Allan Feldman, Professor, Science Education and Teacher Education

School of Education, University of Massachusetts,

Amherst, MA 01003

email: afeldman@educ.umass.edu

Teachers learning from teachers: Knowledge and understanding in collaborative action research

http://www-unix.oit.umass.edu/~afeldman/TLFT.html

Disclaimer: The article below is taken from Allan Feldman's website http://people.umass.edu/afeldman/. I had adjusted the formatting and added the italics to emphasize the significance of the discussion.
Associate Prof. Dr. Jaafar Jantan
Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam
http://drjj.uitm.edu.my; email: drjjlanita@hotmail.com; Mobile: +60193551621

Introduction

> *A chance conversation occurs between two physicists standing in a hallway outside a room where a research presentation has just been made. They realize that they have common interests, and that while the findings being discussed inside the room are of interest to both of them, the implications of those findings become more salient as they talk about them in reference to their own work. They decide to meet for coffee later, and begin an exchange of e-mail.*

Recent work in the sociology and history of science suggests that interactions like the one described above, and others including visits to each others' laboratories (Watson, 1968), are an integral part of the informal structures through which scientific knowledge grows -- that for physicists, knowledge grows not only from the reading of texts and analyses of data, but also through the exchanges among colleagues that occur during meetings of research associations, in hallways, or over a cup of coffee.

Similarly, knowledge about teaching physics grows through informal and formal exchanges among physics teachers. For example, a physics teacher in a school in California was concerned about how to teach the kinetic theory of gases to her students. While attending a meeting where physics teachers got together to talk about what they are doing, she told of how she had explained the section in the text on the kinetic theory but still the students did not "get" how microscopic molecules could exert macroscopic pressures. After she told her anecdote there was an exchange among the teachers about ways in which they have explained the theory that "worked." One teacher responded with this anecdote:

"I had the same problem, I looked through all the physics textbooks that I could get a hold of. I knew that the molecular theory of gases was taught in chemistry classes so I looked in ChemStudy also. There just seems to be something about that theory that the kids don't get. And then I got the idea of using a mechanical analog. ...That did it. As soon as I took that out and demonstrated it to the kids, I could see their faces light up. They were able to see real things moving like we tell them that the molecules are moving and exerting pressures.[1]"

Through interactions such as this, teachers form bonds that result in an exchange of knowledge,and in the generation of new knowledge.

If we want to improve the quality of knowledge development in professional communities, it would be unwise to work (or do research) only at the formal level of knowledge development or transmission. My experience during 14 years as a physics teacher points to the saliency of exchanges like these. I learned much of what I know about teaching, as have many teachers, through conversations with other teachers in my department, school, and at regional and national meetings of professional societies; participation in in-service programs, workshops, institutes and post-graduate course work; and through readings of the professional and research literature; as well as through individual inquiry and reflection, and deliberation about moral and political dilemmas. In my work with the Stanford Teacher Education Program (STEP), I saw novice teachers' knowledge and understanding grow through course work, and through the collaborative action research that they did as part of their training. These observations seem to indicate that a significant source of teachers' knowledge is their interaction with other teachers.

Focus of the Study

The purpose of this study is to better understand the ways in which teachers use their own experiences and those of their colleagues to become better teachers. That is, in general, "Where does their knowledge originate?" and, more specifically, "What are the ways in which teachers' knowledge about teaching and their educational situations grow when they are engaged in collaborative inquiry about their own practice with other teachers?" Implicit in these questions is the acknowledgment that teachers are engaged in professional practice, and are, therefore, primarily interested in "getting smarter" about teaching in order to do it better.

Although there are investigations of the types of knowledge both novice and experienced teachers possess, little research has examined the origin of that knowledge (Grossman, 1988; Wilson, 1988; Hashweh, 1987). In addition, when the lens of research has been focused on how teachers accumulate or generate knowledge about teaching, little attention has been paid to the ways in which teachers learn from each other and from their own experience. My field research and experience suggests that much of teachers' knowledge and understanding of teaching, of their students, and of the micropolitics of their educational situations arises through exchanges with other teachers. This inquiry has been an attempt to understand the importance of these activities as a source, among others, of teachers' knowledge as they attempt to improve their practice. Therefore, it has significance for teacher educators and policy makers as they engage in the current debate on how best to prepare teachers, and on the working conditions that most effectively foster their continuing intellectual and professional development.

The Physics Teachers Action Research Group

As a way to look closely at the ways teachers learn from one another and the ways that they generate knowledge and understanding from practice, I worked with a group of eight physics teachers engaged in collaborative action research -- the Physics Teachers Action Research Group (PTARG). I convened the group during the 1990-91 academic year, year 1 of this study. Year 2, 1991-92, was the primary data collection year. Most of the data analysis occurred during year 3, 1992-93, during which I continued to meet with the teachers. At the time of this writing the PTARG teachers continue to meet on a regular basis even though I am no longer a part of the group.

I invited the teachers to become a part of the group to participate in Lee Shulman's project, Towards a Pedagogy of Substance (TAPS). One of the foci of this project was to study how teachers develop and use representations of subject matter in their teaching. Representations are "models that may convey something about the subject matter to the learner: activities, questions, examples, and analogies, for instance (McDiarmed, Ball, and Anderson, 1989, p. 194)." The domain of teaching representations for physics includes demonstrations, laboratory activities, graphs, and mathematical formulae. I convinced Shulman that it would be worthwhile to see what could be found if teachers were to investigate this aspect of their practice. As a result, PTARG was established with the use of TAPS' Spencer Foundation funds.

During the ensuing two years, I collected and analyzed data about the physics teachers' engagement in action research. The conceptual framework that I describe in the next sections of this paper arose during that time. Prior to year 2, my conceptual framework relied on the teacher knowledge and teacher reasoning perspectives. This was similar to Shulman's model of pedagogical reasoning (Wilson, Shulman, and Richert, 1987) but expanded to include the influence of other teachers. As I progressed through my data analysis, it became clear to me that both perspectives were problematic. In order to understand what was problematic and to resolve it in some way, I began a second exploration of the literature. This eventually led to the conceptual framework laid out in this paper with its distinctions between context and situation, and between knowledge and understanding, and the identification of three varieties of teacher wisdom.

I then revisited the data using the focusing device of the new conceptual framework to come to a better understanding of what was happening in PTARG re the generation and sharing of knowledge and understanding. While this suggests a fairly well-formed structure, such as

data collection ---> data analysis---> theorizing---> data analysis---> theorizing

and so on, the actual process was more of a mélange. That is, data collection, analysis, literature searches and reviews, discussions with others, the trying out of new ideas, and theorizing were more concurrent than serial. I ask readers to keep this is mind as they continue through this paper.

