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# Reforms That Call for Teaching More Than You Understand

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Reform is a perennial condition of schooling in the United States. Whether motivated by apparently poor performance in international comparisons, concerns about economic productivity, or changing conceptions about fundamental knowledge, the public repeatedly asks schools to improve. Reforms spring up to meet each request, often seeming to recycle recommendations from previous decades.<sup>1</sup> Although no reform ever achieves all it sets out to, each new movement gathers optimistic proponents, is embraced by many schools and educators, and is eventually replaced by a successor. The reforms often deposit a residue but leave the basic structure of schooling intact.<sup>2</sup>

The continual press to change has many sources. Some reforms are spurred by changes in knowledge about teaching and learning; others grow from changes in priorities for student learning. Americans see schools as the solution to a host of social problems, calling on them to train workers for tomorrow's jobs, develop character, empower a democratic citizenry, and build community. Schools cannot serve all those functions adequately, so priorities shift among them, swayed by changes in the political winds. The public's relatively short attention span also contributes to repeated changes in educational goals.<sup>3</sup> Educational leaders, both in the schools and outside the schools, make their careers by championing new initiatives, so the focus of reform changes as its leaders do.

Although any attempt to change schools must take teachers into consideration, some past reforms have sought to minimize dependence on teachers. Curriculum reformers of the 1960s, for example, often saw the development of "teacher-proof curricula" as a way to change schools while bypassing teachers. Experience with reforms based solely on new curricula was disappointing, so current reforms recognize that teachers must play a leading role in change. This shift, together with arguments that teachers can and should be seen as professionals, has convinced reformers that teachers are central to improving education.<sup>4</sup>

Although skepticism about the staying power of any one reform tempers teachers' enthusiasm, they are typically willing to embrace new content and instructional approaches,<sup>5</sup> at least early in their careers.<sup>6</sup> To make these changes, teachers need to learn new content, new approaches to teaching, and new information about how students learn and how to involve parents. The inevitable shifts in the focus of reform mean that such learning is always required; new expectations call for new learning, often before the expectations of the prior reform wave are met.

The need for teacher learning, prompted by reform, is thus repeatedly present. Sometimes the needed learning amounts to a brief review or study of a new topic or two. A "back-to-basics" reform, for example, may require teachers to review topics learned some years before that are once more appearing in the curriculum. At other times training in specific teaching techniques is needed. Teachers might, for instance, be encouraged to wait longer for student responses or to call on pupils in order rather than letting them volunteer.

Other reforms, however, ask teachers to make more radical changes in content, in classroom process, or in both. In such cases, the learning needed goes beyond a slight adjustment or a reminder of something once familiar. Some of the curriculum reforms of the 1960s were demanding in this way. The "new math," for example, asked teachers to teach the formal foundations of mathematics, with in-service preparation scarcely sufficient to cover spelling the new vocabulary. That reform failed, partly because teachers weren't taught enough of the new content. Teachers were asked to teach content they hadn't learned themselves, with results that satisfied no one.

The current reform again calls for teaching more challenging content. The goals seem more appealing to a broad audience this time around—teaching for understanding, solution of real problems, and application. Once again, however, the revised standards for student achievement call for students to master topics—within and about the subject area—that were not previously part of the K-12 curriculum or part of the content of teacher preparation. Understanding *why* the algorithms of arithmetic work, for example, was not a requirement when today's teachers attended elementary school, and their further studies in high school and college seldom returned

to this topic. Preparation for teaching likewise stressed proficiency in using, but not understanding, those algorithms. How can teachers respond to this wave of reform, given that they will, once more, be expected to teach new content with little time and resources for their own learning?

A sharp discrepancy between the content teachers have learned and the content they are now expected to teach is found in many subject areas, not just mathematics. A teacher preparing to teach high school history, for example, might have completed a history major with honors and have earned strong ratings on the practical aspects of teaching, yet never have pondered questions about the nature of evidence and argument. Just such an appreciation for how historians know is, however, what some reformers hope high school seniors will learn.

The resulting predicament for teachers is that they are asked to teach content they have never learned. Teachers are expected to help students understand how historical evidence should be evaluated, but those teachers have not typically learned the procedures and criteria for such evaluation. Teachers are asked, in other words, to teach more than they understand.

This predicament would be of little consequence if the new instructional content could be learned quickly and easily. In mathematics, for example, if new standards called for teaching only a few additional algorithms, teachers could quickly expand their repertoires. Reforms would require teachers to work a bit more but would not create a predicament.

