Erzberger's Dilemma: Validity in action research

and science teachers' need to know

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In recent years, action research has increasingly become a part of university programs in teacher education. Courses for pre-service teachers and for teachers returning to the university for advanced degrees are requiring some form of teacher-research (Gore and Zeichner, 1991; Ross, 1987; Zelazek and Lamson, 1992). This trend can be seen in individual schools of education spread throughout the US and in major reform efforts. Action research is also being recognized as a method of in-service staff development, as can be seen in recent dissemination efforts by the Association for Supervision and Curriculum Development (ASCD) (Sagor, 1992), its inclusion in edited books on staff development (Holly, 1991), and its use as a tool in school restructuring (Sagor and Curley, 1991).

While there is this growing acceptance and encouragement of action research within schools of education and in school districts, little attention has been paid to what counts as tests of validity for teacher-research. Although this question might appear to be somewhat esoteric and removed from the world of practice, it has significant implications for the way that action research is enacted. That is because how one validates research shapes the methods used. In this article I examine the issue of validity in action research and how it affects methodology. I begin with a brief history of action research. That is followed with a description of a collaborative action research project in which eight physics teachers and I have been engaged (Feldman, 1993). This leads to the statement of Erzberger's dilemma and a critical examination of what counts as validity in action research. I conclude with some implications for policy makers and for the pre- and in-service education of science teachers.

Action research

Most credit the invention of action research to Kurt Lewin. In his work in social services in the late 1930s he began to encourage social workers to use research to further social change. Susan Noffke, in her critical history of action research, has described Lewin's in this way:

> In Lewin's formulation of action research, there is a clear focus on
> instituting change -- taking actions, carefully collecting information on
> their efforts, and then evaluating them, rather than formulating hypotheses
> to be tested, although the eventual development of theory was important.
> This represents not only a clear distinction from the dominant educational

research forms of the time, but also emphasizes Lewin's concern with resolving issues, not merely collecting information and writing about them. The theory developed as a result of the research was theory about change, not about the problem or topic itself (Noffke, 1990, pp. 35-36).

Lewin's conception of action research was of research to effect change in society. It depended upon the taking of actions within the situation that is problematic, collecting information about the actions and their effects, and then some sort of evaluation. This is a pragmatic style of research that seeks to resolve problems by changing the conditions in which the problem exists rather than accepting those conditions as given.

Action research flourished in US schools of education in the 1950s through the encouragement of Stephen Corey at Teachers College, Columbia University. While Lewin's conception of action research was of practitioners in the field doing research to enact change, Corey appears to have been more concerned with generating knowledge through hypothesis testing, and in encouraging the acceptance of action research as a legitimate form of educational research (Noffke, 1990). A look at his "elements of design" for action research supports this:

1. The identification of a problem area about which an individual or group is sufficiently concerned to want to take some action.

2. The selection of a specific problem and the formulation of a hypothesis or prediction that implies a goal and a procedure for reaching it ...

3. The careful recording of actions taken and the accumulation of evidence to determine the degree to which the goal has been achieved.

4. The inference from this evidence to generalizations regarding the relation between the actions and the desired goal.

5. The continuous retesting of these generalizations in action situations (Corey, 1953, pp. 40-41)

While Corey's design is pragmatic and seeks to resolve problems and then test the solutions in practice, there is an assumption in this model that the best way to do this is through the hypothesis testing.

Action research nearly disappeared as a research methodology in the USA in the 1960s, and 1970s. It appears as if it was something that teachers were willing to engage in while associated with schools of education, but not something that they would often do on their own. So at the same time that action research relied on university sponsorship, scholarship in the schools of education was beginning to move away from a focus on practice to the application of the social sciences in education (Oja and Smulyan, 1989).

The re-emergence of action research in the USA

In the USA, action research began to re-emerge in the mid-1980s within the tradition begun by Lewin and Corey. A look at current works describing action research processes (Altrichter and Posch, 1992; Carr and Kemmis, 1986; Elliott, 1991; Sagor, 1992; Winter, 1989) lay out a conception of action research as a problem solving process that relies on data collection and analysis in order to solve that problem. Typically the process is described as some sort of step-by-step process. For example, Carr and Kemmis illustrate their action research cycle as a four step process: planning, acting, observing, and reflecting. As a collaborative process among teachers, they see the planning and reflecting occurring among a group, while the acting and observing is done as individual activities (1986). While the ultimate purposes of the action research might differ among the writers of these texts, the shape of the cycles and the methods used for data collection and analysis are quite similar.

