A Knowledge Base for the Teaching Profession: What Would It Look Like and How Can We Get One?

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To improve classroom teaching in a steady, lasting way, the teaching profession needs a knowledge base that grows and improves. In spite of the continuing efforts of researchers, archived research knowledge has had little effect on the improvement of practice in the average classroom. We explore the possibility of building a useful knowledge base for teaching by beginning with practitioners' knowledge. We outline key features of this knowledge and identify the requirements for this knowledge to be transformed into a professional knowledge base for teaching. By reviewing educational history, we offer an incomplete explanation for why the United States has no countrywide system that meets these requirements. We conclude by wondering if U.S. researchers and teachers can make different choices in the future to enable a system for building and sustaining a professional knowledge base for teaching.

Improving classroom teaching is receiving renewed attention as the nation searches for ways to increase students' learning (Lampert, 2001; National Commission on Mathematics and Science Teaching for the 21st Century, 2000; National Commission on Teaching and America's Future, 1996; Stigler & Hiebert, 1999). One result of the new focus on teaching has been a stronger emphasis on providing teachers with opportunities for high quality professional development.

There is a growing consensus that professional development yields the best results when it is long-term, school-based, collaborative, focused on students' learning, and linked to curricula (Darling-Hammond & Sykes, 1999; Garet, Porter, Desimone, Birman, & Yoon, 2001; Joyce, Wolf, & Calhoun, 1993; Loucks-Horsley, Hewson, Love, & Stiles, 1998; National Staff Development Council, 2001). In such programs, teachers examine student work, develop performance assessments and standards-based report cards, and jointly plan, teach, and revise lessons. Teachers, who traditionally have worked in isolation, report favorably on programs that bring them in close contact with colleagues in active work on improving practice (Garet et al., 2001).

However, as teachers collaborate to improve education, an old problem is revealed in a new light. Teachers rarely draw from a shared knowledge base to improve their practice. They do not routinely locate and translate research-based knowledge to inform their efforts (Grimmett & MacKinnon, 1992; Huberman, 1989; Richardson & Placier, 2001). As teachers begin to examine their students' learning of the curriculum, for example, they rarely search the research archives to help them interpret their students' conceptions and misconceptions, plot their students' learning trajectories, or devise alternative teaching practices that are more effective in helping their students master the curriculum. Although special programs have demonstrated that, with carefully designed support, teachers can use specific research information for improving their practice (Carpenter, Fennema, Franke, Levi, & Empson, 1999), there is a persistent concern that educational research has too little influence on improving classroom teaching and learning (National Educational Research Policies and Priorities Board, 1999).

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Efforts to broaden the impact of research for teachers have taken a variety of forms, including government produced summaries of "what works" in the classroom, interpretations of research for schools and districts wishing to improve, and prescriptions for effective teaching (Berliner & Casanova, 1993; Joyce et al., 1993; Rosenshine, 1986; U.S. Department of Education, 1987). Helpful as some of these efforts have been, educators recognize that translating research into forms useful for teachers is a continuing, stubborn problem (Huberman, 1985; Lagemann, 1996; Kennedy, 1999; Raths & McAninch, 1999; Shavelson, 1988).

A variety of proposals have been advanced to solve the translation problem. Some exhort researchers to find new and more innovative ways to represent their knowledge; others focus on better ways to engage teachers in the adaptation of research knowledge for their classrooms (Anderson & Biddle, 1991; National Research Council, 1999). Variations on this approach include Willinsky's (2001) suggestion to provide the public, including teachers, with easier direct access to research, for example, through Internet technologies.

Most approaches for bringing research to teachers assume that researchers' knowledge is the best foundation upon which to build a professional knowledge base because of its generalizable and trustworthy (scientific) character. A significant alternative view claims that the knowledge teachers use is of a very different kind than usually produced by educational researchers (Cochran-Smith & Lytle, 1990, 1993; Doyle, 1997; Eisner, 1995; Huberman, 1985; Kennedy, 1999; Leinhardt, 1990). Called "craft" knowledge by some, it is characterized more by its concreteness and contextual richness than its generalizability and context independence. From this point of view, bridging the gap between traditional research knowledge and teachers' practice is an inherently difficult, perhaps intractable, problem.

In this article, we recognize the inherent difficulties of translating traditional research knowledge into forms teachers can use to improve their practice, and we recognize the value of teachers' craft knowledge. We now ask whether it is possible to build this personal craft knowledge into a trustworthy knowledge base that can be accessed and shared widely in the profession. Is there a road that could lead from teachers' classrooms to a shared, reliable, professional knowledge base for teaching? This pathway, already explored by some (Clark, 2001; Hargreaves, 1998; Munby, Russell, & Martin, 2001; Olson & Bruner, 1996; Richardson, 1994), still can be viewed skeptically because practitioners' knowledge is highly personal and, under current conditions, lacks the public vetting of researchers' knowledge. But, given its origins in practice and the fact that everyday millions of teachers produce knowledge of teaching, it is worth examining what would be needed to transform teachers' knowledge into a professional knowledge base for teaching. What would the road look like?

We begin by taking a closer look at practitioner knowledge—the kinds of knowledge practitioners generate through active participation and reflection on their own practice. We examine two cases that illustrate the personal, unshared knowledge that many teachers acquire to improve their practice. We continue by identifying several characteristics that this practitioner knowledge must take on for it to become a professional knowledge base for teaching. In brief, we propose that professional knowledge must be public, it must be represented in a form that enables it to be accumulated and shared with other members of the profession, and it must be continually verified and improved.

We then address the issue of how practitioner knowledge can be transformed into a knowledge base for teaching by considering a research and development system, outside of the United States, that generates, accumulates, and shares knowledge for teaching. We argue that such a system is not alien to the United States, either in principle or in practice, for at least two reasons. First, this system builds on key features of the new kinds of professional development that are being recommended and implemented in the United States. Second, the processes the system requires are already in place in many local sites and are being deployed by various innovative movements and programs. But why are these just local phenomena in the United States, rather than a national system? We relate a story from American educational history that explains, in part, why the United States moved toward a different system in the last century and why the system we envision is not a part of American educational culture. We conclude by wondering if U.S. educators can make different choices in the future to enable a system for building and sustaining a professional knowledge base for teaching.