The difference between the old and the new instructional content, however, is not a simple increase in the list of skills and knowledge to be learned; instead, the changes introduce new and unfamiliar dimensions into old content. Mathematics must be understood, not merely performed. Historical interpretations must be justified using incomplete, contradictory records, rather than recalled from a standard text. Comprehension of scientific theories must be demonstrated by applying them to unfamiliar circumstances rather than by choosing which of four options is the best answer.

Teachers cannot acquire the content they are asked to teach simply by attending "brush-up" or "content-update" workshops for a few afternoons or even for a week's intensive study.<sup>7</sup> The time needed is measured in months and years, rather than hours and days. For a subject that a teacher feels confident about and is eager to learn, a college course or two might be enough to get a handle on the new content. That knowledge could then be brought to bear on K-12 instruction with further work and coaching. More is required, however, when teachers doubt that they will themselves ever achieve the deep understanding expected of their students. Many elementary school teachers, for example, are women whose experience as elementary and secondary school students led them to believe that they were poor students of science and mathematics. As a result, they stopped taking science and math courses midway through high school. They now feel that

they might be able to memorize vocabulary and algorithms but despair of ever seeing the sense in those words and rules.

Those elementary school teachers, even more than other teachers, face the predicament: How can I teach what I don't understand? Addressing the predicament raises concrete questions such as: When students put forward ideas that I don't feel I can evaluate, should I give them general encouragement or raise questions about the grounds for their positions, grounds that may be equally difficult to judge? What should I do if a student's answer to a test question doesn't match the scoring guideline but seems creative?

Current policies give teachers little guidance about how those questions should be answered or about the initial directions in which changes in teaching are moving. The language of reform encourages teachers to move away from comfortable modes of practice, without clarity about what they should move toward. The reforms give general guidance, rather than specific suggestions. Teachers are told: "Listen more carefully to students," "Teach for understanding, not for recall," and "Create a community of learners." Teachers are to assess students by having them perform "authentic" tasks as part of instruction.

Knowing how to follow such advice depends on having a good grasp of central terms such as *understanding*, *community*, and *authentic*. So teachers face another version of trying to teach more than they know. They are asked to change to practices of which they have no clear images. Teachers with experiences of "understanding" and "community" in their own learning are in good shape; those without such experiences find little specific guidance.

Even if the prescribed ways of teaching were clearer, the proposed changes increase the uncertainties of teaching by revealing more of what students do and do not understand, by linking the progress of any given lesson to the unpredictable contributions of students, and by highlighting the uncertainties inherent in the subject matter.<sup>8</sup> The upshot is that this reform is not one in which teachers can simply be encouraged to implement specific changes in practice; they must become involved in creating a new practice.<sup>9</sup> If the new practice addresses both subject matter and student learning, teachers must understand how to learn as they teach, working with students when they encounter content neither they nor the students have mastered, and attending to what students are learning in deciding how teaching practices should be revised.

In what follows, I consider whether teachers can escape from their present predicament, a challenging version of the enduring problem of being asked to make changes with apparently insufficient time to prepare for them. Although I argue that the predicament cannot be completely dissolved, its force can be reduced by shifting from thinking of the teacher as the sole source of knowledge to recognizing that students themselves, cur-

ricular materials, and new technological tools are all teaching resources. An advantage of the current reform is that it highlights those resources, emphasizing classroom discourse as a source of learning and enthusiastically embracing information technologies. Teachers are still central, but their altered role means that what they need most is knowledge about how to find and evaluate answers to questions—questions about the subject matter and about teaching and learning. Traditional course work and in-service workshops have not been oriented toward helping teachers become better inquirers, but other professional activities, such as the development of new methods of student assessment, may give teachers the help they need.

### Can We Conceive of Teaching What We Don't Understand?

Just how serious is this predicament? Is it true that teachers have no hope of teaching more challenging content until they have mastered it? Does this mean that educational reforms must be put on hold while teachers undergo a lengthy period of intensive study? One interpretation of "teaching" compels a discouraging answer to those questions. The necessity of understanding what you teach is the point behind Shulman's aphorism, "Those who understand, teach,"<sup>10</sup> and its relative, "Those who don't understand, can't teach." The strong link between understanding and teaching also undergirds the arguments for increased subject matter preparation for teaching.<sup>11</sup> What sorts of understanding are considered necessary or most important depends on the operating conception of teaching.

Commentators voice two major opinions on how strong the link between understanding and teaching should be. Each view is connected with a different idea of what constitutes teaching. One group holds that the link should be strong, that successful teaching for understanding is *impossible* for *topics* the teacher does not understand. This strong position implies that teachers should not bother to try to teach for understanding until they understand the material themselves, because they cannot be successful.

