BRIDGING PRACTICES
INTERTWINING CONTENT AND PEDAGOGY IN TEACHING AND LEARNING TO TEACH

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Subject matter and pedagogy have been peculiarly and persistently divided in the conceptualization and curriculum of teacher education and learning to teach. This fragmentation of practice leaves teachers on their own with the challenge of integrating subject matter knowledge and pedagogy in the contexts of their work. Yet, being able to do this is fundamental to engaging in the core tasks of teaching, and it is critical to being able to teach all students well. This article proposes three problems that would have to be solved to bridge this gap and to prepare teachers who not only know content but can make use of it to help all students learn. The first problem concerns identifying the content knowledge that matters for teaching, the second regards understanding how such knowledge needs to be held, and the third centers on what it takes to learn to use such knowledge in practice.

At the turn of the 20th century, John Dewey (1904/1964) articulated a fundamental tension in the preparation of teachers: that of the "proper relationship" of theory and practice. At the turn of the 21st century, this tension endures. In fact, many of the same questions persist: On one hand, to what extent does teaching and learning to teach depend on the development of theoretical knowledge and knowledge of subject matter? On the other hand, to what extent does it rely on the development of pedagogical method?

Clearly, the answer must be that it depends on both. Yet, across the century, this tension has continued to simmer, with strong views on both sides of what is unfortunately often seen as a dichotomy. Policy makers debate whether teachers should major in education or in a discipline. Others argue that what matters is caring for students and having the skills to work effectively with diverse learners. Dewey's (1904/1964) conception of the relationship of subject matter knowledge and method was sophisticated and subtle, so much so that 100 years later, his idea is still elusive. He wrote, "Scholastic knowledge is sometimes regarded as if it were something quite irrelevant to method. When this attitude is even unconsciously assumed, method becomes an external attachment to knowledge of subject matter" (p. 160).

Dewey (1904/1964) believed that good teachers were those who could recognize and create "genuine intellectual activity" in students, and he argued that methods of such activity were intimately tied into disciplines. Subjects, he believed, were the embodiments of the mind, the product of human curiosity, inquiry, and the search for truth. A mind "which is habituated to viewing subject-matter from the standpoint of the function of that subject matter in connection with the mental signs of intellectual activity when exhibited in the child of four, or the youth of sixteen" would, in his view, be prepared to hear and extend students' thinking. To do this, teachers would need to be able to study subject matter in ways that took it back to its "psychical roots" (p. 162).

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Despite these prescient ideas, teacher education throughout the 20th century has consistently been structured across a persistent divide between subject matter and pedagogy. This divide has many faces. Sometimes it appears in institutional structures as the chasm between the arts and sciences and schools of education, or as the divide between universities and schools (Lagemann, 1996). Sometimes the divide appears in the prevailing curriculum of teacher education, separated into domains of knowledge: educational psychology, sociology of education, foundations, methods of teaching, and the academic disciplines corresponding to school subjects. These knowledge chunks are complemented by experience: supervised practice, student teaching, and practice itself. In all of these, the gap between theory and practice fragments teacher education by fragmenting teaching.

In recent years, in yet another peculiar fragmentation, commitments to equity and concerns for diversity have often been seen as in tension with concerns for content preparation. Yet, understanding subject matter is essential to listening flexibly to others and hearing what they are saying or where they might be heading. Knowing content is also crucial to being inventive in creating worthwhile opportunities for learning that take learners' experiences, interests, and needs into account. Contending effectively with the resources and challenges of a diverse classroom requires a kind of responsibility to subject matter, without which, efforts to be responsive may distort students' opportunities to learn (Ball, 1995). Moreover, the creativity entailed in designing instruction in ways that are attentive to difference requires substantial proficiency with the material. The overarching problem across these many examples is that the prevalent conceptualization and organization of teachers' learning tends to fragment practice and leave to individual teachers the challenge of integrating subject matter knowledge and pedagogy in the contexts of their work. We assume that the integration required to teach is simple and happens in the course of experience. In fact, however, this does not happen easily, and often does not happen at all.

A closer look at a sliver of the work of teaching serves to remind us of its demands. Consider a teacher examining and preparing to teach the following deceptively simple math problem (Gelfand & Shen, 1993),

> Write down a string of 8's. Insert some plus signs at various places so that the resulting sum is 1,000.

At first glance, this task may look trivial and uninteresting. One way of solving it entails simply adding 125 8's together. A closer look reveals that if several 8's are written together (i.e., 888 or 88), many more solutions are possible. Working on the problem a little further reveals interesting and provocative patterns in the solution set. Figuring out how to organize the solutions is itself an interesting component of the work; depending on how they are organized, different elements of the problem and its solutions are visible.