Practitioner Knowledge: Two Examples

Teachers are not always learning. Often it takes all of their energy just to get through the day. But all teachers learn some of the time, and some teachers learn much of the time. When teachers do learn from their experience, what do they learn and how is this knowledge organized? We explore these questions by analyzing two cases of teacher learning.

A Literacy Case

Children work through hundreds of stories on their way to competent readership. Each provides a unique interpretive challenge and a multitude of ways apprentice readers can relate what is new in the text to what they already know. Providing many opportunities to relate the known to the new, to develop new ideas and understandings, is the major goal and work of reading comprehension lessons. To effectively conduct such lessons, teachers must be prepared for all combinations and permutations of children and texts—an overwhelming body of teaching knowledge.

A case in point is Grace Omura's attempt to use the familiar folk tale Billy Goats Gruff in a reading comprehension lesson (Tharp & Gallimore, 1989, chap. 10). The story is a cautionary folk tale that involves three goat brothers who are successively challenged by a wicked troll. When the youngest and smallest goat attempts to cross a bridge to reach grass on the other side of a stream, he avoids being eaten by the troll who is persuaded to wait for the next, larger brother goat. The ploy works for the second brother as well. When the third and very large brother goat crosses the bridge and is challenged, the troll discovers his greedy appetite to be a fatal flaw.

A dedicated young teacher, Grace worked with her coach, Stephanie Dalton, to make her lessons more challenging and helpful for her Native Hawaiian students by using responsive interactions that stretch student thinking about text and by reducing her use of "known-answer" questions. She and Stephanie met regularly to review videos of Grace's lessons. After watching part of a lesson video, Grace stopped the tape and noted how unhappy she was with the lesson. The problem, she believed, was the story: It is very "shallow," she said. As a result, the children often made "off the wall" comments and did not comprehend what they were reading. However, some student reactions were intriguing. To illustrate, she directed Stephanie's attention to a child on the video who suggested the troll's greediness might evoke punishment. Grace recognized that the child's comment represents an interesting reaction to the story but during the lesson she did not know how to build on it.

Stephanie realized that Grace was focusing only on students' comments that conformed to a common interpretation of Billy Goats Gruff as a cautionary tale about the consequences of greediness. Stephanie suggested there are other interpretations of the story. In fact, Stephanie pointed out, perhaps the child Grace mentioned was thinking about the context of the troll's behavior and was opening up a richer interpretation of the animal's behavior that could relate to the students' personal experiences and background knowledge:

> Stephanie: . . . it could relate to some bigger concepts in the story. In fact, [you could begin] the investigation of the character of the troll in terms of why is he acting this way. One reason may be that he is plain hungry. Another reason might be that he is [being territorial] and they are invading his place. And [there are] other things that you know about animal behavior that make them operate in certain ways. . . . [the troll] is so strong and so adamant in his position and so assured of himself and he is the guy that ends up with nothing in the end.

Stephanie suggested that Grace could draw a parallel between these animals and the experiences of the children in her group.

> Stephanie (continuing): . . . especially those from families with older children . . . where the older ones use

[the troll's] strategy [and] the younger ones come out on top.

Grace: Oh, how interesting . . .

The coaching session continued. The tape was started again. Grace and Stephanie watched a long sequence in which the students discuss what trolls really are. Are they monsters? Are they real?

Kanani: Hawaii doesn't have any trolls.

Grace: Hawaii doesn't have any trolls? Oh. Is there a real . . . are there real live trolls?

Children: No. They not. They like giants.

Grace: They're like giants?

Sheida: When the—you know, when the dinosaurs, when they alive, trolls was alive.

Grace: Oh, so dinosaurs and trolls were alive at the same time?

Kanani: Trolls and dragons.

Grace: Trolls and dragons were alive at the same time?

Tosufa: And the trolls . . .

Louise: Dragons . . . we don't have any dragons.

Grace: Do we have any trolls?

Tosufa: No. The trolls was stepping one little bit and he fell in the tar.

Grace: So let's get this straight. Are trolls like us?

The students are responding to the texts and her questions with rich ideas, but as the tape rolled Grace repeatedly noticed instances in which she did not know how to respond to what, in hindsight, seemed like rich opportunities. She stopped the tape.

Grace: Oh my God. What I am going to do with all this information. . . . I did not expect to get myself in this direction. I'm really amazed with what these kids give me. I didn't expect that much. . . . I think that's my one problem. . . . I'm not experienced enough to make the most out of the situation while I'm in it right then. [I get a lot out of watching my tapes with you] but I really need your feedback. Because there's tons I would have missed, really, without you. . . . [I'm beginning to] feel more comfortable . . . because each time I read the story I see a little bit more. Maybe I'm reading it slower and slower as I go down the line with these kids or maybe I'm [letting the children have more time for] figuring things out.

Over the next few months, Grace and Stephanie reviewed additional lesson videos allowing themselves multiple observation and replication opportunities with different stories and lessons. Grace gradually discovered the value of detailed, particular story knowledge as well as knowledge about student experiences and possible "takes" on other stories. With this knowledge and added experience, she moved closer to her goal of helping students build a deeper understanding of what they read by relating it to their experiences and knowledge.

A Mathematics Case[1]

Ms. D. is a veteran first-grade teacher working in a racially and economically diverse school in the upper Midwest. She always has been a good teacher, with a certain charisma, but never had studied teaching in a detailed or systematic way. One summer she enrolled in a workshop offered by the developers of Cognitively Guided Instruction (CGI) (Carpenter et al., 1999). The workshop was on children's methods for solving addition and subtraction problems.

"What can I learn about adding and subtracting?" wondered Ms. D. "It's pretty easy to teach. I just have the children do some counting activities and then show them how to add and subtract on simple problems, like $1 + 2 = \_\_$ and $3 - 1 = \_\_$. After that, it's mostly a matter of practice." She was surprised to learn that addition and subtraction are quite complex, especially if you look at them through children's eyes. She found that many children learn to add and subtract by counting in increasingly sophisticated ways. More than that, she learned there are a variety of addition and subtraction problems and the methods children use depend, in part, on the kind of problem they are solving.

Ms. D. learned all of this information well, but what distinguished her from some of the other teachers in the workshop was that Ms. D. became very curious about how her students would solve different kinds of addition and subtraction problems and what mathematical relationships she could help her students construct as they thought about the strategies they were using. Over the next few years, Ms. D. studied her students intensively. She posed problems like those presented during the workshop and observed how her students solved them. She became interested in the details of their solution strategies.