The origin of the resurgence of action research in the USA was the emergence of curriculum action research in the late 1960s in Britain due to the influence of Lawrence Stenhouse. This has been described in detail by John Elliott in his recent book on action research (1991). Stenhouse began to have teachers take an active part in the shaping of the implementation of the Humanities Curriculum Project, an integrated humanities curriculum that was developed in Britain to meet the needs of students in the new comprehensive high schools as the school leaving age was increased. By involving teachers in this way, and by recruiting teachers to play important roles in the structure of the project, Stenhouse sparked the growth among British teachers and educational researchers in the use of action research as a way to improve curriculum. In his history of the action research movement in Britain, Elliott described two other projects -- the Ford Teaching Project and the Teacher-Student Interaction and Quality of Learning Project) that played important roles in the spread of its use and the origin of the Classroom Action Research Network (CARN). It was through these projects, CARN, and the publications that came out of this work, especially from the faculty of the University of East Anglia, that traditional action research spread to the European continent (Altrichter and Posch, 1992), Australia (Carr and Kemmis, 1986), and back to the USA (Oja and Smulyan, 1989; Sagor, 1992; Watt and Watt, 1991).

Collaborative action research

Collaborative action research, as I have conceived it, consists of science teachers working together to take actions within their situations in order to improve their practice and to come to a better understanding of that practice. By collaborative, I mean a group of teachers working together in contrast to a relationship between university researchers and school teachers (Feldman, 1993a). In using the term research, I begin with Stenhouse's (1975) definition -- systematic, critical inquiry made public. And by action, I mean that there is an assumption that a good way to come to a better understanding of a complex system -- teaching and learning science, in particular -- is to take action within that system and pay close attention to the results of taking those actions.

The Physics Teachers Action Research Group

Beginning in the fall of 1991, eight San Francisco Bay area physics teachers and myself have been engaged in collaborative action research. The group was originally convened to be a part of Lee Shulman's Spencer Foundation-funded project, Towards a Pedagogy of Substance (TAPS). As part of this project, the teachers were encouraged to inquire into their own practice to uncover the ways that they use and generate representations of physics. 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.

The physics teachers met every three weeks, usually in one of their homes, to talk about their teaching, their knowledge of physics, to engage in a systematic inquiry of their teaching, and to eat dinner. It was during these meetings that Andria Erzberger, a member of the Physics Teachers Action Research Group, began to ask questions about the nature of action research.

Erzberger's Dilemma

Erzberger, like most of the teachers in the group, has had her primary training in physics and not in education or the social sciences. As she engaged in action research during the 1991-92 school year, she repeatedly wrestled with what I am calling Erzberger's dilemma. Erzberger thinks of herself as a teacher who is always trying something new. She has told me that she "never teaches anything twice the same way." She is on the lookout for different ways of presenting old material, and new ways to encourage her students to think about physics in their everyday lives. This past year she has paid close attention to what she has asked the students to do and how they have responded to her assignments and requests. She feels that she is successful at what she is trying to do -- the students tell her about the ways in which they have seen physics outside of school, and she has had feedback from parents about discussions of physics over the dinner table. But Erzberger is an empiricist. She wants to know whether what she is doing differently this year is more effective than what she has done in the past. That is, by embracing new forms of pedagogy and assessment, are her students learning at least as much physics content as before while coming to a better understanding of how physics relates to their everyday lives?

Recently, Erzberger and several other members of PTARG made presentations about their research at a meeting of teacher-researchers. She concluded her remarks with the following:

> ... here are some of the questions that I have. I'm one of the people who keeps asking, "Well is this really research? How do I know if my students are learning any better? How do I know if I've changed? How do I know if the students have changed?" Coming from a physics point of view, I keep asking, "What is the data? How do we really know if we're doing anything better or not?" In physics we see research more as controlled experiments,

variables and data, and so forth, which is not what we're trying to do with this (Erzberger, 1992).

To Erzberger the best way to answer this question would be through careful collection and analysis of data. However, her training in the physical sciences has led her to conclude that there is no way that she could have the faith in the data that she could collect in her classes that she would have in data from a physics experiment. She is aware that there are too many variables in her teaching, classes, and students to do the sort of controlled experiment, or even a statistical analysis, that would satisfy her demands.