An important aspect of this inquiry is that it is a study of a group of teachers engaged in research. During the three years of the study, I have acted as facilitator for the physics teachers engaged in collaborative action research. Although this label can be applied to a variety of different activities, I am using it in a very particular fashion. First, I am using Stenhouse's (1975) definition of research: systematic, critical inquiry made public. Second, although the term collaborative has been used to label research arrangements between university researchers and school teachers (Feldman, 1993), I am using it here to refer to a

relationship among teachers. And by action, I mean that the teachers investigated their own practice by acting within their settings to improve their teaching and to come to a better understanding of their educational situations.

Conceptual framework

In order to begin to explore the questions that I have raised, I will first look at how others have examined similar questions. In my review of the relevant literature, I have identified two perspectives on teaching that have framed other inquiries: the first of which I have labeled the teacher knowledge perspective, and the second, teacher reasoning.

The teacher knowledge perspective

In the teacher knowledge perspective I have examined several sets of literature. The first is the work of Shulman and his colleagues (Shulman 1986; 1987a; 1987b; Grossman, 1988; Wilson, 1988; Hashweh, 1987). Shulman's conceptual work laid out the concept of a knowledge base for teaching including categories of teacher knowledge such as pedagogical content knowledge. However, in addition to beginning a taxonomy of teacher knowledge and the exploration of pedagogical content knowledge, Shulman has constructed a framework of forms of teacher knowledge and types of each form . He specified three forms of teacher knowledge: propositional, case, and strategic.

Propositional knowledge is stated in propositional form -- it can be written or expressed in statements in which something is claimed to be true or false. He has identified three types of propositional knowledge: principles that result from empirical research, maxims that are claims that arise from practice -- the "wisdom of practice," and norms, which are statements of values, ideology, philosophy and ethical practice (Shulman, 1986).

Knowledge can also be expressed in the form of cases which can be case studies, vignettes, or narratives. Shulman has outlined three types of cases: Prototypical cases "exemplify theoretical principles ... precedents capture and communicate principles of practice or maxims ... [and] parables convey norms or values (Shulman, 1986, p. 11)." Finally, strategic knowledge is the knowledge that teachers have to apply their other forms and knowledge to the context of their educational situation "as the teacher confronts particular situations or problems, whether theoretical, practical, or moral, where principles collide and no simple solution is possible (Shulman, 1986, p. 13)."

Shulman and his colleagues have also developed a model for the generation of teacher knowledge through practice: pedagogical reasoning.[2] *It proceeds through a process that begins with comprehension and then transformation, instruction, evaluation, reflection, and then to new comprehension. Teachers comprehend when they "critically understand a set of ideas, a piece of context, in terms of both substantive and syntactic structure (Wilson, Shulman, & Richert, 1987, p. 119)." Teachers' comprehension is transformed through critical interpretation -- a review of curricular materials with respect to the teachers' understanding of the subject matter; representation -- the use of "metaphors, analogies, illustrations, activities, assignments, and examples that teachers use to transform the content for instruction (Wilson, Shulman, & Richert, 1987, p. 120);" adaptation -- the fitting of representations to students in general; and tailoring -- the adapting of representations to specific students. New comprehension then arises when teachers reflect on their*

transformation of curricular material, their instruction, and their students' understandings (Wilson, Shulman, & Richert, 1987, pp. 119-120).

While Shulman's school of thought permeates current work in teacher education (e.g. Reynolds, 1989), there are other formulations of the notion of teacher knowledge such as Carr and Kemmis' critical view (1986), and practical and craft knowledge (Elbaz, 1981; Lampert, 1981: 1984; Leinhardt 1990). For the most part these formulations do not differ significantly from Shulman's categories of knowledge. Carr and Kemmis, who from their critical standpoint, do offer a somewhat different perspective by including explicitly knowledge of the effects that arise from the interactions of individuals: knowledge of the moral, the philosophical, and the political. This is not missing from Shulman's conception of teacher knowledge, but while Carr and Kemmis claim that it is the socio-moral qualities that are of primary importance in teaching, Shulman has denied this outright (Shulman, 1987c). It is also important to note that while followers of Shulman have been quick to adopt his notions of the knowledge base and of pedagogical content knowledge, little attention has been paid to his model of pedagogical reasoning.

Critique of the teacher knowledge perspective

The teacher knowledge perspective has become an important way to think about teachers and their work. In addition to its use as a conceptual framework for empirical studies, its terminology has found its way into the worlds of policy and practice. For example, the Commonwealth of Massachusetts now includes the demonstration of pedagogical content knowledge as one of its standards for teacher certification.

But given the ubiquitousness of this perspective, it is important to identify several of its problematic aspects. The first arises from its origin in cognitive science and its computer-based model of cognition.[3]. By building on this model, there is a lack of attention to intention and motivation (Searle, 1984; 1992). Teachers are seen to possess a set of knowledge of what they do, but there is little attention paid to why they do it. Related to this is a suggestion that there is a mechanistic cause and effect relationship between teachers' actions and the actions of students.

It is also possible that this base in computer science can lead to inadequate models for teacher education. These models arise from the image of a computer data base. The novice teacher can be thought of as a set of memory chips ready to be "loaded" with the information of the knowledge base which is at odds with constructivist theories of learning. In addition, this conceptualization of teacher knowledge could lead others to assume that if a knowledge base for teaching is produced, then all that a teacher needs to do is to consult this knowledge base in order to know what sorts of actions to take in particular situations. This can also lead to the notion that teacher education should consist primarily of training teachers to use an "expert system" to which they will turn when faced with an educational problem or dilemma.[4]

Finally, although some attention has been paid in the teacher knowledge literature to the ways that teachers generate knowledge, there has been more attention paid to the knowledge that teachers possess. The result is a tendency to think of teacher knowledge as knowledge generated by others that is then given to teachers (Reynolds, 1989). This is especially apparent in the lack of focus on teachers learning from other teachers. As a result, the teacher knowledge perspective does not tend to support the growing teacher research movement or collaborative relations among teachers to improve their practice.

The teacher reasoning perspective

A second set of literature has played an important part in my development of a conceptual framework from which to explore the questions of this study, that of teacher reasoning. Within this body of literature I have taken a critical look at Fenstermacher's practical arguments (1986), practical theories (Sanders and McCutcheon, 1986), and Schön's notion of the reflective practitioner (1983).