The other group claims that teachers' understanding of a topic helps them teach for understanding but is not necessary. This group acknowledges the importance of teachers' knowledge but emphasizes understanding how to approach new content, rather than concentrating on mastery of every topic to be taught. With a sense of what to do when they get "stuck," teachers may help students understand topics that are initially puzzling to the teachers and the students alike.

At first glance, the first viewpoint seems self-evident. How could a teacher effectively fulfill any instructional roles—offering information, answering student questions, designing learning opportunities, responding to

student comments—without understanding the content students are to learn? How could a teacher offer the appropriate information without understanding what is offered? How could student questions be answered? How could the teacher devise learning opportunities or, more importantly, evaluate their appropriateness and effectiveness? How could the teacher decide whether to support a student response, suggest that it be modified, or recommend a sharply different perspective?

Although the first belief has surface appeal, it is grounded in the questionable view that teaching means having teachers transmit knowledge to receptive students. Proponents of this view hold that teachers cannot teach what they do not understand because teaching consists of moving knowledge from teachers to students. If teachers lack understanding, they cannot pass understanding on to their students. But this knowledge-transfer model of teaching and learning is now in disfavor.

How is it that teachers can teach more than they understand? Why, in other words, should we reject the idea that a strong link between understanding and teaching is necessary? The key is recognizing that teachers are not the sole font of information. Students have many other sources of knowledge, or more accurately, opportunities for learning. Although scholars do not agree on exactly how students acquire knowledge (for instance, on the degree to which it is constructed or assimilated), they agree that learning occurs by means of students' mental activity, not by means of passive reception. Students' opportunities to learn arise from encounters with other students, with curricular materials, and with adults other than their teachers as well as from listening to explanations teachers themselves offer.

### Where Else Might Content Knowledge Arise?

Students can learn things the teacher doesn't understand from other sources inside and outside the classroom. Two important sources of knowledge are the students themselves and curricular materials. To what extent do those sources of knowledge extricate teachers from their predicament? In what ways do the limits of teachers' understanding continue to impede or limit student learning? What sorts of teacher knowledge are most important for helping students learn when educational reforms introduce content that goes beyond teachers' understanding?

#### *Students as Their Own Teachers*

The current wave of reform combines its call for student understanding with advocacy for greater student engagement in active learning. The reforms promote transforming classrooms into communities of learners, in

which the teacher is only one of many participants. Cooperative learning is the topic of many in-service workshops. Construction of knowledge through discourse among peers is seen as a major route to understanding. Placing students more at the center of the classroom—active in creating knowledge as well as in learning—alters the terms of the predicament teachers face. Rather than having responsibility for providing answers, teachers must know how to guide classroom discussions so that the participants build appropriate, grounded understanding.

If classroom learning can rely heavily on interactions among students and on insights that students achieve independently, the need for teachers' content understanding is reduced, or at least revised. For concepts that the teacher feels shaky about, the students can serve as a resource. More importantly, the classroom community can, according to some constructivist theorists, build the understanding, from the bottom up, as it were. Students gain knowledge by working through problems and puzzles, much as would scholars. No one—including the teacher—needs to possess the understanding in advance; it is developed as a solution.

The teacher still has a role in promoting student understanding, however. Given the human propensity for errors in reasoning, classroom discourse may not lead to well-justified beliefs unless participants attend to rules of evidence and argument, such as those established by scholarly communities. Teachers can help their classes learn to follow such rules, even if the teachers themselves do not understand all the concepts and domains to which the rules may be applied.

Teachers may ask students to pursue topics on their own, applying intellectual tools they have acquired (with the teachers' help) to new content areas. A simple example makes the point: A teacher may use her understanding of literary analysis to help students learn how to study a poem, how to analyze its themes and structures. The teacher may then ask students to use their understanding of literary analysis to examine the work of poets the teacher has not herself read. By working on this assignment, students may come to understand poets and poems that the teacher does not understand. Although the teacher might be able to understand those poets if she took the time to do so (in other words, it is not that the teacher *cannot* understand the poems), the students have in this example managed to learn something the teacher does not currently understand.

One might ask whether, in this example, it is accurate to say that the teacher *taught* content she didn't understand, since it was the students' effort that produced the learning. That challenge begs the question, because it restricts "teaching" to those circumstances in which the teacher "gives" knowledge to students. The teacher helped the students acquire the tools to do the analysis, created an assignment in which the students read the poetry, and may even have checked whether the students used the analytic

tools appropriately. The teacher thereby engaged in instructional activities that led to student learning. Barring some specific objection, this should count as teaching.