And so she is faced with this dilemma: She would like to do more than the monitor and adjust that is Schön's (1983) reflection-in-action. She wants to come to a better understanding of her educational situation so that when she changes the way in which she teaches physics from year to year, she has a basis from which to make those changes. She wants to base her decisions on what and how to teach on an understanding of what is happening with her students in her classroom. But this understanding seems always just out of her grasp. It is not there when all that she has to rely upon is her casual observations and her reflections on those observations. And when she attempts to be more systematic in her reflection -- to engage in systematic, self-critical inquiry -- it serves her no better. The data that she collects, or that others collect for her do not meet the warrants for validity that she expects from her work in the physical sciences. She is caught in a void between the uncertainties of the observations made in practice and the demands that she puts on propositional statements before she will accept them as knowledge. The dilemma that she is faced with is that she wants to inquire into her practice to gain a better understanding of her educational situation and to get better at what she does, but yet finds teacher-research, and particularly action research, inadequate to the job. Why should she attempt to be more systematic? What does she gain from interviewing students or analyzing tapes of her lessons?

It is important to note that although I have singled her out for the purpose of describing and analyzing this dilemma, it has not been unique to Erzberger. It has been an aspect of the ways of thinking about research of many of the science teachers I have worked with as action researchers. I will attempt to examine Erzberger's dilemma by first trying to understand her need to know through a review of the ways in which others have sought to validate knowledge generated through that research, and then posing an alternative epistemology of teacher-research.

The need to know

The need to know is there for Erzberger and other teacher-researchers because they are seeking both new understandings of their educational situations and valid reasons for their actions. This is due to the developmental and ethical aspects of their research. My calling this process developmental is based on the assumption that at later times, the teacher will be "better at" or "smarter" about what she does. And implicit in the ethical aspects of the research is that the educational situation for the students will improve and that they will be treated with respect and consideration. The need to know

suggests that if there are no internal checks to the validity of the data and analysis, there will no ways for the conscientious teacher to confirm that her actions will result in her development or will be ethical. Teachers feel a need to know in order to pursue right practice --they are concerned about what to do, and how to do it, to increase the intellectual, political, and moral growth of particular students in particular situations. This need to know sometimes leads teachers to seek out the methods of traditional educational researchers to warrant their beliefs.

I include in traditional educational research studies that are experimental, quasi-experimental, or survey, and case studies including those modeled after ethnography. Within this tradition, ways in which the validity of both quantitative and qualitative data can be maximized have been described by many writers. Many of these methods and techniques have been used by teacher-researchers. Some teacher-researchers make use of quantitative as well as qualitative data (Feldman, Mason, and Goldberg, 1992). However, when accepting the methods of educational researchers they are most attracted to qualitative methods. Erickson (1986), Eisner (1991), and Lincoln and Guba (1985) have described ways in which ethnographic and other varieties of qualitative research can be warranted. In her recent piece on Validity in action research, Watkins (1991) has shown how Lincoln and Guba's guidelines can be used to assess the validity of teacher's research. Although some have questioned the warrant to claims of validity made by qualitative researchers (Phillips, 1987), these methods have entered the mainstream of educational research (Gage, 1989). While strict adherence to these methods to seek warrants for knowledge claims might satisfy Erzberger's need to know, there is a limit to the resources that she has available for implementing them. Therefore her efforts could only approximate them, which brings the knowledge claims into question for her.

The validity of action research

Proponents of teacher action research have not left the question of validity and warrants for knowledge claims unexamined. They are aware of the difficulty in laying on to teachers' work and lives the additional role of researcher (Goodson, 1991). Elliott (1991) has addressed this issue of validity of data, if somewhat obliquely, in his book Action research for educational change. Under the rubric, "Developing the next action steps," Elliott recommends that the following be remembered when a teacher-researcher monitors the effects of his or her actions:

> (a) One needs to use monitoring techniques which provide evidence of how well the course of action is being implemented.
>
> (b) One needs to use techniques which provide evidence of unintended as well as intended effects.
>
> (c) One needs to use a range of techniques which will enable one to look at what is going on from a variety of angles or points of view (Elliott, 1991, p. 76).

That is to say, first, one must collect data which can be used to evaluate the implementation of the actions; second, that it is important to collect data that will provide evidence for the existence or non-existence of unintended effects; and lastly, that the teacher-researcher should triangulate the data to gain different perspectives on the situation. It is not clear how this list differs significantly from the methods of traditional educational researchers.