Fenstermacher has recognized that there is a problem that educational researchers have in the conflict between "theoretically sophisticated prescriptive concepts of teaching" and the "morally explicit context" within which they are set (Fenstermacher, 1986, p. 41). In order to resolve this conflict he has developed the concept of the practical argument, based on the work of Green (1976), as a way to explain the intentional activity of teaching. Fenstermacher's practical arguments are both similar in form and purpose to Aristotle's practical syllogism (Nussbaum, 1978). Practical arguments differ from syllogisms in that in addition to a major and minor premise and conclusion, they can have multiple minor premises that influence the concluding statement about action.

Fenstermacher (1987) has suggested several reasons why attention should be paid to teachers' practical arguments. First, they illustrate how educational research perspectives can affect practice by influencing the minor premises of the practical argument. Second, teachers are represented as intentional agents. And third, they provide a way for moral, ethical, and political issues to be included in the discourse on teaching (Fenstermacher, 1987).

Practical theories

To Sanders and McCutcheon (1986) practical theories are guidelines or rules-of-thumbs used to guide behavior and provide reasons for actions in response to practical problems. Since practical problems are context-bound, any practical theory must be mutable, indeterminate, and particular. As a result, practical theories cannot be part of a system of universal rules (Nussbaum, 1986; Wiggins, 1987). Instead, they must be able to be accommodated to the particular context. Practical theories arise from life histories and from ethical and moral lessons. These ethical and moral lessons are found in literature, religion and the popular media. Practical theories are shaped by life experience, professional experiences, and by reflection on personal experiences and the experiences of others. All teachers, whether novice or experienced, enter classrooms with a set of practical theories that has arisen through these avenues.

Sanders and McCutcheon (1986) suggest that new practical theories can be developed through a process of practice-centered inquiry that is a form of practical reasoning. In this process, the teacher first encounters a new idea and tests it conceptually. If it passes this first test, the teacher tries it out in the classroom, and then reflects on and interprets the experience. The teacher then decides whether to use it in the future, to modify it, not to use it, or to search for an alternative idea to reach the same end.

The reflective teacher

Donald Schön has approached practical reasoning through an analysis of the practice of professionals. He recognizes the utility of the fruits of scientific study of practice, but also

notes that there are uncertain situations in practice in which those findings can at best inform but not resolve. That is because these situations are not problems to be solved, but are dissonances or dilemmas in practice that do not necessarily have unique solutions (Schön, 1983).

In noting the difference between the nature of scientific study and practice, Schön distinguishes between the model of problem solving of the former, which he calls "Technical Rationality" -- procedures or algorithms -- from the methods that practitioners use, "problem setting," to work their ways through dilemmatic situations. He describes problem setting as a "process in which, interactively, we name the things to which we will attend and frame the context in which we will attend them (Schön, 1983, p. 40)." Within this frame, the knowledge of practitioners is tacit: It is in the feel of that which they are doing (Schön, 1983).

In Schön's conception, teachers' practical knowledge is the tacit knowledge in their actions. Particular actions "feel right" for particular frames. Reflection-in-action occurs when teachers, or other practitioners, find that their intuitive performance, based on their tacit knowledge, leads to unexpected results (Schön, 1983). If the teacher experiences this sort of surprise, due to being in situations which are uncertain or unique, he or she reflects of phenomena and on implicit understandings of his or her prior behavior. The practitioner then carries out an experiment that generates both new understanding and a change in the situation (Schön, 1983). Therefore, to Schön, practical reasoning is the process by which the teacher's tacit knowledge is transformed through reflection on problematic situations, the enacting of frame experiments, and reflection on the results of those experiments.

Critique of the teacher reasoning perspective

While these three examples of models for how teachers decide how to act in practice appear to be different, they share characteristics that can be considered shortcomings of the teacher reasoning perspective. First, while they seem to be more than adequate post hoc explanations of how practitioners decide to act, it is difficult to envision teachers proceeding through the logic of the practical argument, deciding upon appropriate practical theories, or reflecting on frame experiments while in the act of teaching. That is, each of these models of teacher reasoning serves better as a way to understand why a teacher decided to act in a certain way than as a model of the actual reasoning process.

A second criticism is that not enough attention is paid in these models to what teachers must know if they are to reason effectively and make defensible decisions in practice. Teachers, as they reason about their practice, refer to their subject matter knowledge, their pedagogical content knowledge, their knowledge of their students and their educational situations, and all the other variants of knowledge that Shulman and his colleagues have suggested. And, it can be claimed that the more knowledge deliberators have, the more defensible their decisions will be.

A final criticism relates to the problem of expounding upon, or in teaching, reasoning skills. A look at the ways that the authors attempt to explain their models for teacher reasoning suggests that what at first appears to be heuristic processes begin to look more algorithmic. And, in attempting to teach reasoning, there is the tendency to formalize the process into a series of steps resulting in the collapse of the heuristic into an rigid algorithm.

A review of the two perspectives

In this section I have reviewed two sets of literature, the first of which I have called the teacher knowledge perspective, and the second that I have labeled teacher reasoning. Both of these perspectives have been useful for reformulating the conception of teaching. The teacher knowledge perspective has put the focus of research on teachers, and has allowed, and even encouraged, the university research community to recognize that teachers are thinking, intentional beings. As a result, it has opened up a new field of inquiry that recognizes that teachers are experts at teaching, that they possess a unique type of knowledge -- pedagogical content knowledge -- and that they possess a wide variety of teaching strategies -- repertoires of teaching representations -- that they have created and used for instruction. This perspective has also been useful in helping policy makers to envision new forms of pre- and in-service teacher education, and has provided a basis for research that supports the need for formal instruction in teaching.

The teacher reasoning perspective has also played an important part in changing conceptions of what it means to teach. It has suggested a vision of teachers as reasoning beings who reflect upon and make decisions about their practice, and that their expertise in doing so lies in their abilities to identify goals, to make defensible decisions based on practical and moral considerations, and to plan and carry out actions to meet those goals. It also suggests that good teaching requires teachers to be flexible and able to respond to particular spatial and temporal situations. It allows for the possibility of multiple solutions to problems and recognizes the existence of insolvable dilemmas. And, it suggests that the role of researcher is appropriate for teachers.