One day early in the year Ms. D. posed the following problem to her first graders: "Jenny had 4 pieces of gum and Esther had 7 pieces of gum. How many pieces did they have together?" After students had worked a few minutes, the class discussed what they found.

Ms. D.: Luis, how did you solve that problem?

Luis: I counted the blocks.

Ms. D.: But how did you count them?

Luis: I counted Jenny's pieces 1, 2, 3, 4 and then I counted the other girl's 5, 6, 7, 8, 9, 10, 11.

Ms. D.: Thanks, Luis. Sarah, how did you do it?

Sarah: I counted in my head.

Ms. D.: OK. Do you remember what numbers you said?

Sarah: I started at 5 and said 5, 6, 7, 8, 9, 10, 11.

Ms. D.: How did you know to stop at 11?

Sarah: I don't know. I guess I just counted seven times and stopped.

Ms. D.: How did you keep track that you counted seven times?

Sarah: I don't know.

Ms. D: Did anyone else do it Sarah's way? I'm trying to figure out how she kept track of seven when she was counting.

Juan: I did it like that. Sometimes I keep track on my fingers and sometimes I just keep track in my head.

Ms. D.: OK. I'm going to keep thinking about that. Did anyone else do it a different way?

Rasheed: I started at 8 and went 8, 9, 10, 11.

Mira: I knew that 4 and 6 was 10 so 4 and 7 would be 11.

As she watched her students solve simple addition and subtraction problems, listened to their descriptions, and discussed what she was hearing with her colleagues, Ms. D began learning a good deal about how her students solved these problems. She learned that many of her students moved through a progression of methods for solving the same kind of problem. For addition problems, the progression looked much like the sequence of methods presented by students in the classroom episode presented above.

Ms. D. learned that the methods themselves contained important properties of numbers and operations. For example, the fact that Sarah's method and Rasheed's method both produced the correct answer was an early encounter with commutativity, a form of this property that Ms. D. had not thought of before. The question of whether this would always work became a rich question for students to explore. Mira's method contained a decomposition and recomposition of numbers that Ms. D. began to recognize as an essential character of numbers, especially as students began adding and subtracting two- and three-digit numbers.

From Practitioner Knowledge to Professional Knowledge

What do these cases have in common? And what more would be needed to constitute a professional knowledge base for teaching? In this section we note the features of practitioner knowledge, then propose what more is needed to create a professional knowledge base.

Features of Practitioner Knowledge

Practitioner knowledge, of the type represented in the two cases, has both strengths and weaknesses. As Olson and Bruner (1996) note, it has been common to focus on the limitations of practitioner knowledge but, as we alluded to earlier, there is a growing awareness of the richness of this knowledge (Clandinin & Connelly, 1991; Cochran-Smith & Lytle, 1993; Doyle, 1997; Elbaz, 1991; Leinhardt, 1990; Schon, 1983). We begin by identifying three features that make practitioner knowledge useful and valuable for teachers.

Practitioner Knowledge Is Linked With Practice

Practitioner knowledge is useful for practice precisely because it develops in response to specific problems of practice. Grace, for example, was motivated by a problem: Her comprehension lessons, she observed, did not engage her students in sufficiently deep analysis of the Billy Goats Gruff story. The knowledge she developed as she worked to make progress on this problem is directly usable by other teachers if they are trying to use the same story in the same way. Grace's knowledge can be applied directly, without translation, albeit to a restricted number of situations.

In addition to addressing problems of practice, knowledge linked with practice is grounded in the context in which teachers work. The processes that yield knowledge of this sort are collaborative and involve teachers in the following activities:

- Elaborating the problem and developing a shared language for describing the problem,
- Analyzing classroom practice in light of the problem,
- Envisioning alternatives, or hypothesizing solutions to the problem,
- Testing alternatives in the classroom, and reflecting on their effects, and
- Recording what is learned in a way that is shareable with other practitioners.

By engaging in this work, teachers create knowledge that is linked to practice in two ways: first, its creation is motivated by problems of practice; and second, each new bit of knowledge is connected to the processes of teaching and learning that actually occur in classrooms.

Practitioner Knowledge Is Detailed, Concrete, and Specific

A consequence of generating knowledge linked with practice is that it is detailed, concrete, and specific. Although Grace's knowledge might apply to teaching comprehension more generally, it is directly related to, and instantiated by, the teaching of Billy Goats Gruff. It is important to note that this differs from the knowledge typically produced by researchers—knowledge that is more abstract because it is designed to apply to a wider variety of potential problems.

Some might see the concreteness and specificity as a negative feature of practitioner knowledge. What if other teachers do not use the story Billy Goats Gruff; does that mean they have nothing to learn from Grace? Yes and no. It depends on what they need to learn. For now, we simply make the point that if other teachers do use Billy Goats Gruff, the kind of information they can get from Grace is exactly what they need to improve their teaching of this story.

Practitioner Knowledge Is Integrated

Another characteristic of knowledge that is linked with practice is that it is integrated and organized around problems of practice. Whereas researchers often are interested in making distinctions among types of knowledge, practitioners often are interested in making connections. Researchers have identified many kinds of teacher knowledge—content knowledge, pedagogical knowledge, and pedagogical content knowledge (Shulman, 1986). There also is knowledge of students—what they know and how they learn. In practitioner knowledge, all of these types of knowledge are intertwined, organized not according to type but according to the problem the knowledge is intended to address. Although it might be possible to analyze Grace's knowledge deficiency as one of content knowledge or knowledge of what students think on first reading of Billy Goats Gruff, it is not helpful to do so if the goal is to improve the teaching of Billy Goats Gruff. Knowledge types traditionally separated must be tightly integrated to teach Billy Goats Gruff more effectively.

Additional Requirements for Practitioner Knowledge to Become Professional Knowledge

Our description of practitioner knowledge is intended to highlight the uniquely positive features of such knowledge. However, as we already noted, there are shortcomings to practitioner knowledge that have prevented it from becoming a knowledge base for the teaching profession. In this section we discuss what is missing from practitioner knowledge; later we will discuss how these limitations might be addressed to enable the construction of a knowledge base for teaching.