The teacher must contemplate: Would this be a good task for my students? What would it take to figure out the patterns and nuances? Is it worthwhile in terms of what students might learn? At the very least, it would be important to know what the problem is asking, whether it has one or many solutions, and how the solutions might be found. It seems obvious that the task entails some computation, for example, verifying any one solution, but what is the mathematical potential of the task? Are there important ideas or processes involved in the problem? What would it take to use this task well with students? It would help to know what might make the problem hard, and how kids might get stuck, and anticipate what the teacher might do if they did. Would students find this interesting? What might it take to hook them on it?

Perhaps, after looking at this problem, the teacher decides that it is interesting, but a little too difficult for her students. What would it take to make a mathematically similar problem that is a bit easier? At what grade levels would some mathematically equivalent but simpler version of this problem be accessible? How might one rescale the problem, for example, for third graders? First graders? Suppose, in contrast, that the teacher worries that this problem is too easy. What would it take to make a more challenging,

but again, mathematically similar task? What happens to the problem if one replaces 1,000 with other numbers or 8 with some other digit? How might one modify the problem so that there are no solutions or infinitely many solutions? Would this be fruitful?

This sort of analysis and preparation of a single math problem reveals how much core tasks of teaching involve significant mathematical reasoning in the context of practice. And these represent only a fraction of the work that a teacher would do to make productive use of this problem with students. When the teacher collects students' work and peruses it, the teacher may grade it, determine where her students are, or decide whether to go further. When teachers hold class discussions, they make decisions about which (and whose) ideas to pick up and pursue and which (and whose) to let drop. The teacher formulates probes, pushes students, offers hints, and provides explanations. Students get stuck: What does one do to help them remobilize? None of these tasks of teaching is possible to do generically. No matter how committed one is to caring for students, to taking students' ideas seriously, to helping students develop robust understandings, none of these tasks of teaching is possible without making use in context of mathematical understanding and insight.

Herein lies a fundamental difficulty in learning to teach, for despite its centrality, usable content knowledge is not something teacher education, in the main, provides effectively. Although some teachers have important understandings of the content, they often do not know it in ways that help them hear students, select good tasks, or help all their students learn. Not being able to do this undermines and makes hollow the efforts to prepare high-quality teachers who can reach all students, teach in multicultural settings, and work in environments that make teaching and learning difficult. Despite frequently heard exhortations to teach all students, many teachers are unable to hear students flexibly, represent ideas in multiple ways, connect content to contexts effectively, and think about things in ways other than their own. For example, in their study of a middle school teacher's attempt to teach the concept of rate, Thompson and Thompson (1994) highlight the crucial role played by language. They vividly describe the situation of one teacher who, although he understood the concept of rate himself, was restricted in his capacity to express or discuss the ideas in everyday language. Satisfied with computational language for his own purposes, when these did not help students understand, he was not able to find other means of expressing key ideas. In addition, teachers may not be able to size up their textbooks and adapt them effectively; they may omit topics central to students' futures or make modifications that distort key ideas. They may substitute student interest for content integrity in making choices about subject matter. Knowing subject matter and being able to use it is at the heart of teaching all students.

A recent analysis provides a glimpse of the importance of the distinction between knowing how to do math and knowing it in ways that enable its use in practice. This distinction is key to understanding how mathematics knowledge matters in good teaching. In general, astonishingly little empirical evidence exists to link teachers' content knowledge to their students' learning. One hypothesis has been that what is being measured as "content knowledge" (often teachers' course attainment) is a poor proxy for subject matter understanding. However, in an article describing their analysis of data from the National Education Longitudinal Study of 1988, Rowan, Chiang, and Miller (1997) report strong positive correlations between teachers' responses to items designed to measure the use of mathematical knowledge in teaching and their students' performance (see Kennedy, Ball, & McDiarmid, 1993).[1] This analysis provides some confirmation that understanding the use of mathematics in the work of teaching is a critical area ripe for further examination. It is not just what mathematics teachers know, but how they know it and what they are able to mobilize mathematically in the course of teaching.[2]

An important challenge for teacher education at the turn of the 21st century is to bridge the chasm identified by Dewey (1904/1964) almost 100 years ago. Our schools are more

diverse than ever, and we ask more of both teachers and students. Finding ways to integrate knowledge and practice is essential if we are to help teachers develop the resources they need for their work. This is a call to preservice teacher education, where academic studies dominate, as well as to professional development, where opportunities to study content are far more rare (Wilson, Theule-Lubienski, & Mattson, 1996). In neither setting is this divide being closed. What would it take to bring the study of content closer to practice and to prepare teachers to know and be able to use subject matter knowledge effectively in their work as teachers?

Three problems stand out, problems that we must solve if we are to meet this challenge to prepare teachers who not only know content but can make use of it to help all students learn. The first problem concerns identifying the content knowledge that matters for teaching, the second regards understanding how such knowledge needs to be held, and the third centers on what it takes to learn to use such knowledge in practice.