Altrichter and Posch have identified four quality criteria for action research:

1) Consulting alternative perspectives: "Are the understandings gained during a research process confronted with the perspectives of other persons concerned or other researchers?"

2) Testing through practice: "Is care taken in the research process that the results are tried out and evaluated in practical action?"

3) Ethical justifiability: "Is the research process compatible with the educational aims and does it correspond with principles of human interaction?"

4) Practical compatibility: "Are the research process and the instruments of investigation structured in a way that can be used by professional practitioners for the further development of their practice without an excessive additional expenditure of time (Altrichter and Posch, 1992, unpaged)?"

Although this list corresponds to a high degree with criteria lists for qualitative research (Erickson, 1986), there are some significant differences. The first is that of ethical justifiability. This difference is not nearly as great as it would have been before the institution of human subjects boards and the need for their approval became a part of scientific research projects. Even so, what Altrichter and Posch are suggesting goes beyond that. Their claim is that ethical considerations must be an integral part of all aspects of teacher-research. One example of this is in the acknowledgment that ownership of data is an ethical issue (Elliott, 1991; Simons, 1987). In order to ensure against the misuse or misinterpretation of sensitive data, Elliott (1991) suggests the following:

Cross-checking eyewitness accounts of events and observations.

Giving individuals opportunities to reply to accounts of their activities and views, and have these incorporated into documents and reports.

Presenting alternative descriptions, interpretations and explanations of events and practices.

Consulting individuals about the contexts in which their actions and views are represented and reported (p. 64).

In this way, he brings the questions of ownership of data to the forefront of the research.

The second difference is that of practical compatibility. Because the teacher-researchers are employed full-time before they begin to do research, it is important that the inquiry that they engage in be embedded in some way in what they are already doing. This is both because they have very little time in which to do these activities, and that by making sure in some way that the research is developmental, they have an important intrinsic reason for pursing the research.

The third difference, and possibly the most significant, is that of testing through practice. Again, contemporary traditional researchers have been moving more in this direction. The development and informal testing of hypotheses during the data collection process has become an accepted part of qualitative research. For teachers, this is operationalized as the collection and analysis of data, and the generation and testing of hypothesis while teaching. The problem, again, for Erzberger, is how to do this in a way that adequately tests the hypotheses with limited data about a highly particularized and fluid situation.

A review of different epistemologies

At this point I will examine several authors' attempts to search for a basis for validity of teacher-research in non-positivistic epistemologies. In both Elliott (1991) and Altrichter and Posch (1992) there is a suggestion of positivism that has been questioned by other proponents of action research that arises from the import of data collection and analysis in their action research methodologies. This can be seen clearly in Elliott's chapter, "A practical guide to action research (1991)" which is almost entirely devoted to the collection and analysis of data. Winter (1989) raises the question of the importance of data and the "positivist echoes" that arise from that importance by suggesting a continuum of professional decision making. Winter puts on the smallest scale those decisions that are a routine part of all professional work. This is the monitoring and adjusting that is routine for all professionals. For a science teacher it might be noting the looks on students faces when explaining a particularly difficult concept and deciding to offer a different explanation, or for a physician it might be changing a patient's prescription because he is not responding to it. On the end of the continuum, which represents the largest scale, Winter places decisions made on the basis of policy research. Here a governmental agency might commission a large scale survey of teacher education institutions to determine if credentialling standards should be revised (Winter, 1989, pp. 31-32).

It is between these extremes that, according to Winter, action research, and other forms of developmental teacher-research, lie. Teachers engaged in research collect data which they use to gain new understandings of their educational situations and to have defensible reasons for their actions. On the smallest scale end of the continuum of

professional decision making, there is no claim that research is being done. One may talk about reflective practice (Liston and Zeichner, 1987; Schön, 1983) on this level, but it is not often spoken of as research. The policy studies are seen as research, and if they are based on survey or other quantitative data there is enough data to claim statistical generalizability. Even when the policy research consists of case studies or other forms of qualitative research, there is enough data of the proper types to warrant any claims that arise from it. But, according to Winter, when teachers who are engaged in action research in their own classrooms use a positivistic epistemology, their work is open to the criticism that there is not a large enough "n" to warrant claims quantitatively or qualitatively. That is,

> ... the number of observations will be too small to be able to claim that they are based on a representative sample, and this in turn threatens to undermine the value of any conclusions (Winter, 1989, p. 32).

