if we collectively and individually develop ways to isolate our most compelling current ideas, and subject them to testing, questioning, and study, will we be able to make the sort of progress that the field needs.

Our beliefs are resources for such progress if we wield them as hypotheses rather than mantras. It is to that endeavor that this session intends to turn us. Instead of arguing about the mathematics requirements needed for certification, without grounding or evidence, ask: what difference *does* advanced mathematical study make to teachers' mathematical resources, or to any aspect of the practice of teaching, and how could we know? How *do* teachers use textbooks and what do they learn as they use them? How *does* professional development interact with the materials that teachers are using? Or take the one-shot workshop: Are there *no* things that lend themselves to this format, and how could we find out? Are there things one might try to do within such workshops that would intervene in their assumed limitations?

Converting assumptions to empirical questions, beliefs to testable hypotheses, and ideology to theory, the field of teacher learning and teacher education will begin to develop more reliable, warranted knowledge—and new and more subtle and sophisticated ideas that can, in turn, be tested. Not only do we need to deploy our ideas as questions, but we need also to think more systematically about where and with whom we investigate these questions. How can we design work such that we test ideas across settings and with teachers with different backgrounds, levels and kinds of experience, attitudes and needs? Developing a self-critical and constructive enterprise in which we seek to use our well-honed beliefs as resources for the development and improvement of our knowledge about teacher learning and teacher education is an endeavor well worth our collective commitment and engagement.

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