It might appear that the benefits of each of these perspectives outweigh the negatives that I have pointed out. Great advances have been made in the researching of, and theorizing about, teaching during the past ten years because of the primacy that these perspectives have had in the worlds of academia and policy making. However, as I have done the study of the Physics Teachers Action Research Group, it has become apparent to me that these perspectives do not adequately provide a framework with which to understand what has happened as these eight teachers and I explored and inquired into their practice, both individually and as a group. As a result I sought other scaffolding to aid in building the analysis that fills the remainder of this paper. Through a series of events, including my analysis of the data that I collected for this study, I began to explore hermeneutics and critical theory, and the work of contemporary philosophers of the mind. To my surprise, these works not only served to help me to better understand the nature of teaching, but also allowed me to see the criticisms I laid out above as being related to a particular conception of the human mind.

Teaching as being

In this section of the paper I develop a perspective which when combined with the other two, will serve as a theoretical framework upon which research on teaching can be based. This perspective, which can be traced to the work done in Europe by Husserl and Heidegger (1962) and of Dewey (1938) during the early part of this century, and is derived more directly from recent work by Searle (1992) and Dreyfus (1991), will serve as an alternative perspective but not one that will replace the former ones. In this perspective, I first expand the idea of what it means to know by making clear the distinction between knowledge and understanding (Midgely, 1989). A second distinction that I make is between context and situation. In doing so I expand the notion of context relationally, spatially and temporally. This allows me to recast what is meant by wisdom to include Shulman's wisdom of practice,

the deliberation of the wise practical reasoner, and, in addition, a third variety of wisdom that relies on living and acting authentically in situations.

The mind as computer

What I would like to suggest is that the criticisms of the perspectives that I have outlined above have as their basis a computational model of the mind. This is clearest in the teacher knowledge perspective which has its origins in cognitive science and the language of artificial intelligence. While the connection of terms such as knowledge base to computational models of the mind is obvious, the connection between case knowledge and the computational model is murkier. A key to the connection can be found in what computer scientists call the frame problem, which is an attempt to capture human experience in a computer (Dreyfus and Dreyfus, 1986). It is arguable that the writing or telling of stories or narratives of various sorts does not necessarily relate to the frame problem, but the idea of situated knowledge captured in the form of a case becoming a part of a knowledge base resonates with the language of artificial intelligence. The notion of teachers' case knowledge being subsumed into a knowledge base of facts and rules to solve problems can be seen to be similar to, if not modeled after, this idea of the frame.

My criticism that the teacher knowledge perspective does not pay enough attention to the ways that teachers generate knowledge can also be seen to be connected to this computational model. The teacher knowledge perspective, by framing cognition in terms of generating and accumulating knowledge in a knowledge base, places problem solving within an expert system that is separate from the teachers. That is, although it is assumed that teachers have this knowledge and might even generate it in some way, the teacher knowledge perspective focuses on the sort of cognition that consists of manipulations of knowledge according to rules, and that this collection of knowledge and rules is exterior to the teachers.

I should make it clear that this is not an attempt to show that there is a one-to-one connection between the teacher knowledge perspective and computer science. Rather, what I have suggested is that much of the language, and therefore ways of thinking and theorizing about teaching within this perspective, conjures up images and ideas from the fields of artificial intelligence and computer science. I would now like to do the same for the teacher reasoning perspective. This can be seen clearly in Fenstermacher's practical arguments. In this model of reasoning there is a set of logically connected thoughts that culminate in, first, the decision to act, and, second, the action itself. Where this begins to look like a computational model is that practical arguments are algorithms of sorts and reminiscent of Boolean algebra.

Similar arguments can be made for practical theories. Although practical theories are more mutable than scientific theories, they can still be thought of as sets of rules that operate on knowledge in order to make decisions about what to do. And the mutability of practical theories is similar to the expert systems envisioned by contemporary proponents of artificial intelligence that can "learn" to modify their rules as more contextual information is loaded into their data bases (Dreyfus, 1992). That is, there seems to be little difference between a conception of the mind that relies on immutable rules operating on knowledge and that of mutable rules acting on knowledge.

Schön's conception of practical reasoning as reflection can also be seen as computational in origin. If I were to continue my current line of argument, I would write that this is computational in origin because of its formulation of practical reasoning as a reflection on

categorical knowledge. However, this is much less obvious than in the previous models. That is because Schön's model of the reflective practitioner leans more towards the heuristic than the algorithmic. But it is still set up in a way that reflects a model of human thought as problem solving, and the solution of these problems coming about through some sort of mental manipulation of input data.

The purpose of a third perspective for the study of teachers and teaching is to have a model of human thought and action that is more holistic and non-computation. This perspective leads me to a better understanding of teaching and what it is to be a teacher through the study of teachers immersed in educational situations. I develop this third perspective by examining several ways of understanding human interaction without using computational models of the mind. The first will be that of the philosopher of the mind, John Searle (1984, 1992). I will then look at the stage model of expertise suggested by Dreyfus and Dreyfus (1986). And finally I will use Heidegger's analysis of Being (1962) with reference to the later work of Dewey (1938) and Bruner (1990).

The biological mind

During the past decade John Searle has argued against the notion that computation is an intrinsic feature of the mind (Searle, 1984; 1992). Instead he claims that consciousness and intentionality are intrinsic and ineliminable aspects of the mind while computation is observer relative (1992). To Searle, consciousness consists of the processes going on in the brain that we are aware of as our thoughts.

Searle's arguments are important to the study of teaching for two reasons. The first is that his suggestion that computational models of the mind are deficient conceptions of how people think implies that any attempt to understand teachers and the act of teaching through those models will also be deficient. The second has to do with his discussions of intentionality and what he calls the Background: "the set of skills, habits, abilities, etc., against which intentional states function (1984, p. 68)." Consciousness and action are tied, according to Searle, through the existence of intentional mental states, both prior and those in action, that operate relative to the Background. Therefore, if one is interested in understanding the actions of teachers, intentional states and the Background become important foci for research on teaching.

Searle is not alone in the use of this conception of consciousness. Dreyfus (1991) has traced the idea of intentional mental states to the work first of Bretano and then of Husserl. It also is a part of Bruner's recent work to develop a cultural psychology (1990). He is doing so based on the conviction that a human psychology has at its basis the desire to understand meaning and the processes that are involved in the construction of meaning. To Bruner, it is through the participation in the symbolic systems of the culture that a shared background is developed in front of which not only human action but also human understanding occurs (Bruner, 1990).

So Searle's model of the mind provides researchers with the possibility of examining teachers' beliefs, intentions, conceptions and other types of intentionality without being concerned with an underlying mechanism. There is no need to develop a model of reasoning or reflection, either -in- or -on-practice, to account for teachers' actions. However this model does make it necessary to be aware of the Background against which intentionality functions.