Professional Knowledge Must Be Public

Karl Popper (1972), the philosopher and historian of science, described three worlds of knowledge: World 1, knowledge of physical and real-world objects and experiences; World 2, individuals' knowledge and skills; and World 3, shared ideas treatable as public objects that can be stored and accumulated.[2] Mostly, American teachers live in Popper's Worlds 1 and 2. They interact with their students and the curriculum in World 1, and they create knowledge for themselves in World 2. But building a profession's knowledge for teaching requires that teachers live in World 3 as well. They must operate in a system that allows them to treat ideas for teaching as objects that can be shared and examined publicly, that can be stored and accumulated and passed along to the next generation (Snow, 2001).

[Teachers] must operate in a system that allows them to treat ideas for teaching as objects that can be shared and examined publicly . . .

For knowledge to be public it must be represented in such a way that it can be communicated among colleagues. Collaboration—a process considered central to successful professional development programs—ensures that what is discovered will be communicable because it is discovered in the context of group discussion. Collaboration, then, becomes essential for the development of professional knowledge, not because collaborations provide teachers with social support groups but because collaborations force their participants to make their knowledge public and understood by colleagues. The insights Ms. D. acquired about her own students, regardless of how powerful, will not contribute to the profession's knowledge until they are made public and examined by others. In a sense, what Grace learned was public because she shared it with Stephanie; they both could describe and understand what they were learning. But professional knowledge must also be public in a more expanded sense: It must be created with the *intent* of public examination, with the goal of making it shareable among teachers, open for discussion, verification, and refutation or modification.

Professional Knowledge Must Be Storable and Shareable

Even public knowledge will wither if there is no means of accumulating and sharing it with others. Practitioner knowledge exists in a particular time and place. Its life might be extended briefly as it is shared locally with a small number of colleagues. But this is not sufficient to create the foundation of a professional knowledge base. Teachers must have a means of storing knowledge in a form that it can be accessed and used by others if it is to take on a life of its own and exist in Popper's World 3.

Other professions have created ways to accumulate and share knowledge. In medicine there is a case literature; a physician can read the latest reports from other physicians who have tried and refined new ways of treating specific illnesses. Lawyers have the case law; they can follow the interpretations of laws as they evolve through court decisions. Teaching, unfortunately, has yet to develop a professional knowledge system. Think of Grace. The story of Grace and Stephanie was published, making it rare indeed. Yet it still was not widely available to other practitioners. In thinking about the accumulation and sharing of knowledge for teaching, we are left with a number of questions: How can knowledge of teaching be represented so that others can understand it? What is the best medium for storing this knowledge? And, how can it be indexed so that other practitioners can find what they need?

Representing professional knowledge. In general, knowledge for teaching is most useful when it is represented through *theories with examples.* Theories offer abstract knowledge that transcend particular classrooms and contexts and ensure that the knowledge rises above idiosyncratic technique. In this sense, theories are a hallmark of professional knowledge (Yinger, 1999). Examples, on the other hand, keep the theories grounded in practice and reveal the meaning of verbal propositions. Although teachers readily can provide examples, it is not obvious that they can transform their classroom-based knowledge into theories of teaching.

What is required to construct theories of teaching? We propose that useful theories, in this context, are teachers' hypotheses or predictions regarding the relationships between classroom practices and students' learning, along with explanations for observed connections. Why was this instructional activity created to support this kind of learning? In what way was students' thinking expected to change over the course of the lesson, and why did such change (not) occur? These hypotheses or rationales begin transforming knowledge gained in one classroom into a form that can help other teachers think about how this practice might work in their contexts. Local hypotheses gradually develop into theories that can be tested and refined across a range of contexts.

Researchers' knowledge of teaching, in contrast to teachers' knowledge, traditionally has been generated with the intent of building abstract, propositional knowledge. A common approach has been to isolate a few features of teaching and study their effects on students' learning over a range of contexts (Brophy & Good, 1986). The promise of this and other research approaches is that the knowledge rises above particular classrooms but, as we noted earlier, translating the knowledge into a useful form for teachers has been an enduring problem.

The central question becomes, then, how can teachers represent the knowledge they acquire in a more principled and abstract form than in the past, while retaining its practical character? A key enabling condition is to identify a unit of analysis and improvement that allows teachers to simplify teaching for study. Teaching is such a complex activity that it must be parsed in some way to study it and to share what is learned. Isolating features of teaching, as has been common in the research community, is not an option. Teachers usually do not have the resources to conduct controlled studies across classrooms. More than that, the knowledge produced by these studies often is not immediately useful for teachers because it is the interaction among the features of teaching, not their effects in isolation, that give teaching its meaning and character.

One possible unit of analysis is a natural one for teachers—daily lessons. In each classroom lesson, the relevant factors for students' learning are woven together—goals for students' learning, attention to students' thinking, analyses of curriculum and pedagogy, and so on. Analyzing lessons requires focusing on the interactions among the many elements that make up the flow of teaching. And lessons are small enough units that the complexity of teaching can be reduced to a manageable size. Because most teachers plan and teach through daily lessons, this way of parsing teaching also fits a familiar form that teachers can use. So, a promising approach for teachers is to develop and test hypotheses and local theories about the way in which particular lessons facilitate (and undermine) students' learning.

Why would teachers want to represent their knowledge in more generalizable forms? As teachers collaborate to assist each other in solving problems of practice, and as they mentor younger teachers, this kind of local theorizing can be useful, and even necessary. It provides a principled way to move what was learned in one context or classroom into another. Collaboration and mentoring provide settings in which representing knowledge in more general forms is genuinely beneficial.

Choosing a medium for storing professional knowledge. If teachers wish to record their knowledge for others to use, the most common medium has been words on paper. Written records preserve ideas and allow them to be accessed by others. They can be handed across time and space. With the advent of video technologies, however, the possibilities have expanded. Knowledge now can be stored in the form of observable examples that make teaching visible.

If lessons are the units for representing and storing knowledge of teaching, video technologies provide an especially useful medium. Lessons can be videotaped, digitized, indexed, and stored in a way that allows easy access and digestible size. Videos provide concrete examples of instructional practices that avoid much of the ambiguity of written descriptions. Because the U.S. educational community lacks a shared language for describing teaching, key phrases such as "problem solving" or "language experience" often mean different things to different teachers. Videotapes of lessons can illustrate concretely what a teacher has in mind.