Moreover, teaching is not only about helping students acquire understanding. Reformers also hope that students acquire a desire to continue learning outside school, gain the ability to work cooperatively, and develop their powers of creativity. None of those attributes can simply be transmitted to students. Motivation, cooperation, and creativity can grow out of participation in activities that involve a variety of subjects. The teacher's role in promoting such learning is a combination of exemplifying those goals (for example, displaying her own eagerness to learn) and arranging classroom activities that encourage creative, cooperative efforts.

The poetry example can be extended to other subject areas. The teacher of a science class, for example, can teach students general principles of inquiry (such as how to measure accurately, how to analyze fluctuations in experimental results, how to control variables, and how to interpret graphs). The teacher might subsequently assign experiments involving light and prisms, then check to see whether students were measuring properly, representing their data accurately on graphs, and so on. By completing those experiments, students could gain an understanding of light and prisms that exceeds the understanding of the teacher. As the teacher in the poetry example does, the science teacher teaches the students things that she herself does not understand. By drawing on students themselves, teachers can teach more than they know; teachers' knowledge does, however, help to ensure that what students learn is well grounded.

### *The Roles of Curricular Materials and Information Technology*

Teachers can also teach more than they know by using curricular materials that fill in the areas where teachers feel weak. With such materials, teachers need not understand everything students learn. If teachers know enough to follow the materials, even though they don't really understand the content of the lesson, the curricular materials can do the instructional work. The systems of "programmed instruction" created in the 1960s are examples of such "teacher-proof" curricula. In creating those systems, subject matter experts and curriculum developers took on the job of explaining concepts, devising student assignments, and creating tests to monitor student progress. The classroom teacher's job was to oversee a system in which students read assigned pages in a book, completed assignments and tests, and checked their answers against an answer book.

While such curricula were designed to convey subject understanding without depending on teachers' expertise, the typical experience with the

systems demonstrated that teacher knowledge remained a critical factor. In the worst cases, attempts to bypass the teacher led to situations such as that described by Ertwanger, in which a student managed to progress through the curriculum despite his fundamental misunderstanding of the content.<sup>12</sup> Had a teacher with an understanding of the subject area been more closely involved with the student's work, a correction in course could have been achieved.

That misfiring of the system is one way in which teacher understanding continues to be important. Teachers' understanding may also continue to be important because instructional processes recommended in reforms involve students' learning to talk to one another in particular ways. To the extent that those ways are dependent on content accuracy, it is necessary to have someone there who does understand what the point is. Whether in print or in a more modern medium, curricular materials are not able to follow student discussions and decide how and when to interject, redirect, or summarize.

Teachers can also use information technology to supplement their knowledge or to connect students with experts and information. The technologies are rapidly evolving, building on network connections to people and data, multimedia resources on media with rapidly expanding storage capacities, intelligent tutoring systems, and systems for managing classroom investigations. Such tools do reduce student dependence on the teacher and the text as sources of information. The predicament for teachers does not disappear, however; it takes another shape.

The wealth of available information can also be a confusing welter. Information obtained from individuals outside the classroom can be misleading or inaccurate. Not everyone who responds to a query is an expert in the relevant field. Students need to learn how to make productive use of these tools, how to master these rapidly evolving information systems. Once more, teachers need to increase their understanding, with limited support for that learning.

Heaton's work includes an example that illustrates the problems with using tools (in this case, the curriculum) as the sole source of content understanding.<sup>13</sup> Heaton has a stronger background in mathematics than most elementary teachers do, including course work (and good grades) in college calculus and experience working with outstanding mathematics educators, such as Ball and Lampert, who focus their work on teaching elementary school mathematics for understanding. Moreover, Heaton has an outstanding record as a teacher, including recognition as Vermont's teacher of the year.

As part of her doctoral study, Heaton taught elementary school mathematics on a regular basis, using the CSMP curricular materials. The materials present addition and subtraction as functions, using arrows to represent op-

erations such as adding 2 or subtracting 15, and ask students to work with the arrows rather than write computation problems in standard notation. The intent of the curriculum developers was to help children see arithmetic operations as particular cases of mathematical functions, a basic concept about the relationships among numbers. Although students practice computation, the materials are intended to get them to understand simultaneously such concepts as addition, subtraction, function, inverse, and number.