The development of expertise

In Mind over machine Dreyfus and Dreyfus (1986) have shown how a critique of computational models of the mind can lead to a conception of expertise that is independent of the idea that human understanding and action rely on knowing facts and relational rules. I review this model of expertise for several reasons: First, it is an application of a non-computational model of the mind. Second, it differs significantly from the prevailing models of teacher development that rely on the examination of teacher concerns, theories of moral development, or on methods of providing in-service education for teachers (Feiman-Nemser and Floden, 1986). And third, it points to the inadequacies of models of teacher cognition that rely on computational models of the mind in understanding the generation and sharing of knowledge and understanding by experienced teachers.

Dreyfus and Dreyfus have delineated five stages of skill acquisition: novice, advanced beginner, competence, proficiency, and expertise. At the novice stage, there is a reliance on decontextualized facts and rules. By learning these, the novice has a starting point from which to proceed to act. The rigidity of a system of facts and rules soon becomes a hindrance as novices become familiar with their new situations. Dreyfus and Dreyfus suggest that the advanced beginner uses new elements that are "situational." Situational elements depend upon when, where, and with whom the person is interacting, and are learned more through experience than through any form of verbal description. When people become competent performers in their new situations, they rely not only on situational elements, but also a hierarchic procedure for decision making. In a sense, the novice and advanced beginner appear to be behaving in an algorithmic mode while the competent performer has begun to act heuristically.

For the novice and advanced beginner, human behavior and understanding are analytic. In contrast, the competent performer uses a "Hamlet" model of decision making -- "the detached, deliberative, and sometimes agonizing selection among alternatives (p. 28)" -- a model that underlies the deliberation and reflection of the practical reasoning perspective. Proficiency, however, is not dependent upon this sort of analysis. Instead what occurs is holistic discrimination and association -- "the ability to intuitively respond to patterns without decomposing them into component features (p. 28)." This intuition is not a mystical power nor guessing; it "is the product of deep situational involvement and holistic discrimination (p. 28)." That is, while for the novice, advanced beginner, and competent performer, performance in situations is dependent upon decision making involving rules, the proficient performer relies on a holistic understanding and intuition for making decisions related to practice.

Expertise differs significantly from the previous stages. In each there is a process of decision making or coming to understand that is conscious to at least some extent. However, "When things are proceeding normally, experts don't solve problems and don't make decisions; they do what normally works (pp. 30-31)." There is no conscious reasoning underlying most expert behavior. Dreyfus and Dreyfus do provide the exception, that while most expert performance is not reflective, there are circumstances when experts will deliberate or reflect. But they point out that even in these cases the expert's reasoning is not computational; that "this deliberation does not require calculative problem solving, but rather involves critically reflecting on one's intuitions (p. 32)."

The stage model of expertise of Dreyfus and Dreyfus makes a clear distinction between the novice, advanced beginner, and competent performer on one hand, and the proficient performer and expert on the other. The distinction lies in how readily the thoughts behind action can be modeled using computers. That is, given a certain level of expertise, computational models of the mind might well be useful for understanding cognition. As has

become clear in other stage theories of development, individuals can be in different stages when engaged in different tasks. This is most likely true for expertise, and specifically teacher expertise. While in many domains highly experienced teachers are experts, there are others where they are at various levels of inexpertise. This suggests that while the first two perspectives reviewed in this study might be inappropriate for the analysis of proficient or expert performance, they might be well suited for understanding novice, beginner, or competent performance.

There is also the implication that at times even the expert needs to become more conscious of his or her reasons for actions. That is the point at which the dissonances or dilemmas of practice loom large. While the expert's behavior in these circumstances might seem to be more like those of more novice performers, there still remains a large difference: what in the less expert performers is reflection on context, knowledge, and rules of operation, is that and more in the expert. What is added is critical reflection on all that and on intuitions. In addition, the expert has a more complex set of background capabilities from which to act.

Knowledge and understanding

In order to develop a better understanding of this holistic view of expertise in practice, I distinguish between what I mean by *"to know"* and what I mean by *"to understand."* These verbs are linked together in the vernacular and are made distinct only through particular usage in philosophy. There is, of course, the philosopher's definition of knowledge as "validated true belief" and the more operational definition that has been used in the teacher knowledge perspective, that a person has knowledge when he or she "knows-how" or "knows-that." To understand tends to have the same meaning: a persons understands when he or she "understands how" or "understands that."

My distinction between knowledge and understanding may seem to be sharper than necessary, but it is important for the rest of my analysis that the reader share my understanding of this distinction. Obviously, when one speaks and writes of people and their ways of thinking and interacting with the world, distinctions blur. And, although there might appear to be some sort of hierarchy or valuation in the way that I make the distinction, I am not claiming that one way of naming is better than another. What I am suggesting is that the distinction that I am laying out is tied to a difference in the way that we think of and conceive of the knower or "understander."

In my analysis of the teacher knowledge perspective, I suggested that it conjures up a model of the knower as a computer data base, and that teaching and learning is then seen as the equivalent of the programming of, and the entering of data into, a computer. While this might seem to some to be far-fetched even if the language of computers is discounted, it still suggests an image of knowledge as a commodity. That is, knowledge becomes something that a person can have in the same way that a person can possess any commodity (Lyotard, 1979).

There are good reasons for thinking of knowledge as "chunks" of know-that or know-how that can be added to some sort of compendium. Much of scientific and academic knowledge is in these forms, and the information that is needed to run a business or govern a country is often categorical. But where this begins to lose its saliency is in trying to understand the actions of individuals and interactions among people. This might be due to the complexity of human interaction that would then make a such a compendium too large and too unwieldy.[5] Or, as Heidegger has argued, it is due to the difference between the existence of inanimate objects from the way that people exist immersed in situations (Heidegger, 1962). It is out of

Heidegger's analysis of the Being of Dasein[6], those beings who "in their Being, comport themselves towards their Being (1962, p. 67)" -- that is, those entities who are aware of their existence, or, as Searle would put it, are conscious -- that my use of the word understanding arises.

Being-in-the-world[7]

Being and time (1962) is Heidegger's analysis of Being, and particularly of the Being of those beings who are aware of their own Being -- human beings. Because of this choice of subject for his analysis, Heidegger's concern parallels that of Searle's -- human consciousness. In order to come to a fuller understanding of consciousness he begins by rejecting the Platonic ideal that one can understand the universe in a detached way. Once this is recognized, Heidegger attempts to clear away five traditions that have arisen from Plato's idea of the theory: explicitness, mental representation, theoretical holism, detachment and objectivity, and methodological individualism.