Indexing professional knowledge. The most natural indexing framework for teachers is the curriculum. If teachers share the same curriculum and are expected to teach the same topics, the profession's knowledge can be indexed with the curriculum. From this perspective, it is clear that a shared curriculum is a key enabler for a system that supports the building of a profession's knowledge for teaching. A shared curriculum provides a compelling reason to move personal knowledge into the public world; what one teacher knows about teaching a particular topic is likely to help another teacher faced with teaching the same topic. The problems that teachers encounter and the solutions provided by the creation of new knowledge are more likely to be shared across locations and time. Teachers have a genuine interest in trying out new ideas that address problems that are real for them. And, knowledge that becomes part of the professional base can be indexed and accessed by topics that all teachers will teach.

A fact that might strike some readers as ironic is that the more detailed and specific the knowledge, the more likely it is to be retrievable. This is because specific knowledge can be linked to specific curricular topics. Returning to the example of Billy Goats Gruff, the knowledge that Grace develops about the story will be evoked each time she uses it with her class. And, if she wanted to access other teachers' insights on the story, she could search by story title through books and the Internet, join a journal group who exchange ideas about stories for young children, and so on. Similar possibilities exist for Ms. D. and her colleagues around the country who are teaching beginning addition and subtraction.

Archiving such detailed knowledge in a multimedia database that is widely and easily accessible to teachers is now possible with new and emerging technologies. Imagine large digital libraries linking video examples of teaching, images of students' work, and commentary by teachers and researchers, all integrated around shared topics, and even shared lessons—and imagine further that all those resources are linked to specific curricula a teacher is responsible to teach. Teachers faced with teaching particular topics and particular lessons could have immediate access via the Internet to a range of ideas accompanied by vivid examples of alternative practices.

Professional Knowledge Requires a Mechanism for Verification and Improvement

A final characteristic of professional knowledge is that it must be accurate, verifiable, and continually improving. There is no guarantee that the knowledge generated at local sites is correct or even useful. Teachers working together or a teacher working with his or her students might generate knowledge that turns out to undermine rather than improve teaching effectiveness. Local knowledge is immediate and concrete but almost always incomplete and sometimes blind and insular.

Consider the case of Benson Elementary School where most of the staff believed that kindergarten teachers should emphasize developmental learning and "readiness" skills (Goldenberg & Gallimore, 1991). Although the teachers felt that such an emphasis was best for children in general, most believed it was essential for their low-income, mostly Spanish-speaking students who were considered unready for literacy instruction in kindergarten. This local "readiness" theory was compounded by an overwhelming prevalence of phonic and syllable instruction in first-grade reading. As a result, children's lack of progress in first-grade reading did not challenge local theories and practices; it supported them in the eyes of Benson faculty and administrators. Because children were not "getting it" (i.e., sounds, blending, and the syllables), teachers assumed that children needed more, and more creative, instruction in sounds, blending, and the syllables. It was such a fundamental local issue with respect to children's reading achievement that the foremost, but implicit, question was, "How can we get these children to learn the syllables?" Indeed, teachers were unbelievably creative in designing games and activities intended to help children learn the syllables. But they were asking the wrong question—the real issue was not learning the syllables: It was learning to read. Exclusive reliance on local knowledge and understandings precluded introduction of outside knowledge about how best to promote literacy development (Goldenberg & Gallimore, 1991, p. 11). Changes began when new ideas and practices were introduced, producing significant gains in early grades reading achievement for the school as a whole.

How does a system designed to build a profession's knowledge for teaching deal with quality control? How does it correct the Benson cases before they influence the base of knowledge from which other teachers draw? One solution is expertise. If the Benson teachers had access to appropriate expertise, they might have tried some different approaches before moving too far down the narrow path they chose.

A second solution to quality control is continual evaluation of practices as they are shared among teachers and tested out in different local contexts. With the diversity of contexts in the United States, this becomes an essential aspect of knowledge verification and improvement. Return again to the story of Grace and Stephanie. They were learning to teach Native Hawaiian students in the Kamehameha Early Education Project (KEEP) laboratory school (Tharp & Gallimore, 1989). Although internal (Gallimore, Tharp, Sloat, Klein, & Troy, 1982) and external (Calfee et al., 1981) evaluations indicated the reading program was effective for Native Hawaiian students, there was no evidence it would work as well in other contexts. To explore that question, Vogt, Jordan, and Tharp (1987) transposed the program to Rough Rock Demonstration School on the Navajo Reservation in Arizona. By trying out the program and collecting feedback, it was found that some features of the program required modification to fit the local context and some features worked well across contexts.

Repeated observations over multiple trials can, over time, yield trustworthy knowledge. This includes knowledge of practices that must be modified to fit local contexts and practices that are effective across many contexts. Repeated observations over multiple trials is, in fact, how individual teachers have long learned to teach—by observing their own practice and revising it using students' feedback. But, to ensure improvement, the insularity of local contexts must be surmounted. Recommended practices must be tried and observed in many contexts and the results accumulated and shared over time and location.

A familiar case can be used here as an analogy to make the point. Most readers have driven through farming land and noticed signs posted next to, say, a cornfield labeling the field as a test site for a particular strain of corn. As part of the massive agricultural extension system in the United States, the results of growing this strain of corn in these conditions is fed into a huge database, reviewed and indexed by extension agents, and made available to other farmers who are hoping to improve their yields. There have been many such test fields every year during the past century. Repeated observations over multiple trials have yielded, over time, the knowledge that supports continuously improving crop yields and that turned the agricultural profession in the United States into one of the most scientifically advanced and productive in the world.[3] Although educating students is, in many ways, unlike growing corn, the image of continuously improving practice over time by accumulating and sharing relevant information is instructive.

Japanese Lesson Study: Turning Practitioner Knowledge Into Professional Knowledge

We began this article with a question: What would be required to build a professional knowledge base for teaching from practitioner knowledge rather than from researcher knowledge? We have outlined a number of characteristics that practitioner knowledge would need to acquire for such a transformation to occur. Now we want to outline a vision for a system that could support such a transformation. We will rely heavily on the example of lesson study from Japan, one of the only large-scale systems we are aware of that intentionally facilitates this kind of transformation.

