

# Teacher Development: Roles of Domain Expertise and Pedagogical Knowledge

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The problems of teaching have now become a domain of active, systematic research by psychologists, anthropologists, linguists, sociologists, educational practitioners, and disciplinary specialists. What did not exist 30 years ago has become a vigorous and active field of research. Our theories of teaching demand principles of both exposition and discussion. Most of the pedagogies emerging from the seminal research on student concept learning reveal that some form of dialogue, exchange, conversation, or alternating argument—some kind of social manifestation of the understanding—is central. Therein lies the enormous pedagogical complexity that derives from this work. That complexity is the reason why, even though we know discussion is necessary, the dominant form of pedagogy is the lecture. Lecture is relatively simple, and it reduces much of the technical and economical complexities of teaching. This paper centers on pedagogies for externalizing students' knowledge and then encouraging them to reconstruct the information and internalize and represent these new understandings.

Nearly 40 years ago, an impressive group of scientists and educators gathered at the Woods Hole, Massachusetts conference center to discuss national response to the Russian laurels of Sputnik. The proceedings of the conference, summarized creatively by Jerome Bruner in his now-classic, *The Process of Education* (Bruner, 1960) called for a renewed investment in curriculum development and a more vigorous effort to develop the science of learning.

The specific research domain of a psychology of student learning and understanding of science did not really exist at the time of Woods Hole and shortly thereafter. It is even more the case that the field of research on teaching did not exist until at least a decade later. In large measure there was no research on teaching because of a prevalent misconception among psychologists and educators that the problem of teaching would be solved simply by solving the problems of learning, then applying those findings in some unspecified way.

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I would like to illustrate the differences between understanding the problems of teaching and of learning with four brief exercises. They all have the same structure.

### **First Exercise**

Divide 7 by 0. What answer do you get? How do you know? Now explain it to a third grader. Now explain it to a graduate student in English literature. Now explain it to an undergraduate physics major.

### **Second Exercise**

Divide three-quarters by seven-eighths. What rule do you use? Invert and multiply; we all know that rule. Remember the old rhyme: it is not mine to reason why, just invert and multiply. Now explain how and why you did that to a third grader, to a graduate student who is writing a dissertation on 18th century English poetry; and to a psychology major who has just finished her first statistics course.

### **Third Exercise**

Read Faulkner's "A Rose for Emily." What is the theme of that short story? How do you know? Explain what you did. You can continue now that you see the pattern.

### **Final Exercise**

Imagine that you are an internist confronted with a patient who has chest pain and shortness of breath under exertion. How do you determine whether the cause is congestive heart failure, angina, or a muscle pull? When you have made a diagnosis and have come up with a treatment plan, explain the problem and the treatment to the patient who is going to have to act on your plan. How would you explain what is wrong and what you are recommending if your patient were a physiology professor? What if the patient were a plumber? A poet? A fourth-grade dropout?

As you begin to experience the difference between what it means to know and understand something yourself and what it takes to help someone else come to know and understand it, and as you begin to recognize the complexity of that process, you have come a very short distance into studying the problem of learning and teaching.

Now imagine you are explaining these things not just to one person at a time, but to a classroom of 25, 30, or 40 students from various cultural and language backgrounds, with different assumptions about what you're doing, and with spotty attendance patterns so you cannot depend on everyone being there every day. I will not even ask you to add national and local standards, or parent interest groups that think they know far better than you what arithmetic really is and that are supported, as in Palo Alto, by a mathematics professor who says that the problem with the math curriculum is that there is not enough computation.

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tioners, and disciplinary specialists. What did not exist 30 years ago has become a vigorous and active field of research.

#### AN ILLUSTRATIVE PROBLEM: ILLUSORY UNDERSTANDING

I would like to take one problem of learning and trace the challenge it presents for the study of teaching. In this way we can begin to see how the problems of the study of teaching can be mapped onto the problems of the science of learning but are quite different from them. The reason we have not put much research on teaching into practice is more than a lack of will or dissemination. A profound gap of both understanding and politics is at least as much of an impediment as the simple absence of transmission.

What is the oldest problem of pedagogy? The appearance of learning, or *illusory understanding*, that is, the problem of people who appear to know something that they really don't know. This problem is not limited to young children who are not yet ready to match their theory to a target. It is a universal phenomenon, and all of the great teachers have wrestled with it in one way or another. Read the Socratic dialogues. Socratic teaching is essentially an attempt to wrestle with the illusion of understanding. Every Socratic dialogue begins in the same way. Socrates encounters a pupil, let's call him Sam, and asks Sam, "What do you know?" Sam tells him what he knows with great confidence. Socrates says, "That's interesting. I find that confusing. Can I ask you a few questions about that?" That is how the teacher Socrates made his living and, one might say, his dying.