Partway through her work with the materials, Heaton realized that although she was following the directions in the teachers' guide and her classes seemed to be going well, she did not understand some of the basic ideas being taught. She was asking students to notice "patterns" in the results of their work with the function arrows, but Heaton found that she did not know which of the "patterns" students saw were mathematically relevant and which were mere superficial similarities. Despite her background in mathematics and her experience in teaching, she did not know what counted as a "pattern" and what did not. She found, to her surprise, that she was trying to teach something that she didn't understand.

The CSMP materials were constructed with the thought that they would carry the burden of "understanding" the mathematical content to be taught. The curriculum developers intended for students to understand basic ideas in mathematics, such as "function," but did not think that they could assume that typical elementary teachers already understood those concepts. So the materials and teachers' guide were written so that if teachers followed the directions in the guide and children did the problems, there was a good chance that students would begin to grasp the mathematical ideas.

As Heaton's example illustrates, however, an instructional approach that still involves the human teacher (as most do in elementary school mathematics) is likely (perhaps certain) to depend on some teacher judgments and comments to students. The teacher's guide suggested that Heaton ask students to look for patterns. For the students to make mathematical sense out of this exercise, Heaton had to make some indications of which "patterns" made mathematical sense and which did not. Given the unusually strong background Heaton possessed, it is likely that few teachers would have a better idea than she did. In other words, although the curriculum was carrying some of the burden of setting up experiences that would promote student understanding, the package required the teacher to have more than the usual degree of content understanding.

### What and Where Should Teachers Learn?

If classrooms place student discussions more at the center, make use of the content explanations embedded in curricular materials, and use information

technology for access to further content expertise, teachers need not understand all the content their students are supposed to learn. Teachers' content knowledge remains important, but emphasis shifts from transmitting knowledge to helping direct student learning, avoiding unproductive paths, and guarding students against alluring misconceptions. The additional resources of students, curricula, and technology ease the demands for teachers to learn some topics, but teachers continue to face the need to learn, with limited resources and time. Given that predicament, what opportunities for learning should they pursue? What learning should be given highest priority?

The typical occasions for teacher learning, college courses and in-service workshops, seldom focus on the learning that seems most urgent. Opportunities for learning also arise in activities, such as assessment, that blend learning about new subject matter with other professional work.

### Learning to Inquire

I argued above that the predicament teachers now face should not be seen as a gap in their own understanding of the *topics* students are expected to learn. Because they are not the sole source of information on the topics, teachers can reenvision their role as helping students build understanding by participating in classroom discussions, working with curricular materials, and reaching outside the classroom for information. To organize such classrooms, teachers need knowledge about inquiry. To guide classroom discussions so that they lead to justified conclusions, teachers need to understand the criteria for evaluating arguments and conjectures. Some principles of evaluation are general, such as that plausible counterarguments should be recognized and addressed. Other principles are specific to individual subject areas.

As they try out the changes in pedagogy recommended by reforms, teachers need to understand how to adapt and extend their practice in light of its effect on students. Applying to teaching the habits and tools of inquiry—close observation, probing student understanding, reflection, imagining alternatives—will lead to better informed choices.

Assigning priority to habits of inquiry is not new. John Dewey argued for it in the first half of this century,<sup>14</sup> and Joseph Schwab later echoed Dewey, with a special emphasis on the knowledge teachers need.<sup>15</sup> The return to Dewey is appropriate, because the curricular emphases of the current reform resemble his emphasis on solution of real-world problems, drawing on accumulated understanding found in the disciplines. The challenges Dewey posed for teachers also seem familiar—to understand the subjects well enough to guide student learning, but not simply to transmit inert bodies of fact. Like the teachers who faced an "impossible role" (to borrow from Schwab's title) in trying to realize Dewey's vision, today's teachers feel as though they must

learn much more. What opportunities do they have to learn, especially to learn about inquiry in their subject areas and in their classrooms?

### *Study in Courses and Workshops*

College courses are commonly available opportunities for teacher learning. Most teachers continue to take courses while they are teaching, sometimes in pursuit of an advanced degree. Given the scholarly orientation of most colleges and universities, such courses seem promising places to learn more about inquiry and to gain greater understanding of the subjects to be taught.