First, we would need to reexamine what content knowledge matters for good teaching. Subject matter knowledge for teaching has too often been defined by the subject matter knowledge that students are to learn. Put simply, many assume that what teachers need to know is what they teach, along with a broad perspective on where their students are heading. Nothing is inherently wrong with this perspective. However, the lists of what teachers should know that are produced by analyzing the school curriculum are long as well as arbitrary and unsubstantiated. Little is known about how "knowing" the topics on these lists affects teachers' capabilities. The unexamined conviction that possessing such knowledge is what teachers need to know has blocked the inquiry needed to bring together subject matter and practice in ways that would enable teacher education to be more effective.

Instead of beginning solely with the curriculum, our understanding of the content knowledge needed in teaching must start with practice. We must understand better the work that teachers do and analyze the role played by content knowledge in that work. What are the recurrent core task domains of teachers' work? For example, the teacher examining the 8's problem would have to probe the task, consider how it might be done by particular students, decide how difficult it might be, and perhaps rescale it to make an easier or more challenging version. In teaching it, the teacher would have to listen carefully to what students said, interpret what they meant, ask them questions, give hints, and observe.

To improve our sense of what content knowledge matters in teaching, we would need to identify core activities of teaching, such as figuring out what students know; choosing and managing representations of ideas; appraising, selecting, and modifying textbooks; and deciding among alternative courses of action, and analyze the subject matter knowledge and insight entailed in these activities. This approach, a kind of job analysis of classroom teaching focused on the actual work that teachers do, could provide a view of subject matter as it is used in practice.

Turning the usual approach on its head, this approach would uncover what teachers need to know and what they need to be sensitive to regarding content to teach well. This kind of analysis may bring some surprises. For example, in our recent work with Bass on mathematics teaching (Ball & Bass, in press), we expected to see that concepts such as place value and decimal notation would be central, and they have been, as have operations and methods of reasoning. However, beyond that, we have been struck by the unanticipated but recurrent prominence of certain mathematical notions. For instance, we have found that ideas about equivalence, similarity, and even isomorphism emerge across many instances of ordinary and extraordinary teaching and learning. We have also uncovered salient issues involving mathematical language: symbolic notation, mapping among representations, and definitions of terms. Similarly new notions are emerging from parallel work in the teaching and learning of history and science (Rose, 1999; Wilson, in press). Inquiries that begin with practice are

revealing subject matter demands of teachers' work that are not seen when we begin with lists of content to be taught derived from the school curriculum. These content demands emerge from analyzing the sorts of challenges with which teachers must contend in the course of practice, as they mediate students' ideas, make choices about representations of content, modify curriculum materials, and the like.

A second problem we would have to solve concerns the assumption that someone who knows content for himself or herself is able to use that knowledge in teaching. This is the problem of how subject matter must be understood to be usable in teaching. Simply increasing teachers' opportunities to study mathematics, English, history, or physics—one easy response—will be insufficient to impact their capacities as teachers. We need to probe not only what teachers need to know but also what sort of content understanding and insight matters in practice.

Viewed from the perspective of practice and the actual work of teaching, at least two aspects seem central. First is the capacity to deconstruct one's own knowledge into a less polished and final form, where critical components are accessible and visible. This feature of teaching means that paradoxically, expert personal knowledge of subject matter is often ironically inadequate for teaching. Because teachers must be able to work with content for students in its growing, unfinished state, they must be able to do something perverse: work backward from mature and compressed understanding of the content to unpack its constituent elements (Cohen, in preparation). Knowing for teaching requires a transcendence of the tacit understanding that characterizes and is sufficient for personal knowledge and performance (Polanyi, 1958). Understanding why a 6-year-old might write "1005" for "one hundred five," and not reading it as a mistaken count, "one thousand five," requires the capacity to appreciate the elegance of the compressed notation system that adults use readily for numbers but which is not automatic for learners. After all, Roman numerals follow precisely the same structure as the young child's inclination, each element with its own notation, CV for "one hundred five," without the place-value core of our system. Being able to see and hear from someone else's perspective, to make sense of a student's apparent error or appreciate a student's unconventionally expressed insight requires this special capacity to unpack one's own highly compressed understandings that are the hallmark of expert knowledge. Even producing a comprehensible explanation depends on this capacity to unpack one's own knowledge, because an explanation works only if it is at a sufficient level of granularity, that is, if it includes in it the steps necessary for the reasoning to make sense for a particular learner or a whole class, based on what they currently know or do not know (Bass & Ball, in press).