When you begin to wrestle with people's deeply held, private, intuitive theories, you are engaging them in a process that is as deeply emotional as it is cognitive. This is why conceptual change is so difficult to negotiate. Where there is no pain, I suspect there has not been much conceptual change. The emotional aspect is something we have to learn to deal with. Socrates dealt with this problem on a regular basis, as do all teachers who require that their students confront their most deeply held, and typically unexamined, beliefs. The unexamined life may not be worth living, but it is surely more comfortable while you are living it.

This emphasis on the illusion of understanding also fascinated Francis Bacon, whose most famous essay discusses "Idols of the Mind," (Bacon, 1962) the ways in which our everyday reasoning fails to provide us with rational bases for our decisions. Bacon's work anticipated the modern contributions of psychologists like the late Amos Tversky and Daniel Kahneman (Kahneman & Tversky, 1972). They addressed the problems of misleading judgmental heuristics in their magnificent theoretical and experimental studies of the flaws in everyday uses of probabilistic reasoning.

People misconstrue the likelihood and reasons for events in intuitive ways. When Alfred North Whitehead (1929) talked about "inert ideas," his pun on Plato was more than simply clever. He was observing that we all have things that we believe we know and understand, but are often merely glib phrases which, once probed, turn out to be very fragile.

If illusory understanding is one of the great enemies of science teaching and learning, what strategies do we have available to combat this problem? Two ideas

characterize the approaches to ameliorate the impact of illusory understanding: reflection and interaction. That is, if we can teach learners to engage in active thinking about what they know and how they know it and if we can create conditions where they can discuss what they know with others, we significantly raise the likelihood that the problems diminish.

### OVERCOMING ILLUSORY UNDERSTANDING

The combination of reflection and social collaboration was well reflected when Ann Brown and Annmarie Palinscar (Brown & Palinscar, 1984) invented reciprocal teaching as a strategy for improving reading comprehension. Reciprocal teaching is a strategy of *comprehension monitoring*, of systematically scrutinizing one's own understanding of prose passages. I would argue, and I think Brown would agree, that it is a way of attacking illusory understanding. It is a way of moving the appearance of learning into deeper, more generative, less fragile learning through disciplined clarification via discussion. When Simon, Carey, and Gelman (this issue) discuss experimental interventions for dealing with misconceptions or prior conceptions, they describe approaches that involve fostering conversations or exchanges between the person who was the teacher or experimenter and the person who was the learner or subject. Verbal interaction, hence conversation, contributes to the prevention of illusory understanding.

#### Talking at and Talking with

Although lectures have dominated teaching in universities, the fact is, since the creation of the medieval university, we have understood that to teach something requires that one be able not only to explain it verbally, but also to engage in a disputation or discussion about it. That's why the final doctoral examination, which is a teaching examination because the doctorate is a teaching degree, requires Ph.D. candidates to explain what they know, then engage in a disputation or dialogue about it. You do not know whether people really understand something until you push them in discussion, conversation, and dialogue. If all you have is evidence of their understanding in written form, that is valuable information. All of us have had the experience of thinking we understand something, then trying to write it down and discovering the gaps in our comprehension. But we also have to be able to communicate the idea to others and to engage them in conversation or discussion around it. This all seems so straightforward. Why then, if illusory understanding is the enemy and we understand the strategies needed for solution, is better teaching not more commonplace?

### WHAT MAKES EXCELLENT TEACHING DIFFICULT?

Our theories of teaching demand principles of both exposition and discussion. If you look at most of the pedagogies emerging from the seminal research on student concept learning, you will find that some form of dialogue, exchange, conversation, or alternating argument—some kind of social manifestation of the understand-

ing—is central. Therein lies the enormous pedagogical complexity that derives from this work. That complexity is the reason why, even though we know discussion is necessary, the dominant form of pedagogy is the lecture. Lecture is relatively simple, and it reduces much of the technical and economic complexities of teaching.

As soon as a teacher enters into conversation and dialogue, that teacher begins to lose control of the discourse. As long as you are the only one doing the talking, 85 percent of the time you know what is going to be said. When you start inviting students to speak, the complexity rises and the unpredictability increases. But without dialogue, there is no way to know whether the appearance of understanding is illusory. (I do not think one ever gets beyond some degree of illusion; every time I teach something, even after 30 years, I realize that the last time I taught it I didn't quite understand it.) The only way we as teachers know whether our students understand something is by getting them to write or talk about it. As long as it remains inside their heads, we cannot teach, and in fact they don't know whether they understand it either. Deborah Meier (1995) once put it very well, in explaining why pedagogy was both straightforward and dauntingly difficult. She observed that, when properly understood, teaching is mainly listening, whereas learning is mainly talking.