Too often, however, teachers find it difficult to locate a course of study focused on their needs. College courses typically focus either on teaching methods or on subject matter intended for students preparing for graduate school in the field. Visits to the classes with the first focus suggest that they are likely to concentrate on general and specific methods for teaching certain topics, helping teachers see what their students might get out of particular approaches and giving teachers opportunities to exchange ideas to add to their bags of tricks. But teachers are unlikely to spend much time increasing their own understanding of either the subject matter they are learning to teach or its distinctive methods of inquiry.<sup>16</sup>

Content courses offer opportunities to learn about advanced topics but seldom focus on the topics included in the K-12 curriculum or on how to gain more understanding of those topics. Those courses, usually offered by the disciplinary departments, are oriented toward students preparing for careers in the disciplines. They focus instruction on content needed to pursue advanced degrees in the disciplines, not on content needed to understand the topics taught in elementary and secondary school. The result is that doing well in such course work is no guarantee that teachers understand the content they are expected to teach or how to guide classroom discussions that focus on those topics. Studies of subject area majors in mathematics, history, and English show that successful majors often have difficulty explaining content taught at lower levels.<sup>17</sup>

Many mathematics majors, for example, know what rules to follow in doing arithmetic but have difficulty explaining the logic behind the rules. They may think that the impossibility of dividing by zero is simply a rule one has to memorize, rather than seeing how it follows from the explosion of the quotient as the divisor approaches zero.

For workshops taught outside the higher education system, the situation is similarly mixed. It can be difficult to find in-service workshops that pay serious attention to content learning, though some do exist.<sup>18</sup> Information on in-service programs often takes the form of advertisements. General directories of available offerings are seldom available. Moreover, even activities intended to build subject matter knowledge sometimes skirt subject

matter issues because of the fear that directly addressing misunderstandings may offend teachers or reduce their motivation to participate.<sup>19</sup>

In-service offerings are generally seen as lacking in substance, led by consultants with polished but superficial presentations. Popular programs for professional development often focus on structural changes, such as restructuring schools and creating career ladders. On close examination, it seems that such efforts seldom contribute much to the improvement of instruction, let alone focus on increasing teachers' subject matter knowledge.<sup>20</sup>

College courses and in-service workshops could be redirected to offer content that would help teachers with their predicament. If the topic focus were shifted to parallel the K-12 curriculum, teachers might have opportunities to fill the gaps in their understanding of what they are expected to teach.<sup>21</sup> If teachers could participate in guided discussions of unfamiliar topics, those teachers might learn how to guide such discussions in their own classrooms. By being engaged in inquiries into classroom practice, teachers could develop habits of inquiry to assist them as they figure out how reform pedagogy can be adapted for effective local use.

At present, such courses and workshops remain rare. In any case, they are unlikely to address all teachers' needs for greater understanding. Given the press of time, such learning opportunities outside the ongoing activities of professional life can make only a partial contribution to helping teachers teach more than they know. Other opportunities for teacher learning are needed.

### *Learning from Doing Assessment*

Assessment systems are often used to check on whether teachers are being successful in helping students reach new learning goals. Dissatisfaction with multiple-choice tests has prompted many states and districts to adopt assessments in which students demonstrate in other ways that they have the hoped-for abilities, such as the ability to write or to solve mathematics problems.

Reformers argue that assessments should be "authentic," asking students to perform tasks representative of the desired learning goals, rather than completing test items that serve only as indicators of some related constituent ability. If the goal is for students to be able to write short stories, going through multiple drafts to reach a final version, then an authentic assessment would involve examining short stories written and revised over a period of time, rather than asking students to take a test of grammar and knowledge of story structure. Such authentic assessments are also claimed to solve the problem of teaching to the test. If the desired performance becomes the test, then teaching to the test is simply teaching to the hoped-for outcome—a virtue, not a vice.

Assessments that make new learning goals transparent, like the curricular materials discussed previously in this chapter, may help teachers teach more than they understand. If the assessment matches what students should learn, learning to assess student progress involves learning the content to be taught. Although a multiple-choice exam can be administered and scored without any understanding of the content being tested, teachers may not be able to carry out the newer type of assessment if they do not understand the content over which students are supposed to demonstrate mastery. It is difficult to gauge the chain of mathematical reasoning a student has used to solve a problem if the teacher has a weak grasp of mathematics.

Activities focused on learning to do the assessment may help teachers learn enough of the new content to evaluate the products of student work. The workshops and the teacher network organized in support of Vermont's performance assessment illustrate how attention to assessment can help teachers through their predicament.

In the early 1990s, the Vermont Department of Education instituted statewide assessment in writing and mathematics, focusing on the collection and scoring of student portfolios. In grades four and eight, teachers had students put samples of work into folders across the year. At year's end, classroom teachers scored those portfolios using state guidelines, and a sample of students in each district was selected for scoring by a statewide group of teachers. To be scorable, the work in the portfolios had to have certain general characteristics. The writing portfolios had to contain work from specific genres; the work in the mathematics portfolios had to include solutions to problems along with the steps used to solve the problems and the reasoning supporting those steps.