The teacher-research is then criticized for being insufficiently warranted by the data. Winter takes this as a reason to reject a positivistic epistemology which separates "findings" from implementations.

Altrichter (1991) makes the same claim. In answering the questions, "How can I ensure quality in my action research?" he writes that it

> cannot be ensured by using specific methods and instruments of research ... [or] by sticking to a set of methodological criteria which have been imported from other fields of research, be it from traditional empirical research, be it from newly developed qualitative methodologies (p. 4).

Instead, quality is achieved by "... tightly interlinking theoretical and empirical, inductive and deductive aspects." He concludes with the saw, "What's good for practice is good for research (p. 4)." Both Winter and Altrichter seem to be suggesting that Erzberger modify her epistemology and present alternatives to a highly structured conception of research.

Feminist theory offers additional possibilities. Patti Lather and Susan Noffke have written in this area and have suggested alternate epistemologies from feminist theory and post-modernism. Lather has addressed the issue of validity in what she calls praxis-oriented research programs (1991). She claims that due to the current paradigmatic uncertainty in the human sciences, the "best tactic at present is to construct research designs that demand a vigorous self-reflexivity (1991, p.66)." She suggests four ways in which to encourage this: triangulation, construct validity, face validity, and catalytic validity (pp. 66-68). Lather's conception of triangulation is no different from that described by Erickson (1986) or Eisner (1991). It is based on multiple sources of data and multiple perspectives. By construct validity, she is referring to an awareness by the researcher of the ways in which theories and other constructs are created. She claims that "A systematized reflexivity which reveals how a priori theory has been changed by the logic of the data seems essential in establishing construct validity in ways that will contribute to the growth of illuminating and change-enhancing social theory (p. 67)."

Face validity is related to "a click of recognition," a realization that what is being described or explained rings true. And catalytic validity "represents the degree to which the research process re-orients, focuses and energizes participants toward knowing reality in order to transform it (p.68)."

Of these four ways to encourage validity, the first two are well within the domain of traditional educational research. Both require the sort of data collection and analysis that Erzberger finds problematic. Triangulation can be made less problematic by reconceptualizing it so that it is loosely defined as seeking multiple perspectives. Even so, the latter two seem more promising. Face validity often comes up as a way in which teachers assess one anothers' hypotheses and conclusions. Noffke (1991), has suggested a similar warrant. She has used as the basis of her analysis the concept of "epistemic privilege of the oppressed." Epistemic privilege is one of experiential knowledge, the knowledge that is gained from "being there." Noffke reminds us of the words that educational researchers who have had classroom experience often hear, "You've been there. You know." She does add two caveats to this concept. The first is that "situation alone does not privilege one's view (p. 4)." And second, that there is no unified view of who that person is who engages in the labor process of teaching (p. 4)." What this suggests is that teachers do not have an epistemic privilege simply because they are people who teach in schools, and that epistemic privilege is not reserved for those who fit a certain set of criteria. Instead it comes about from living an experience in a particular context. That is, "Who we are, where we find our 'homes,' both physical and ideological, plays an integral part in our knowledge claims (p.5)."

It is clear that teachers have an epistemic privilege. Their schools are their homes in both a physical and an ideological sense. As insiders they have a view of what happens in schools that is only approachable by the outside researcher. However, privilege does not necessarily lead to fidelity. An appeal to epistemic privilege reinforces the notion that outsiders researching alone cannot get the whole picture without working with insiders, but it does not resolve Erzberger's dilemma. She accepts that her vantage point is privileged -- what she wants to know is that what she sees is not an illusion. She is aware when she feels that something is valid on the face of it, but that does not satisfy her need to know.

It is catalytic validity that might serve as a way out of Erzberger's dilemma. However Lather has described this with the language of the neo-Marxist, post-modernist, and feminist paradigm within which she works, which is alien to many US teachers. In the next section of this paper I will develop a way of looking at teaching that will result in a rejection of the question of validity while developing a construct parallel to catalytic validity.