Heidegger claimed that understanding is not a completely explicit human activity. Rather it comes about through "shared everyday skills, discriminations, and practices into which [people] are socialized (Dreyfus, 1991. p. 4)." This is, in short, Searle's Background, or what Heidegger calls the understanding of Being (Heidegger, 1962). It is through an understanding of Being that arises through this shared, social background, that is the basis for intentional human activity, and not explicit or tacit knowledge acted operated on by theoretical rule systems. Therefore by the term "understanding," Heidegger has in mind "a fundamental existentiale, which is neither a definite species of cognition distinguished... from explaining and conceiving, nor any cognition at all in the sense of grasping something thematically (Heidegger, 1962, p. 184)."

Situation, interpretation, and understanding

My use of the word understanding is closely tied to the notion of meaning-making that Bruner has written about in *Acts of meaning* (1990). He sees meaning as "a culturally mediated phenomenon that depends upon the prior existence of a shared symbol system (p. 69)." This differs from my conception of understanding because of my use of situation instead of context, and what I mean by interpretation.

By situation I mean more than the context within which people act. The context is their setting -- the backdrops in front of which they act. To speak of context conjures up an image of people as separate entities, distinct from their surroundings, and affected or acted upon by those other entities that make up the context. Those entities include all the people with whom they interact, and all the inanimate objects that surround them. Instead, people find themselves thrown into a situation constituted by all that has occurred in the past and from which they project themselves into the future (Heidegger, 1962). This notion of the individual being a part of a situation suggests a complex interaction among entities that is spatial and temporal.

Dewey has characterized what I mean by situation in a similar fashion. To him, human interactions with the world and its constituent parts grow in ways that appear sequential with "one act growing out of another and leading cummutatively to a further act" but resulting in a "consummatory fully integrated activity ... (1938, p. 31)." This occurs because of the nature of situations:

> *"What is designated by the word 'situation' is not a single object or event or set of objects and events ... For we never experience nor form judgments about objects and events in isolation, but only in connection with a contextual whole. ... In actual experience, there is never any such isolated single object or event; an object or event is always a special part, phase, or aspect, of an environing experienced world -- a situation (1938, pp. 66-67)."*

In the study of teaching, the people of interest are teachers who are immersed in educational situations that are constituted of their settings within which they are situated -- their teaching context -- but also their past and possible future interactions with their students, colleagues, school administrators, and so forth, all within the milieu of particular human "traditions, institutions, customs and the purposes and beliefs (Dewey, 1938, p. 43)."

The importance of situation to my meaning of understanding lies in the idea of Heidegger and Dewey that people, individuals, exist in the world as being a part of the world, and that understanding is related to that being-in-the-world. What this suggests is that understanding of one's own being can never be separated from the individual and can never be fully accessed because it is constituted by our being in the world. It arises from immersion in the world, an immersion that is fundamental to and inseparable from human existence. Understanding is a part of the way people make sense of the situation in which they are immersed, a making sense that can never be fully explicit and is part of background capabilities.

But what of the ways that people try to make sense of the understanding of others? It is here that interpretation plays an important part. Interpretive inquiries into the meanings and understandings of others have long been a part of the ethnographic tradition in anthropology as well as the principal way of knowing in the humanities. It has also begun to make an inroad into studies of human psychology as seen in recent writings by Bruner (1986; 1990).

To Heidegger, all interpretation resides in shared understanding that requires a three part "fore-structure" -- a way in which the interpreter relates to others in achieving meaning. It begins with a shared pre-understanding, a Vorhabe, or fore-having, that is akin to Searle's non-explicit Background or Bruner's shared symbol system. The interpretation then proceeds with some sort of perspective from which to approach that which is being interpreted, an approach with which to make sense with. In addition, the interpreter always has expectations about what meaning will arise from the inquiry (Dreyfus, 1991). While this characterization of interpretation suggests something similar to a heuristic or algorithm with its the fore-having and approach looking very much like data and rules, it instead is based on the method of interpretation of texts, the hermeneutic circle. This circle is a moving back and forth between text, local interpretation, and a more overall interpretation of the text. In that way, the interpretation shapes the reading of the text, and the reading of the text shapes the interpretation (Dreyfus, 1991). To Heidegger, self-understanding is tied directly to being-in-the-world, the thrown projection of Dasein. When it comes to the understanding of others, a hermeneutic interpretation is needed in order to pull together aspects of the individual and the situation in ways that shape the interpretation as the understanding proceeds. For teachers, this suggests different ways of understanding the world, educational situations, and others in those situations. There is the understanding of the self as teacher, and the understanding of the others and the self immersed in educational situations.

Varieties of wisdom in the practice of teachers

In seeking to understand teachers and teaching I have combined these notions of interpretation and situation with Searle's analysis of intentionality and the Background, Dreyfus and Dreyfus' stage theory of expertise, and the teacher knowledge and teacher reasoning perspectives. I have done this by using the construct of wisdom, where wisdom is an aspect of teachers that enables them to teach. But while others have focused on singular aspects of wisdom and have offered conflicting conceptions of this construct, I refer to three varieties of wisdom. The first is Shulman's wisdom of practice (1987b), the propositional statements that consist of knowledge derived from practice. The second is deliberative wisdom, Aristotle's phrono(e,)sis (Irwin, 1985). It is the ability to step out of practice and to reflect on what has occurred in order to make defensible decisions about what to do. This is similar to Schön's reflection-on-action (1983). The third type I call wisdom-in-practice, the expertise of Dreyfus and Dreyfus (1986). It comes about through authentic and genuine being-in-the-world. It is not Polyani's tacit knowledge (1966): It cannot be codified, separated out, or made distinct from the situation in which it is immersed.

I must make it clear that I am assuming that good practice entails all three types of wisdom. Each of these varieties of wisdom is a way of knowing the world, of understanding educational situations, and of generating knowledge, coming to understand, or make meaning. Some of these forms of wisdom are more transportable, generalizable, or codifiable than others. And some are deeply embedded in the teacher's immersion in educational situations. In the latter case, transportability or generalizability take on a different form. It becomes a sharing of understanding by which the person who lives the experience comes to understand his or her own situation and makes that understanding public through a variety of mechanisms. Other teachers then come to understand their own educational situations through the shared understanding and meaning. As I examined the activities of the physics teachers in PTARG I referred back to this model of multiple forms of wisdom and the sharing of the understanding of educational situations.