Since various statewide projects had supported elementary- and middle-school writing instruction for a decade or so before Vermont implemented the statewide assessment program, assembling the writing portfolios was not a great departure from previous practice. In mathematics, however, most elementary school teachers had previously used a traditional approach to mathematics, in which the only problems students solved were word problems matched to the computational skills being taught. Such problems did not lend themselves to inclusion in the portfolios, because they required little, if any, reasoning; students simply plugged the numbers from the problem into whatever mathematical procedure they had been practicing.

To inform teachers about the assessment process and to train them in the scoring rubrics, in-service sessions were held, followed by periodic meetings of regional networks, led by teachers.

Many teachers believed that having to do mathematics portfolios led them to change their practice. One teacher felt that portfolios were the most important education reform in the state. Another characterized the portfolios as "an effective way to get teachers to change. . . . I embrace the [Vermont] standards. . . . I might not have done it otherwise."<sup>22</sup>

As the Vermont teachers learned what was required for the mathematics portfolio assessment, they realized that they had to teach problem solving if students were to have scorable portfolios, let alone do well on the assessment. Like most elementary school teachers, they had little preparation for this new content and often little understanding themselves of mathematical problem solving.

In the initial years of the assessment system, the state offered four in-service sessions per year on the new assessment. In-service activities that focused on scoring the mathematics portfolios offered opportunities for teachers to learn about problem solving. Discussing whether a student response included a good strategy for solving a problem, for example, required analysis of different approaches to solving the problem and of how to decide which ways were better than others. As the teachers worked through those problems, they learned something about problem solving and a bit about how it might be taught.

Working on the portfolio assessment also led teachers to request sources of problems that would be suitable for their classrooms. In response, references to problem-solving materials were included in the handouts distributed at the in-service sessions.

Networks of teachers were also organized. Network leaders led the sessions preparing teachers to carry out the assessments and also served as resources for teachers who had questions about the assessment or the associated approach to instruction.

Embodied in the tasks of helping students produce solutions to problems and scoring those solutions according to guidelines demanding attention to the mathematics content, portfolio assessment serves as a support for mathematics instruction that stretches teachers' understanding. A teacher who knows what a good problem solution looks like is in a position to help students produce good solutions, even when the mathematics of some problems is challenging.

However, as with curricular materials, the support is limited. Some teachers need more than a few in-service sessions to learn how to assign valid scores to mathematics portfolios. Deciding whether mathematical terms are used appropriately, for example, may prove difficult for some. In-service workshops may give teachers a superficial understanding that is sufficient for generating a score for every portfolio and even that approximates the score given by a mathematics expert, but a shallow understanding can lead teachers to include inaccuracies in their instruction.

Furthermore, although a good understanding of assessment can be a valuable guide to instruction, it is not sufficient. Teaching students to be good mathematical problem solvers requires more than the ability to know whether the instruction has been a success. Additional knowledge about students and subject matter is needed to appreciate why a student repeatedly fails to find a solution or persistently arrives at incorrect solutions. Detailed



knowledge of what a good performance looks like will be an aid in helping teachers teach more than they understand, but it cannot completely compensate.

## Conclusion

Much is made of the difficulties teachers face in teaching the challenging content promoted in recent reforms. Quite accurately, commentators note that a major obstacle is that changes in content expectations make it impossible for teachers to draw on their own experience as students as they search for instructional solutions. In particular, they are asked to teach concepts that they never studied, let alone mastered. Given time, they may master the new content, but they face the acute predicament of trying to teach concepts they don't understand.

With the help of good curricular materials and students ready to be active participants in their own learning, that seemingly impossible goal can be achieved. Nonetheless, further teacher learning is important for ensuring that students move toward valid understanding.

Teachers' understanding of subject matter, in particular their understanding of how warranted understanding is developed and tested, is of particular importance. Although critics of contemporary education often press for more attention to learning substantive facts and concepts, teachers may be able to make better use of an understanding of the processes of inquiry. The substance of some fields is constantly changing, with additional discoveries and revisions of prior theories. The processes used for investigation change little, at least in comparison; thus, what is learned about the processes scholars use to develop and test conjectures is less in need of continual updating.

More important, when a curricular unit or classroom discussion goes beyond content that teachers have mastered, an understanding of how to find answers to questions or to test the accuracy of a claim can be used to help students build accurate understanding. With proper guidance, students can be encouraged to learn beyond what the teacher knows. A teacher may be able to ask telling questions without knowing the answers.

## Notes

Suzanne Wilson provided insightful comments on an early draft of this chapter.