The nature of teacher-research

The form of research in which Erzberger has been involved differs significantly from traditional educational research. First, it is self-developmental, and second, it is

insider research. The self-developmental aspect of the research is due to the research process being turned on the researcher herself. As Cochran-Smith and Lytle see it

> Teacher research is concerned with the questions that arise from the lived experiences of teachers and the everyday life of teaching expressed in a language that emanates from practice. Teachers are concerned about the consequences of their actions, and teacher research is often prompted by teachers' desires to know more about the dynamic interplay of classroom events (1993, p. 59).

As my research on the Physics Teachers Action Research Group has shown, the types of research questions that are asked include:

> "How can I get a better understanding of my practice?"

> "How can I improve what I am doing?"

> "How do my actions affect the learning of my students?"

> "How does my knowledge of my subject affect my pedagogy?"

In attempting to answer questions like these, the teachers gain a better understanding of their educational situation. And through this increase in their knowledge, improve their practice (Feldman, 1993). As a result of their research the teachers not only generate new knowledge about their roles, but in addition, learn to do it better and gain a better personal understanding of what it is they do and the situation within which they do it.

Situations and horizons

It is important at this time to clarify what I mean by teachers' educational situations. It is more than the context within which they practice. The context is the setting in which they teach -- the backgrounds in front of which they act. To speak of the teaching context conjures up an image of teachers as separate entities, distinct from their surroundings, and affected or acted upon by those other entities that make up the context. Those entities include their students, other faculty, the school administration, and all the inanimate objects found in the classroom and school. Instead, I claim that teachers find themselves thrown into an educational situation constituted by all that has occurred in the past and from which they project themselves into the future (Heidegger, 1962). In their acts of being a teacher they are immersed in their educational situation which is made up of all the entities which constitute their context, and the past and possible future actions of other animate entities. I am claiming that to come to a new understanding of their educational situations will enable the teachers to make better decisions as to how to act within those situations, and will result in an improvement in practice.

The image of a horizon might be helpful here (Gadamer, 1987). The teacher's view of her educational situation is in some ways like a horizon. While the context is

fixed, the educational situation, like a horizon, travels with the teacher through space and time. And like a horizon, there are no boundaries to the educational situation. As the teachers situation shifts with time and space, the horizon shifts, encompassing new entities, and the histories and futures of those entities.

Because this self-developmental research is done within the teacher's educational situation, it takes on the nature of insider research. As insider research it is completely biased and non-objective. The teacher cannot take on the role of the dispassionate outsider who seeks to find objective truth. Because the object of the research is the teacher's own educational situation, she finds herself, her research and her teaching all immersed in that situation. To attempt to separate her role as researcher from her role as teacher would be as fruitless as trying to separate her identity as a teacher from any other identity . Even as she goes about doing her research, her understanding of her educational situation changes, her horizon shifts, and she finds that the target of her research has shifted with it. Therefore she must acknowledge the place of her research within her educational situation.

It is this change in educational situation and shifting of horizon that results in a significant problematic aspect of teacher-research. In many ways, traditional research methodologies assume a non-temporal object of that research. I am not suggesting that time is not a factor or variable in that research. A study can be extended over a period of time but there is the assumption that if repeated at a different time the results will be similar if not identical. This is seen most clearly in the physical sciences. For example, students typically reproduce historical experiments in physics. There is the expectation that a replication of Michelson's experiment would not find that the speed of light is different for different observers, or that a repeat of Galileo's experiment would find that objects do not accelerate uniformly under gravity. That is, the results of these experiments are identical whether they are done in the 17th, 19th, or 20th centuries. There is a similar assumption made in research in the social sciences: If a study is repeated it should be possible to make the same generalizable conclusions.

On the other hand, the object of teacher's self-developmental research is both temporal and spatial. As the teacher engages in the research process she comes to a different understanding of her educational situation that results in her deciding to act in different ways. The educational situation that she was investigating no longer exists -- her horizon has shifted. This might at first appear to be no different from what occurs in any sort of naturalistic inquiry. The community that the ethnographer is studying changes with time as people interact with one another, geological processes continue and effect the understanding of the earth scientist, and ecosystems are always in a state of flux. But in each of those cases, the object of the research is outside of the professional situation of the researcher. This is not the case for the teacher. The impetus for the research, some discrepancy or dilemma of practice might still be there, but the events that illuminated it for the teacher are in the past. By reflecting on those events, the teacher has gained insight, a new perspective, a different understanding of her educational situation. She has gained knowledge, she knows more about teaching and how to teach.