Many Japanese elementary school teachers participate, throughout their careers, in a continuing in-service program built around the lesson study group (Fernandez, Chokshi, Cannon, & Yoshida, in press; Lewis & Tsuchida, 1997, 1998; Shimahara, 1998; Shimahara & Sakai, 1995; Takemura & Shimizu, 1993; Yoshida, 1999). Small groups of teachers meet regularly, once a week for several hours, to collaboratively plan, implement, evaluate, and revise lessons. Many groups focus on only a few lessons over the year with the aim of perfecting these. They begin the process of improving the targeted lessons by setting clear learning goals and then reading about what other teachers have done, what ideas are recommended by researchers and reformers, and what has been reported on students' learning of this topic. Often, they solicit university researchers to serve as consultants to their group. Researchers add perspective to the group's deliberations, bring in the experiences of other groups they have worked with, and help locate research information that refines the group's problems and hypotheses.

The teachers in the lesson study group design the lesson(s) of interest, one group member tries out the lesson(s) while the others observe and evaluate what works and what does not work, and they revise the lesson(s). Teachers often base their changes on specific misunderstandings evidenced by students as the lesson progresses. Maybe they change the wording of the opening problem, or the kinds of follow-up questions they ask, or maybe they use the information about the methods the students are likely to invent to change the order in which methods are presented during the whole-class discussion. Then, they try out the lesson(s) again, perhaps with other teachers watching. This process of repeated observations across multiple trials might go on for several months. When the replacement lessons are ready, complete with development and test information, they are shared with other teachers and other schools.

Lesson study groups generate knowledge that shares key features with practitioners' knowledge as revealed in the earlier examples. The group members work on a problem that is directly linked to their practice. For example, teachers might spend most of a 2-hour session discussing the pros and cons of a particular opening problem for the lesson. In a case described by Yoshida (1999), a lengthy discussion among first-grade teachers revolved around the best number combination to introduce subtraction across 10 (e.g., 12 – 7, 13 – 7, 11 – 6, etc.). Also, the lesson study groups typically focus on how the knowledge can be made most comprehensible by the students. Thus, in the Yoshida case, the discussion examined the methods students might use to solve each problem, recognizing that different number combinations will trigger different methods. This kind of detailed knowledge building sounds strikingly similar to that being constructed by the teachers in the earlier examples, similar even in content to that engaged by Ms. D.

Targeting very few lessons in the study process also creates the time and opportunity to generate knowledge that integrates traditionally separate components. Indeed, choosing the lesson as the unit of analysis and improvement makes this necessary. Successful lessons must attend to all of the features that work together to create significant learning opportunities for students. Teachers must know the content that will be developed, the students' knowledge as they enter the lesson and how their thinking will change over the course of the lesson, how these changes fit within the broader curriculum, what instructional moves might best facilitate the desired changes, and so on. The lesson provides a unit of practice in which the knowledge of teachers gets integrated into a useful form.

Lesson study also provides mechanisms for teachers to move squarely into Popper's World 3—developing knowledge that is intended for public discussion and examination. The process begins within the lesson study group, moves outward to include all teachers in the school, and expands to include teachers in other schools and districts as they review the materials. The knowledge gained from the yearlong experience also is represented and stored in a form useful for their colleagues. The report of a lesson study group's effort contains descriptions of the learning goals, the rationale for the lesson design, descriptions of activities, anticipated responses of students, and suggested responses by the teacher. These reports are theories linked with examples. Hypotheses about how to help students reach particular learning goals are linked to actual lessons and students; practical suggestions are linked to the teachers' theoretical analysis of the learning goals and ways in which students might achieve them.

In summary, this countrywide lesson study process generates practitioner knowledge but within a system containing features identified earlier as essential for transforming such knowledge into a professional knowledge base.

Could a System for Building Professional Knowledge From Practitioner Knowledge Be Created in the United States?

The images evoked by accounts of a countrywide system for creating, advancing, and improving professional knowledge for teaching prompt a mixed response. It is encouraging to see that countrywide systems exist but, at the same time, substantial cultural features argue against assuming that they simply can be copied elsewhere. There are reasons for both optimism and skepticism that the school and teaching cultures of the United States will evolve to be anything like the new, national research and development system we can imagine.

Reasons for Optimism

There are several reasons to believe that a sustainable U.S. research and development system could be developed for building a professional knowledge base for teaching from the knowledge generated by classroom teachers. First, settings in which teachers generate knowledge, such as lesson study, are not alien to U.S. teachers and schools. The examples described at the beginning of the article, and countless others (e.g., Elmore, Peterson, & McCarthy, 1996; Stein, Silver, & Smith, 1998), share many of the features and implementation demands with the lesson study process. These local examples offer "proof of concept" evidence that a profession's knowledge for teaching can be generated in the U.S. context.

A second reason for optimism is that when local U.S. programs of this kind have been studied, they seem to produce the outcomes that are, in the end, of most importance—improved student learning. Returning to our earlier examples, Grace and Stephanie were working in a laboratory school whose mission was the development of an effective reading program that could be adopted by public schools. Although the context was constrained in many ways, researchers and teachers worked together in the lab school trying out different approaches, learning from mistakes, refining program elements in small steps, and sharing responsibility and risk over time. Lessons were planned, taught, critiqued, refined, and re-taught in a recursive process that stretched out to more than 5 years before a stable and effective program evolved (Tharp & Gallimore, 1982) and was disseminated to a number of schools throughout Hawaii.

Ms. D. and her colleagues have been studied in considerable detail. The authors of CGI collected data about the influence of knowledge like that constructed by Ms. D on students' learning. Early evidence showed that teachers' knowledge of whether their own students could solve various mathematical problems was significantly correlated with student achievement (Carpenter, Fennema, Peterson, & Carey, 1988). A controlled experiment then demonstrated that experimental teachers, such as Ms. D., listened to their students more and knew more about their students' problem-solving processes and the students, in turn, exceeded students in control classes in number fact knowledge, problem solving, reported understanding, and reported confidence in their problem-solving abilities (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Follow-up studies of teachers involved in CGI then showed that the continuing construction of *detailed* knowledge of their students' thinking is what distinguished teachers who continued to develop new knowledge from those who based their teaching on the knowledge acquired during their early years of participation (Franke, Carpenter, Fennema, Ansell, & Behrend, 1998; Franke, Carpenter, Levi, & Fennema, 2001). Teachers who focused on, say, how students counted to find an answer, not just whether they counted, were teachers who recognized that they could generate useful knowledge for teaching and share it with others.