Design of the study

The design and methodology of the study consisted of a set of case studies of the Physics Teachers Action Research Group, a group of physics teachers inquiring into their own teaching. While originally conceived as a set of parallel and contrastive case studies of the individual teachers using the methods of Yin (1984), Wolcott (1990), and Eisner (1985; 1991), the study co-evolved with the conceptual framework into a set of case studies that explore multiple aspects of the nature of knowledge and understanding, collaborative action research, and the ways that teachers go about understanding and changing their practice.

The sample of teachers was distributed with a mix of public and private schools, grade levels, and genders: Two taught in private schools and one was a community college teacher of physics; two of the public schools served an elite suburban population and two were located in urban neighborhoods with large numbers of recent immigrants; and three of the eight teachers were women. They also varied in their own level of schooling and whether or not they have been students in teacher education programs: Two of the teachers had doctorates in physics but had no teacher training, while all but one of the others had done at least masters level work in physics or education.

The data collected includes classroom observations, interviews of the teachers and their students, audio tapes of PTARG meetings, and teachers' writing. The data provided information for teaching biographies and pedagogical baselines for each of the teachers in

addition to records of the discourse during the PTARG meetings about the teachers conceptions of research in general and action research specifically.

There were two primary methods that I used for data analysis. The first consisted of ongoing analysis that occurred during the data collection phase of year 2. I wrote reflective notes and memos in my research notebook, added side comments to transcripts as I transcribed them, and engaged in extensive conversations with other university researchers. This led to both reformulation of my problem statement and significant modifications in the conceptual framework.

Much of the analysis that I did after I concluded data collection occurred through the grouping and coding of data with the software Hyperqual. The transcripts of PTARG meetings, transcripts of interviews of the teachers, and pertinent field notes were entered into special files created by the software package. The use of this software allowed me to do an initial "chunking" of data into thematic categories similar to the sort of coding described by Miles and Huberman (1984). The chunked and coded data then became the source for the writing of the case studies.

Findings and conclusions

Enhanced normal practice and collaborative action research

My systematic look at the ways that the PTARG teachers conducted their action research has led to my construction of a model for the generation and sharing of knowledge and understanding among teachers that goes beyond Shulman's model of pedagogical reasoning. This model, which I have called enhanced normal practice (ENP), includes Shulman's pedagogical reasoning but as a part of three mechanisms: anecdote-telling, the trying out of ideas, and systematic inquiry.

The first of these mechanisms for the sharing and generating of knowledge and understanding is one that I have called anecdote-telling. I use this term to distinguish this mechanism from storytelling and narrative for two reasons. The first is that the anecdote-teller is not necessarily telling a story: There need not be a crisis that is to be resolved, a plot, or a time sequencing of event in the anecdote (Bruner, 1990). And second, I do not call these verbal exchanges among teachers narratives because I do not mean to refer to all that Connelly and Clandinin (1990) and others mean by the term.

While I have labeled this activity anecdote-telling, it is obvious that more must be happening than telling. Because this occurred in a group situation, there were the other PTARG teachers who listened to the anecdote-teller and then responded with their own anecdotes or with questions. The PTARG teachers responded to anecdotes in one of three different ways. In some instances the response was another anecdote. At other times, anecdotes were responded to with questions about the details of what was described or explained in the anecdote. A third type of response also consisted of questions, but ones that were more critical in nature and asked "Why?" as well as "What, where, how, and when?" Therefore, by anecdote-telling, I mean the oral exchange and generation of knowledge and understanding by the recounting and questioning of some teaching event or explanation of one's understanding to others.

It is the trying out of ideas that most closely resembles Shulman's pedagogical reasoning. For example, one of the teachers got an idea about using candles burning at each end to demonstrate torque and moments. He shared that idea with the other teachers through

anecdote-telling. Some of them went back to their classrooms to try it out for themselves, and the first teacher used it again, but modified in response to his peers' comments. Other ideas came from teachers, from educational research, or from reflection upon their own practice. What makes this conception powerful is that the teacher talked with other teachers about what happened through anecdote-telling. The other teachers listened to, and questioned how the teacher tried it out, what the implementation looked like, how the students reacted to it, and whether the idea was appropriate for the goals of the instruction. It is through the group critique that occurs in anecdote-telling that Popperian tests were applied to the trying out of ideas.

The third mechanism of enhanced normal practice is systematic inquiry. By systematic inquiry I mean any pre-planned manner of investigating practice in order to improve that practice and for the teacher to come to a better understanding of the educational situation. It is systematic inquiry that is often referred to as teacher research or action research. The PTARG teachers' systematic inquiry arose out of Shulman's TAPS project and centered on how they explain physics concepts to their students. When the PTARG teachers engaged in the systematic inquiry collaboratively, they first identified research questions through anecdote-telling, and then developed methodology through the trying out of ideas. Data collection tended to be an individual activity and the analysis of that data occurred in the group setting. While the results of their study were inconclusive for Shulman's purposes, it led to the recognition among the teachers of a significant dissonance in their practice between their desire to promote deep conceptual understanding and the ways that they assess their students.

Enhanced normal practice is a mélange of these three mechanisms occurring among groups of teachers. Groups of teachers share anecdotes with one another about their teaching. One tells an anecdote, the others listen and ask questions of the teller. Teachers go back to their classrooms and try out ideas that they have about their teaching. They return to the group to talk about what they have done and what they have observed about their ideas. On occasion it becomes clear that there are dilemmas and dissonances in practice that can only be resolved through some form of systematic inquiry that will illuminate the problem in a new light. In this way, knowledge and understanding is generated and shared among the group. To reach a wider audience, the teachers, as the PTARG teachers have done, can make presentations at professional conferences and conduct in-service workshops for other teachers.

It is systematic inquiry that looks the most like Stenhouse's definition of research (1975). But if the concept of what knowledge is is extended beyond the commodity form to include understanding, and if wisdom is recognized in all of its form, then each of the mechanisms that make up enhanced normal practice can be appreciated as forms of research. Because they all can result in the generation and sharing of knowledge and understanding, they can be recognized as more than the preambles to research, and as research itself.

This then leads to a conception of action research that goes beyond those based on more traditional definitions of research, including that of Stenhouse. When one looks at the literature on how to do action research (Altrichter, Posch and Somekh, 1993; Sagor, 1992; Carr and Kemmis, 1986; Elliott, 1991; Winter, 1989) the methods that are described parallel those of traditional educational research by suggesting that teachers do action research by engaging in systematic inquiry through the collection and analysis of data. An acceptance of a variety of conceptions of what constitutes knowledge and their associated forms of wisdom allows for a different conception of action research -- action research that is enhanced normal practice. This conception of action research, which remains self-developmental and moral in nature, is of teachers engaging in enhanced normal practice in collaborative groups,

and then making public, and open to criticism, their new knowledge and understanding of their educational situations.