The outsider-researcher will return to that event by examining documents, and interviewing informants for different perspectives. By doing this the researcher comes to an understanding of the situation that transcends that situation. The researcher asks "What is this a case of?" or, "To what theory can I generalize this case?" If teachers inquire in the same way, there will be similar shifts in their perspectives. The purpose for the teacher to engage in research is to come to a better understanding of her educational situation to improve her practice. This has occurred in the inquiry that happened at that time. New events that upon reflection can further illuminate her educational situation continue to happen. Her knowledge grows through reflections on those events and circumstances. To do the sort of research that the ethnographer does is to focus on what has happened and not on what is happening. There is a trade-off of reflection-on-practice for reflection-in-practice. The result could be a net loss for the teacher in terms of the efficacy and efficiency of her practice.

The question then becomes, "Why should a science teacher engage in this type of reflective inquiry?" For science teachers held captive in the role of researcher, for example those enrolled in university courses that incorporate teacher-research, the answer is obvious -- it is required. If the science teacher is to get credit for that course, then she must complete that research project. The research report or case study that emerges from the inquiry is completed for the same reasons that a student completes any assignment. Of course there are those who are in the course "to learn" and realize the personal and professional growth that occurs when assignments are completed. And it would be clear to most teachers that research of this type, which focuses on their practice, is more useful to them in their teaching and is not a target of the teacher's complaint about educational research -- that it is removed from practice. Teachers who have joined consortia of teacher-researchers do not have the course requirement hanging over them as a reason for delving into the single instance in detail through writing up their research. However, it has been my experience that many of the science teachers who have been engaged in self-developmental research activities would rather not make a written report. They choose to do so because they have agreed to it as part of their original commitment to the project, or their stipend is tied to successful completion of the report, or they feel a responsibility to the research facilitator.

This is not to say that there are no good reasons for science teachers to inquire in-depth into their practice and to report on it to others. These reasons include adding to the knowledge base of teaching, providing other science teachers with an opportunity to share in the knowledge that they have gained in their research, and to receive critical feedback. It is also possible that the research reports can be written in the form of teaching cases to be used in the education of other science teachers (Shulman, 1992).

This temporal and spatial nature of teachers' work-- the subject of their research -- has added a second dimension to Erzberger's dilemma. Even if the dilemma could be resolved in the way it was originally stated, the effect of engaging in an in-depth inquiry process on the pace of teaching and the rhythm of the classroom must be considered. It is not just a question of the allocation of resources. Because of the self-developmental and

ethical nature of teacher-research, a focus on any instance by the teacher removes her attention from other instances and other children.

Out of the dilemma

The language of educational situations and horizons is a way to begin to get out of the Erzberger's dilemma. What Erzberger is trying to do is to evaluate her teaching using outcome measures. These outcome measures, whether they are questionnaires that seek changes in attitudes towards physics, or scores on standardized achievement tests, or even longitudinal studies of students in their college years and later, all focus on particular aspects of the students situations. What Erzberger is attempting in her teaching, however, is not changes that can be measured in those ways but a change in her students' being. She wants to effect a change that results in their looking at the world in different ways -- to have new horizons. But just as Erzberger has an educational situation that includes the past effects of all the entities that impinge on her teaching and all the possible future actions of those entities, the students find themselves thrown into their own, but equivalent, situations with their own horizons. Erzberger's task then, is not to construct a new horizon for each student to lay open or to push aside the old, or even to transform their existing horizons into her conception. Instead she needs to seek a way to merge horizons -- for her students' horizons to fuse with hers so that they together begin to see the world in the way that she envisions it.

If this is the case, then the task of teaching and the evaluation of that teaching is radically altered. Outcome measures look at what the teacher does to the students, In using them there is the assumption that the teacher can cause a transformation of the students in ways that are discrete and particular. If the task of teaching is re-envisioned to that of the teacher attempting to project out of educational situations so that the teacher's and students' horizons fuse into a new shared understanding, then evaluation of teaching needs to be centered on the teachers' decisions and actions.

This also shifts the focus for teacher-research and alters the question of validity in teacher-research. There is no longer a need for the type of data and analysis that is a part of standard research in the social sciences. The teacher-researcher is not attempting to prove causality of the type that Erzberger was looking for, or the type of generalized propositions that are the products of much research in the psychology of education. She is not even attempting to look at cases of her practice to answer the question of "What is this a case of?" and then generalize to theory. Instead, what she is looking at are the ways in which she can project from her educational situation in a way that generates new educational situations that includes students in a way that results in a merging of horizons. Although there are hoped for outcomes -- for example, Erzberger's of her students looking at the world in a new way -- what is important for the teacher are the decisions she makes and the actions she takes as a result of those decisions. She can then ask whether by deciding to act in a certain way, and then in fact acting, she has modified her educational situation in the way in which she has envisioned it.