Although these examples might "prove the concept," they provide no guidance on how to scale to a national or even a regional system. Even here, however, there is reason for optimism. The conditions required to support, on a national scale, the system we propose have been evolving and expanding during the past decades. The teacher-as-researcher movement has oriented teachers to studying their own practice, thereby making it more public and testing its effectiveness (Berthoff, 1987; Burnaford, Fischer, & Hobson, 1996; Cochran-Smith & Lytle, 1993, 1999). During the same time that the movement has been increasing educators' awareness of the richness of teachers' personal knowledge, it also has focused attention on the kind of teacher learning that is required to teach more effectively. These salutary achievements, and the concomitant attention to professional development, have demonstrated that the same structural conditions needed for a sustainable research and development system are needed for building professional knowledge: Long-term, site-based collaborations among teachers focused on students' learning and linked to curricula (Cohen & Hill, 1998; Cohen & Barnes, 1993; Darling-Hammond & Sykes, 1999; Garet et al., 2001; Loucks-Horsley et al., 1998).

These developments improve the chances that a system like the one we are proposing can be gradually built in the United States. They are yielding knowledge that matches the first three of the six characteristics (linked to practice, detailed/concrete/specific, and integrated), and they have begun the movement toward making the knowledge public, stored, and shared. A significant amplification of these in-progress gains can come from emerging technologies (National Commission on Mathematics and Science Teaching for the 21st Century, 2000).

Indeed, a final reason for optimism is that Internet accessible digital libraries of lesson videos with teacher commentary could provide tools and resources needed to address at least two challenges faced by teachers as they transform personal knowledge into a professional knowledge base. One challenge is to envision alternatives to current practice. Earlier we mentioned expertise as one source of new ideas, but easily accessible digital video libraries that contain examples of other teachers teaching similar topics can provide another source.

A second challenge for teachers is communicating what they have learned by trying out a particular lesson or teaching approach and coordinating multiple trials of similar lessons across different sites. Again, web-based video libraries can help. Lesson videos provide enough detail that multiple trials can be conducted with each test site enacting the same approach. In other words, the rich visual definitions of practice, accompanied by teacher commentary, allow better replications of practice than before. With new technologies supporting the new system, each test site could submit video cases of their replication efforts offering a means for assessing fidelity of implementation of intended practices. These uses of technology, and others yet to be imagined, offer the hope of gradually developing consensus of classroom practices associated with different levels and kinds of students' learning in different contexts. In working toward this goal, much can be learned from the research community, which has made great progress in building structures and processes for verifying quality and accuracy of knowledge.

Reasons for Skepticism

If local U.S. efforts sometimes produce useful knowledge of teaching, why have these efforts remained local? Why have they not been scaled-up and connected to form a national research and development system for building professional knowledge for teaching? We believe the answer to these questions lies in American education history, a review of which causes us to be as skeptical of change as we are optimistic.

A Story From the Past

To understand how the United States created an educational research and development system that is both underused and hinders a more useful system from developing, we visit the University of Chicago at the beginning of the 20th century. John Dewey and his laboratory school colleagues were planting the seeds of a school-based, teacher-engaged system of building professional knowledge (Cremin, 1964; Tanner, 1997). But Dewey was soon succeeded at the University of Chicago by Charles Judd. Judd, wishing to bring a recognized science to education, reached out to psychology. Edward Thorndike had been developing a science of behavior that borrowed methods from physical sciences, with an emphasis on measuring, isolating variables, and comparing quantitative outcomes. Given the recognized success of the physical sciences, Thorndike's program fit the bill and Judd and Thorndike ushered in a new era in educational knowledge building (Lagemann, 1989, 1996). Their approach bestowed on education the higher research-oriented status many universities were demanding for this new field.

The "objective" methods of Thorndike, with their precisely measured outcomes, became the accepted standard for educational research. The approach fit well with the increasingly popular notions of efficiency and division of labor for improving productivity (Darling-Hammond, 1997). For education, all of this had at least two significant consequences. First, the methods produced exactly the kind of knowledge that many teachers find difficult to apply to their particular contexts. The knowledge often is represented in forms that are relatively abstract, ignore contextual influences, and isolate aspects of practice that cannot easily be reintegrated with interacting features of classrooms. Second, the approach to improvement meant the emergence of two professional communities—school practitioners and university researchers. Professional knowledge building became the province of researchers; applying the knowledge was left to the practitioners.

The more integrative approach practiced by Dewey and colleagues that focused on collaborative work in classrooms has been kept alive in pockets around the United States and is reflected in initiatives such as school and teacher inquiry groups (Ball & Cohen, 1999; Clark, 2001; Schaefer, 1967) as well as the examples presented earlier. But these are not the norm. Most teachers who continually develop knowledge about their own practice have seldom accumulated and shared their knowledge. They have learned from each other only in the most haphazard way. As much as they might benefit from the knowledge of their colleagues, most teachers have not accessed what others know and must start over, creating this knowledge anew. Later in his career, Dewey noted that one of the saddest things about American education is that

> . . . the successes of [excellent teachers] tend to be born and die with them: beneficial consequences extend only to those pupils who have personal contact with the gifted teachers. No one can measure the waste and loss that have come from the fact that the

> contributions of such men and women in the past have been thus confined. (1929, p. 10)

In short there is no question that the views of Judd and Thorndike, rather than those of Dewey, shaped the face of American education and educational research. Lagemann writes, "I have often argued to students, only in part to be perverse, that one cannot understand the history of education in the United States during the twentieth century unless one realizes that Edward L. Thorndike won and John Dewey lost" (1989, p. 185).

Lessons From the Past

For an alternative system to win acceptance, it is important to clarify what went wrong in the past. Some have presumed that the costs of the past are due to pursuing a science of education. Making education a science, from this view, leads necessarily to the choices of the past. This is a misinterpretation. In our view, it is a mistake to interpret Thorndike's victory as one of scientific approaches over nonscientific approaches. Accepting the scientific versus nonscientific explanation leaves those who propose alternatives to the Judd and Thorndike legacy in the unappealing and unfounded position of advocating nonscientific approaches to study and improve education.

A more appropriate reading, in our opinion, is that Thorndike and colleagues successfully promoted some scientific methods over others. Experimental, comparative methods that rely on controlling and isolating variables became the methods of choice. But these are not the only scientific methods that yield dependable, trustworthy knowledge. Observation and replication across multiple trials can produce equally rigorous tests of quality and can, over time, produce dependable knowledge as well, a claim that is illustrated by the examples we presented earlier. Put more dramatically, the United States can have a radically different research and development system in education without rejecting scientific methods (cf. Eisner, 1997; Mayer, 2000).