The conceptual framework as outcome of the study

An important point of this study is that its conceptual framework was developed through a combination of my work with the teachers, my observations of them as action researchers, reading that I have done, and conversations that I have had with many people about my work. While it can be noted that this study is an example of traditional educational research, it is an example of how the distinctions between knowledge and understanding and between situation and context, and the recognition of three varieties of wisdom can affect traditional models of educational research. First, the study is not solely an attempt to produce generalizable, categorizable knowledge that is in the form of a commodity. My goal has been, in addition, to lay out my new understandings, and the ways that I have come to them, for others to use to come to their own understandings.

Second, because I have paid close attention to what I have been doing, I have engaged in action research on my practice as an educational researcher. And, the action research that I have done fits within the model of enhanced normal practice that I have developed in the study. In meetings of a Stanford research group, and individually with university researchers, I have told anecdotes about my work with teachers. They have responded with their own anecdotes or with careful questions. I have taken ideas, some my own, some suggested to me by others or that I have read in the literature, and tried them out on my practice as an action research facilitator and educational researcher. And, I have done systematic inquiry in those same roles and made it public (Feldman, 1994; 1993; 1992a; 1992b).

To help make this point more strongly, I want to clarify an important aspect of this study. While I have looked at the generation and sharing of knowledge and understanding among the PTARG teachers, a significant part of this study has been to not only to try to understand how the teachers have done this, but has also been an attempt by me to understand how I have come to understand what they have done. This coming to understand has occurred as I have been a part of an educational situation in which I have lived an authentic being-in-the-world. This educational situation consists of my interactions with the PTARG teachers, our pasts, both as individuals and shared, and our intentions for the future, again both as individuals and shared. My understanding, the conceptual framework that I have described in this document, has grown through talking, listening, questioning, writing, and being immersed in the situations of practice. And, in my role as student in a doctoral program, I have grown wiser about my practice through the accumulation of the wisdom-of-practice of educational research, through deliberating about problematic aspects of this study, and through my being-in-the-world of research situations.

Implications

A significant implication of this study is that if action research is to have a long lasting effect on schooling it needs to be self-sustaining. That is, it ought to be conceptualized and operationalized in a way that makes it something that teachers can and will engage in without the need of external support or cajoling. It is clear from this and other studies of teachers' work that their days are already full of the activities of normal practice, professional activities, caring for families, and the second jobs that economic conditions often necessitate. Obviously, if teachers are to engage in other than normal practice, the

conditions for that practice need to change. But even if those conditions are not changed, the model of enhanced normal practice and the epistemology that I have set forth in this study can lead to action research becoming more self-sustaining. In order for teacher research to be effective, that is, for teachers to come to a better understanding of their educational situations, for practice to improve, and for it to be self-sustaining, a radically different conception of what counts as research must be accepted. It is a conception that fits into what teachers already do -- the monitor and adjust of good practice -- but is extended to include the collaborative activities of anecdote-telling, the trying out of ideas, and systematic inquiry. This conception of research is dependent on the acceptance of what I have called understanding as its product in addition to categorizable knowledge. If this does not occur and if the research that teachers are asked to do remains within the paradigm of traditional educational research there is a strong possibility that the teacher research movement will not have a lasting effect on professional practice. As long as there are no significant changes in the ways that the work of teachers is structured, to ask teachers to engage in traditional forms of research in addition to everything else they do is to ask teachers to find new ways to make bricks without straw.

The implications for in-service teacher education are significant. It suggests that action research operationalized as enhanced normal practice could serve as a model of staff development that will result in teachers both improving and gaining knowledge and understanding about their practice. That is, in-service education can be organized so that there is a combination of the sharing of knowledge and understanding through anecdote-telling, a trying out of ideas, and the sharing of anecdotes or other forms of narrative about how it went. In addition, some sort of systematic inquiry could be a part of this process, especially if the questions that are investigated arise from the dilemmas and dissonances of practice.

There are also significant implications for pre-service teacher education. Action research is becoming an integral part of pre-service teacher education programs and masters degree programs for teachers. In the former it takes the form of an assignment that is done either during student teaching or in a prior observational placement. It is presented as a set of steps that one follows to either solve a problem or to generate new knowledge. To the novice teacher, it becomes an algorithm to be followed to complete the assignment and to fulfill the requirements for the credential. The danger is that action research could become just another hoop to jump through, or even more troublesome, it could be seen as another one of those activities that are a part of teacher education that has no relation to the "real world" of practice. The same can be true of action research that is part of a masters degree program. While the growing acceptance of action research as a methodology for education theses is a significant move towards relating university work to practice, the more that it looks like traditional educational research, because of the demands on time and other resources, and the mismatch of its rhythm and that of teaching, the less likely the teachers will continue to engage in it once the thesis is completed. What this suggests is that if action research in teacher education programs is to have a significant and lasting effect on practice, it, too, must follow a more self-sustainable model.

Finally, my work with the PTARG teachers suggests that there is fertile ground for research that has been left largely untouched. That is the study of communities of teachers that transcend school boundaries. While numerous studies have highlighted the isolation of teachers within schools and the difficulty of forming collegial relationships, my experience with PTARG and other teachers' organizations that I have been involved with suggests that there are teachers who are not isolated and do form collegial relationships in these formal and informal communities that transcend school boundaries. It is in these communities that we might find, or be able to encourage, the professionalism missing in schools, the

significant exchange of knowledge and understanding among teachers, and the opportunities for changing schooling for all.

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Notes:

1. Physics teachers meeting, May 30, 1991, Stanford University.
2. This model was first presented by Shulman at an address to the ISATT, Leuven, Belgium, September, 1985.
3. This can be seen most clearly in the verbal imagery used in this perspective: that of the computer data base. It must also be remembered that Shulman early on embraced the idea of a cognitive science to replace behavioral psychology (Shulman, 1974).
4. That the idea of a teaching expert system is not farfetched can be seen in a recent proposal for the use of hypermedia technology in teacher education (Lampert and Ball, 1990).
5. See Dreyfus' (1992) analysis of Douglas Lenant's artificial intelligence project.
6. Dasein is Heidegger's term for humans. Heidegger often used capitalization to distinguish among multiple meanings. Here Being refers to the act while being refers to the entities.
7. This analysis is dependent on Dreyfus' (1991) reading of Being and time.