Another aspect of being able to use the knowledge one has is the special sort of knowledge that Shulman and his colleagues (Shulman, 1986, 1987; Wilson, Shulman, & Richert, 1987) called "pedagogical content knowledge:" a special amalgam of knowledge that links content and pedagogy. Included here is knowledge of what is typically difficult for students, of representations that are most useful for teaching a specific idea or procedure, and of ways to develop a particular idea, for example, the ordering of decimals or interpreting poetry. What are the advantages and disadvantages of particular metaphors or analogies? Where might they distort the subject matter? For example, both "take away" and "borrowing" create problems for students' understanding of subtraction. These problems cannot be discerned generically because they require a careful mapping of the metaphor against core aspects of the concept being learned and against how learners interpret the metaphor. Knowing that subtraction is a particularly difficult idea for students to master is not something that can be seen from knowing the "big ideas" of the discipline. This kind of knowledge is not something a mathematician would necessarily have, but neither would it be familiar to a high school social studies teacher. It is quite clearly mathematical, yet formulated around the need to make ideas accessible to others. Pedagogical content knowledge highlights the interplay of mathematics and pedagogy in teaching. Rooted in

content knowledge, it comprises more than understanding the content oneself.

These two aspects of content knowledge help to illuminate the territory to which Dewey (1904/1964) called attention almost a century ago, bridging the divide between content and pedagogy. However, they do not sufficiently illumine where and how such knowledge is used in teaching. Teaching is a practice. It is, in Lampert's (1998) terms, "a thinking practice"; that is, it integrates reasoning and knowing with action. Our tendency to focus either on its cognitive demands (teachers' knowledge, reasoning, decision making, reflection) or on its actions (teacher behavior) is yet one more recent form of fragmentation in teacher education, and in particular, in our efforts to help teachers acquire usable content knowledge.

Hence, a third problem we would have to solve is how to create opportunities for learning subject matter that would enable teachers not only to know but to learn to use what they know in the varied contexts of practice. Even with more grounded analyses of what there is to know and a more finely tuned conception of the nature of the understanding needed to teach, simply teaching such content may not solve the problems of use. How do teachers use content understanding in the context of practice to carry out the core activities of their work? How can we design opportunities for learning that are aimed at helping teachers use subject matter knowledge to figure out what their students know, to pose questions, to evaluate and modify their textbooks wisely, to design instructional tasks, to manage class discussions, and to explain the curriculum to parents?

Some such work along these lines is already underway. One promising possibility is to design and explore opportunities to learn content that are situated in the contexts in which subject matter is used, a core activity of teaching. For example, some teacher educators use student work as a site to analyze and interpret what students know and are learning and, in so doing, work on the content itself.[3] Another example is the use of videotaping classroom lessons or cases of classroom episodes (Lampert & Ball, 1998; Stein, Smith, Henningsen, & Silver, 2000), from which, the moves made by the teacher could be analyzed to consider the impact on the course of the lesson, the trajectory of the class's work, and the opportunities for learning for particular students and for the group. In both instances (using student work or using videotapes or cases of classroom lessons), teachers or prospective teachers might engage in content-based design work, developing a possible next assignment in response to their analysis of students' work, or planning a next instructional segment based on analysis of the classroom episode. Each of these activities take a task of teaching that entails content knowledge and creates a possible site for teachers' learning of content in the contexts where they will have to use it.

However, much more work is needed to contend with this endemic problem of use. Working in specific contexts might run the risk of limiting the generality of teachers' learning of content and their capacity to use it in a variety of contexts. How can teachers be prepared to sufficiently know content flexibly so that they are able to make use of content knowledge with a wide variety of students across a wide range of environments? How could teachers develop a sense of the trajectory of a topic over time or how to develop its intellectual core in students' minds and capacities so that they eventually reach mature and compressed understandings and skills?

Solving these three problems—what teachers need to know, how they have to know it, and helping them learn to use it, by grounding the problem of teachers' content preparation in practice—could help to close the gaps that have plagued progress in teacher education. However, we should realize the challenges that doing this would pose. After all, Dewey (1904/1964) thought his vision at the turn of the 20th century was imminently realizable. He thought that what he was describing was "nothing utopian." He suggested that "the present movement... for the improvement of range and quality of subject matter is steady and irresistible" (p. 170). Almost 100 years later, as we stare at university and college catalogs that divide methods courses from disciplinary studies from practice, or at professional development offerings that are devoid of content or chock full of

activities for kids, we should understand that bridging these strangely divided practices will be no small feat.

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NOTES

1. These items were developed at the National Center for Research on Teacher Learning, Michigan State University.
2. These ideas about the use of mathematics knowledge in teaching draw from my work with both David K. Cohen and Hyman Bass. See, for example, Cohen and Ball (1999) and Ball and Bass (in press).
3. Several professional development curricula are built on this idea. See, for example, Schifter (1998) and Barnett (1998).

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