Over time, the observations and replications of teachers in the schools would become a common pathway through which promising ideas were tested and refined before they found their way into the nation's classrooms.

An important parenthetical note is that we have focused our review on traditional quantitative methods of research. Some have argued that the use of qualitative methods would solve the problems we identify (Bolster, 1983). Clearly, the growing number of case studies and ethnographies report information closer to the kind of knowledge that teachers hold—context-sensitive, particular, richly descriptive knowledge. But researchers' knowledge gathered through applying qualitative methods does not solve the larger problem. There often remains a difference in purpose between researchers and teachers (Wong, 1995) and there remains the task of building a reliable knowledge base that is tested across different contexts.

To oversimplify this brief review, past decisions led to the creation of two communities. The research community has worked toward the goal of building a professional knowledge base and has developed an infrastructure for recording, sharing, and accumulating knowledge. But the problems framed and the methods preferred have produced knowledge represented in forms that make it difficult for teachers to use. The teaching community works toward the goal of improving practice at an individual level and many individual teachers gradually learn from repeated observations over many trials. But no infrastructure encourages, or even enables, them to record, share, and accumulate the knowledge they construct. Educators live with two professional communities struggling to bridge the chasm and build a knowledge base that is relevant for classroom practice. Thorndike's victory came at a considerable cost.

The question remains: Is it possible to create one community working toward the goal of building a profession's knowledge for teaching using an infrastructure that enables this work and using methods that generate useful and trustworthy knowledge for teaching?

A Glimpse Into the Future

If a new system were to emerge, it would institutionalize, in a cultural sense, a new set of professional development opportunities for teachers and a new means of producing and verifying professional knowledge. In this new space, teachers would be able to employ the methods of replication and observation across multiple trials to produce rigorous tests of quality and effects. Sometimes they would test practices developed by other teachers, and sometimes they would test ideas generated in the research community. Over time, the observations and replications of teachers in the schools would become a common pathway through which promising ideas were tested and refined before they found their way into the nation's classrooms. And, as intentions became reality in classrooms, a new kind of knowledge about improving classroom practice would emerge, a knowledge that would accumulate into a professional knowledge base for teaching and support long-term continuing improvement in teaching.

Among the most crucial replications would be those that address the many diversities of U.S. society. The system envisioned here would intentionally subject new ideas to replication and observation across many regions and communities. Discrepancies would be contested and resolved as hypotheses were developed to account for them and new trials were undertaken to test the hypotheses further. Some aspects of practice would likely survive testing across contexts, with modification, whereas other aspects would be found to be context dependent.

To be successful in the U.S. context, the research and development system needs to incorporate the expertise and unique skills of both teachers and researchers. Both communities would need to reorient their professional goals and values. Teachers would need to change their view that teaching is a personal and private activity and adopt the more risky but rewarding view that teaching is a professional activity that can be continuously improved if it is made public and examined openly. Researchers would need to move from undervaluing the knowledge teachers acquire in their own classrooms to recognizing the potential of personal knowledge as it becomes transformed into professional knowledge.

Researchers and teachers could work side-by-side as authentic partners in the new system, each gaining from the others' expertise. Teachers, for example, would use the wealth of their experience to test difficult-to-implement but promising new ideas and then, based on their own and the researchers' observations, new hypotheses could be constructed for future tests. Researchers, in turn, would have greater access to investigational contexts and populations, and gain a rich source of new ideas and hypotheses. They would get ideas from teachers that could be turned into testable hypotheses, much as clinicians make discoveries that are exploited by biomedical scientists to create new generalized knowledge. Rather than being made redundant or obsolete, the work of researchers could become more relevant with a system in place to digest and transform their general findings into professional knowledge for teaching.

One reason to think this new system might happen is the confluence of events at the end of the last century and the beginning of the new one. Schools, districts, and states are under great pressure to improve performance. The federal government in 2001 expanded its role in public education with new legislation to motivate annual student performance testing, teacher improvement programs, and a plan to identify under-performing schools. The groundswell of support and interest in new forms of professional development make a new research and development system a more realistic goal. With the convergence of these and other efforts to change the culture of schools to places where teachers learn as well as students and the emergence of enabling technologies, there are unique opportunities to build a new system for generating professional knowledge for teaching.

However, we must close by underlining two formidable barriers that face the evolution of a new research and development system. One barrier, noted above, is the natural cultural conservatism of both public schools and research universities. Social institutions are products of cultural context, and once established as enduring systems, a source of their own persistence. The culture of educational research and development is no more immune to these laws than the culture of public schools, itself oft-noted as highly resistant to change (Sarason, 1971; Fullan, 1993, 2000a, 2000b). More than a century of behavioral and social research teaches that culture changes slowly, on the margins, and in response to significant environmental shifts (Edgerton, 1992). This is no less true of institutional cultures than of any other kind, and to change them requires patience and perseverance.

A second barrier is the proclivity of Americans to look for quick solutions. The history of American education includes a graveyard of good ideas condemned by pressure for fast results. The research and development system we envision could easily become another victim because it clearly is not a quick fix, the desire for which is soaked deeply into American cultural beliefs about educational reform (Elmore & McLaughlin, 1988).

Can our society learn to value small improvements, small changes in practices as a means to larger ends? The coach of the 20th Century, John Wooden of the University of California Los Angeles, who always described his work as teaching, offers this prescription for the quick fix addiction:

> When you improve a little each day, eventually big things occur. . . . Not tomorrow, not the next day, but eventually a big gain is made. Don't look for the big, quick improvement. Seek the small improvement one day at a time. That's the only way it happens—and when it happens, it lasts. (Wooden, 1997, p. 143)

NOTES

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[1] Ms. D. and her students are fictional characters, created from descriptions of teachers who participated in Cognitively Guided Instruction (Carpenter, Fennema, Franke, Levi, & Empson, 1999; Fennema, Carpenter, Franke, & Carey, 1992; Fennema, Franke, Carpenter, & Carey, 1993; Franke, Carpenter, Levi, & Fennema, 2001).

[2] See Bereiter's and Scardamalia's (1996) definitions and interpretations of these worlds for students' classroom activities.

[3] A more complete description of the U.S. agricultural extension system and the way in which it models a large-scale system of continuous improvement can be found in Wilson and Daviss (1994).

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