An understanding of the educational situation arises in a way through what might be thought of as a conversation or dialogue with that situation. The teacher might ask, "What is the question that my students are answering when they behave in that way?" Or, "What question I am answering as I go about my practice in this way?" The actions of the individuals who lie within the horizon of the educational situation are answers to questions being asked by that situation. We respond with our actions that result in a shift in horizon and a modified, apparently new educational situation. When Andria Erzberger asked her students to find out what their parents learned about physics by experiencing the class vicariously through their children, that action was in response to a question posed by the educational situation in which she was immersed. To come to an understanding of that situation she must begin a reflective dialogue with it --by first trying to determine the question to which her action was an answer to. Self-developmental teacher-research proceeds in this way through discourse with the situation being lived to gain a better understanding of it and to improve practice.

It is in this way that it is reminiscent of Lather's catalytic validity. The validity of teachers' self-developmental action research arises from their discourses with their educational situations that leads to a change in their understanding of those situations. From those new understandings comes a transformation toward the shared revisions of the situations. And so, in Lather's words, the teachers are "coming to know reality in order to transform it." For Erzberger, this means that her need to know has been misdirected. While it is important what the students have learned, how their attitudes towards science have changed, and whether they are thinking in new ways, an assessment of students in those domains will not gain her the new understanding of her educational situation that would allow her to shape it and the educational situations that she shares with her students so that their horizons change in the ways that Erzberger desires. By paying careful and critical attention to her practice within her horizon, she can shape the shared educational situation to project towards her goals for her students.

Implications for action research in pre- and in-service science teacher education

What Erzberger's dilemma suggests is that if the research activities that science teachers engage in are to have any lasting effect on their professional lives, it must be reconceptualized so that it is not an addendum to what teachers do, but is seen as an active part of teaching activities. This is what Elliott (1990, 1991) has been calling for in his recent work, that university researchers stop their "hijacking" of teacher-research and the resulting transformation of it into a sad copy of traditional educational research. It is also what Atkin (1992) has reacted to when he called for the separation of the university from teachers' action research -- for teachers' action research to be what teachers will actually do, and for that research to result in new understanding and improved practice, it must be an activity separate from that which university researchers engage in.

While most of this relates to action research done by practicing teachers, it does have significant implications for the pre-service education of science teachers. As I have already stated, some form of teacher-research is becoming an integral part of many credentialling and masters degree programs for teachers. In the former it takes the form

of an assignment that is done either during student teaching of in a prior observational placement. Action research 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 the 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 is 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 an acceptable 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 between 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 that is part of teacher education programs is to have a significant and lasting effect on practice, it, too, must be shaped in ways that match a model that will be more self-sustainable.

And what of action research as a model for staff development? The prevailing models of staff development that pervade schooling are derived from a process-product perspective of educational research (Sparks and Loucks-Horsley, 1990). That is, some treatment is developed, teachers are trained to implement it, and then students are tested for the results of that treatment. When applied to the in-service education of teachers, this model appears as the training of teachers to implement curricula and pedagogy to increase student learning (Joyce and Showers, 1983, 1988). When put into practice, this model is most often realized as outsider experts coming to schools to either train teachers in some new form of pedagogy or to instill them with knowledge derived from educational research. While this model is being challenged (Lieberman and Miller, 1991), there is still the suggestion that outside experts need to come into schools to tell teachers how to be professionals. Both Sagor's how-to book (1992) and Holly's (1991) chapter on action research as staff development are indicative of this. They each present algorithmic models of action research that are heavily influenced by traditional models of educational research.

What I am suggesting is that in order for teacher-research to be effective -- for science teachers to come to better understandings of their educational situations through it, and for practice to improve -- a radically different conception of what counts as research must be accepted. It is a conception that fits into what science teachers already do -- the monitoring and adjusting of good practice. 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 significance changes in the ways that the work of science teachers is structured, to ask them to engage in traditional forms of research in addition to everything else that they do is to ask teachers to find new ways to make bricks without straw.

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