Fundamentally, teaching involves just two processes. Understanding begins with what is already inside the learner's head. All students come to us with prior ideas, and our first pedagogical challenge is to bring what is inside, out: to make the internal external, to make the private public, to make the implicit explicit. We seek to do as Socrates, to make the informal a little more formal, to encourage students to say what they know with greater precision and rigor. Someone once said that philosophy begins in wonder and ends in algebra. If you are going to teach someone, you want them to be able to move from muttering vaguely about it to trying to state it more explicitly, so you (and they) can see what they really know. We engage in a whole series of pedagogical processes to make the internal external, to render it what I have called *community property*.

After the internal has become external, you can work on it together with the students; you can test it, move it around, rearrange it, co-construct it, and repair it. Your new and ultimate goal is to put what has been external back inside, so the intellectual and social cycles of the learning process can begin all over. In a simple, yet deep sense, that is the essence of pedagogy: putting the inside out, working on it together while it is out, then putting the outside back in.

Why is that so complicated? One reason is that it is not easy to discover how to put the inside out. You are not sure you have got it all, and of course you never do; it comes out in different representations and different forms, and you must always make inferences about it. You then want to help students take this reformed, transformed stuff and make it internally their own again in ways that will not leave those ideas inert. This is very hard work.

Another reason for its difficulty is that teachers typically face not a one-on-one clinical interaction, but responsibility for 30 or 35 or 40 students. What pedagogy do you as a teacher use in a classroom when you want this inside-out, outside-in process to happen and there is only one of you and so many of them? That is why group-based strategies like the varieties of cooperative learning, reciprocal teaching,

learning communities, and other types of collaborative groups have become very important in this current round of school reform efforts. They are not just a fad. We are trying to determine how, in a classroom of 35, to create an environment where more than five children per hour have the experience of bringing the inside outside. Then, with the help of others, they are able to wrestle with it; they do it for one another. They need not depend on waiting for the teacher's intervention alone.

This type of teaching is difficult because of its incredible complexity, which is apparent if you compare the lecture, one source of transmitting information to a large, physically passive group, with a classroom, in which students do not have the same prior theories but are trying to wrestle concurrently with complex ideas. How does a teacher manage to create that kind of situation—to hear, to monitor, to know when to intervene and when not? We sometimes hear students communicating actively, but unfortunately exchanging misconceptions.

Deborah Ball (1993) has made a lovely tape of her own third-grade math teaching that illustrates this problem. All of the students on this tape had already passed a test showing they “know” that if the numerator and denominator of a fraction are the same, that fraction equals one. Several weeks later, the students are having an argument about which is bigger, four fourths ( $4/4$ ) or five fifths ( $5/5$ ). Finally, one student wins the day by saying that the answer has to be five fifths, because if you had a pizza that had to be shared among five kids, and it was only cut in four fourths you wouldn't have enough. He's right about the pizza, but wrong about fractions. The notion of illusory understanding and its repair is a fruitful one and helps us to understand the complexities of moving from an understanding of learning to the improvement of teaching.

### EXPLORING THE WISDOM OF PRACTICE

How can we carry out the kinds of studies that will help us understand these issues more fully? Consider a research strategy I have practiced for years, the *wisdom of practice*. There are at least two ways in which we do this kind of work. One is an idea that David Hawkins, the mathematician, philosopher, and curriculum reformer, taught me 30 years ago when Bob Glaser and I were working together on a book called *Learning by Discovery*. Practitioners in teaching know a great deal more about teaching than our theories can yet account for. That is the essence of the notion of the wisdom of practice. In expert–novice research, when we do not have a theory that explains how somebody knows where to drill for oil, we follow experts around for a long time and have them talk to us about what they are doing; then maybe we can develop a model that eventually will lead to a theory. We can also do this with teaching. We find really good teachers, and we ask them to indulge us so we can learn from them—from watching them work, talking with them, videotaping them, engaging them in simulated recall. That's one model of the wisdom of practice.

There is another model that Ann Brown, Allan Collins, and a number of colleagues are beginning to pioneer; we call it the *design experiment*, although this is a misnomer in some ways. The design experiment is an experiment where we

collaboratively enter and partially redesign a classroom with good practitioners. We codesign and coconstruct curriculum and teaching. It is wisdom-of-practice research because we encourage the practitioners (not just permit them) to fix the theories that we designed as they put them into practice and see where they don't work. Then we constantly revise the curriculum and instruction. That, too, is a form of wisdom-of-practice research. I believe it will become even more powerful than earlier models. Taken together, these strategies may well move us ahead in our ongoing battles against the impediments of illusory understanding. We will need them all.

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