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(Berkeley: McCutchan, 1988); David Tyack and W. Tobin, "The 'grammar' of schooling: Why has it been so hard to change?" *American Educational Research Journal* 31 (1994): 453-479.

3. Anthony Downs, "The issue-attention cycle and improving our environment." (Chicago: Real Estate Research Corporation, 1971).
4. For example, Deborah Loewenberg Ball, "Developing mathematics reform: What don't we know about teacher learning—but would make good working hypotheses?" (East Lansing: National Center for Research on Teacher Learning, College of Education, Michigan State University, 1995); David K. Cohen, "Teaching practice: Plus ça change"; Linda Darling-Hammond and Milbrey W. McLaughlin, "Policies that support professional development in an era of reform." *Phi Delta Kappan* 76 (1995): 597-604; Gary Sykes, "Reform of and as professional development." *Phi Delta Kappan* 77 (1996): 465-467.
5. Robert E. Floden, Andrew C. Porter, William H. Schmidt, Donald J. Freeman, and John R. Schwille, "Responses to curriculum pressures: A policy-capturing study of teacher decisions about content." *Journal of Educational Psychology* 73 (1981): 129-141.
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9. Deborah Loewenberg Ball, "Developing mathematics reform."
10. Lee S. Shulman, "Those who understand: Knowledge growth in teaching." *Educational Researcher* 15, no. 2 (1986): 4-14.
11. Hilda Borko and Ralph Putnam, "Learning to teach."
12. Stanley H. Erlwanger, "Benny's conception of rules and answers in IP1 mathematics." *Journal of Children's Mathematical Behavior* 1, no. 2 (1973): 7-26.
13. Ruth M. Heaton, "What is a pattern? An elementary teacher's early effort to teach mathematics for understanding." (East Lansing: National Center for Research on Teacher Learning, College of Education, Michigan State University, 1995).
14. John Dewey, *How we think: A restatement of the relation of reflective thinking to the educative process*. (Chicago: Henry Regnery, 1933).
15. Joseph J. Schwab, "The impossible role of the teacher in progressive education." In *Science, curriculum and liberal education: Selected essays*, edited by Ian Westbury and Neil J. Wilkof (Chicago: University of Chicago Press, 1978/1956).
16. See Robert E. Floden, G. Williamson McDiarmid, and Nancy Jennings, "Learning about mathematics in elementary methods courses." In *Preparing tomorrow's teachers: The field experience. Teacher Education Yearbook IV*, edited by D. J. McIntyre and David M. Byrd, 225-241 (Thousand Oaks, CA: Corwin, 1996). For an example of a course that does focus more on content, see Deborah Loewenberg Ball, "Breaking with experience: The role of a preservice methods

course." (East Lansing: National Center for Research on Teacher Learning, College of Education, Michigan State University, 1989).

17. Examples can be found in Deborah Loewenberg Ball, "The subject matter preparation of prospective mathematics teachers: Challenging the myths." (East Lansing: National Center for Research on Teacher Learning, College of Education, Michigan State University, 1988); Suzanne Wilson, "Understanding historical understanding: Subject matter knowledge and the teaching of history." Doctoral dissertation, Stanford University, 1988; Dianne Holt-Reynolds and G. Williamson McDiarmid, "How do prospective teachers think about literature and the teaching of literature?" (East Lansing: National Center for Research on Teacher Learning, College of Education, Michigan State University, 1994).

18. J. S. Krajcik, J. W. Layman, M. L. Starr, and S. Magnusson, "The development of middle school teachers' content knowledge and pedagogical content knowledge of heat energy and temperature." Paper presented at the annual meeting of the American Educational Research Association, Chicago, April 1991; M. A. Simon, "Towards a constructivist perspective: An intervention study of mathematics teacher development." *Educational Studies in Mathematics* 22 (1991): 309-331.

19. See, for example, Suzanne Wilson, Steve Mattson, and Sarah Theule-Lubienski, "Challenges of multiple commitments: The case of the California Mathematics Project." Presentation at the annual meeting of the American Educational Research Association, New York, April 1996.

20. Richard F. Elmore, Penelope Peterson, and Sarah J. McCarthey. *Restructuring in the classroom: Teaching, learning, and school organization* (San Francisco: Jossey-Bass, 1995).

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22. Margaret E. Goertz, Robert E. Floden, and Jennifer O'Day, "Studies of education reform: Systemic reform. Volume II: Case studies." (New Brunswick, NJ: Consortium for Policy Research in Education, Rutgers University, 1995), 118.