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Teacher Research: Exploring Student Thinking and Learning

Teachers who conduct research in the context of their own teaching practices can contribute to knowledge about reform-based instruction.

Introduction

What does it mean for teachers to do research? Is forming a fleeting question in the midst of teaching an act of research? Making copies of student work and discussing these with colleagues? Videotaping small group activities and writing about what students said and did? Analyzing performance differences among classes taught in different ways? Presenting or publishing findings about student thinking and learning?

All of the above seem to me to be acts of research to be celebrated and nurtured (van Zee, 2005; van Zee & Roberts, in press). As an organizer of Teacher Researcher Day during national conferences of the National Science Teachers Association (http://www.nsta.org), I welcome a wide spectrum of participation, from teachers just beginning to ask questions about their students' learning to presenters who have published their own studies. Some authors, however, prefer to reserve the word "research" for more formal investigations (Hammer and Schifter, 2001; Richardson 1994).

Several phrases refer to research conducted by individuals in the context of their own practices. For example, three special interest groups (SIGs) of the American Educational Research Association (http://www.aera.net) focus on such research. These include the Teacher as Researcher SIG, which "is dedicated to supporting research done in schools by PreK-12 practitioners on their own practice" (http://www.teacherasresearcher.org). Participants in the Self-Study of Teacher Education Practices SIG are "teacher educators who are working on the problems of education through the study of their own practices" (http://www.ku.edu/%7Esstep/about.htm). The purpose of the Action Research SIG is "to involve teacher-as-researchers, administrators, resear chers, and community members in collaborative action research that exami nes educational practice and encourages educational reform and improvement" (http://explorers.tsuniv.edu/ar-sig/).

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The emerging importance of teacher research also is evident from publications, including books about methods of conducting such research (Cochran-Smith & Lytle, 1993; Hopkins, 2002; Hubbard & Power, 1993, 1999; McNiff & Whitehead, 2005; Mills, 2003). A chapter on science teachers as researchers will appear in the upcoming *Handbook of Research on Science Education* (Roth, in press). For the first time, a chapter on practitioner research was included in the fourth edition of the *Handbook of Research on Teaching* (Richardson, 2001). This chapter provided a detailed review of the history and various forms of research in which individuals have investigated their own practices in the context of whatever roles they have played in educational settings (Zeichner & Noffke, 2001). A bibliography of publications about the scholarship of teaching and learning in higher education (Hutchings & Bjork, 2002) is available at http://www.carnegiefoundation.org/elibrary/docs/bibliography.htm.

The potential of including teachers in the research enterprise has been recognized for many decades. Early in the 20th century, for example, John Dewey (1928/56) envisioned teachers as producing "a series of constantly multiplying careful reports on conditions which experience has shown in actual cases to be favorable or unfavorable to learning" (p. 125-126). Late in the 20th century, Eleanor Duckworth (1989) articulated a similar vision in her essay "Teaching as Research." She proposed that teachers could legitimately "contribute to the theoretical and pedagogical discussions on the nature and development of human learning" (1987, p. 168). Cochran-Smith & Lytle (1990, 1999) reflected on many of the issues that arise, however, when research on teaching is conducted by university researchers observing others teach or by teachers on their own practices.

In the *National Science Education Standards*, the National Research Council (1996) recommended that "Professional development activities must … provide opportunities to learn and use the skills of research to generate new knowledge about science and the teaching and learning of science" (p. 68). In a subsequent publication, the Council advocated models of professional development that include reflection, intellectual engagement, and advancement in the profession (NRC, 2001, p. 103). Feiman-Nemser (2001) described a "new paradigm" for professional development in which "teachers must be able to ask hard questions of themselves and their colleagues, to try something out and study what happens, to seek evidence of student learning, and explore alternative perspectives" (p. 1040). Such studies are a form of teacher research and can evolve into systematic efforts that generate knowledge that other teachers find useful.

Most teacher research yields detailed descriptions and interpretations specific to particular situations. Such reports are typical of qualitative research rather than quantitative studies. Differences between these research paradigms have been described in terms of several criteria (Donmoyer, 2001). The emphasis in qualitative research is on transferability (whether a reader views findings as applicable to the reader's own situation) rather than generalizability (whether the findings apply anywhere at any time). Also considered is whether enough sources were consulted over a long enough time period in thorough enough ways (trustworthiness) rather than whether others can get the same results (reliability). A third criterion is whether the interpretations make sense (credibility) rather than whether what was measured matches well with what was asked (validity).

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Teachers who conduct research in the context of their own teaching practices can contribute to knowledge about reform-based instruction. Examples below include documenting inquiry-based science instruction, developing documentary web sites to share findings about science learning and teaching, contributing to knowledge generation at state and national as well as local levels, addressing the needs of at-risk students, and forming collaborative research communities. These examples illustrate research by elementary, middle school, high school, and college faculty as well as the use of data such as transcripts of discussions, reflective journals, and copies of student work. The paper closes with some suggestions for getting started with teacher research.

Documenting Inquiry-based Science Instruction

Teachers who document their students' learning can help interested colleagues in envisioning the inquiry-based science instruction recommended in the National Science Education Standards (National Research Council, 1996). In Doing What Scientists Do: Children Learn to Investigate Their World, for example, Ellen Doris (1991) describes ways in which she engages children in making observations and generating questions that they can explore.

In discussing her role as a facilitator of learning, Doris presents a transcript of seven- and eight-year old children sharing their observations of crickets with one another (Doris, 1991, p. 91): See Figure 1.

The transcript continues with the children's suggestions for what they might do to find out about cricket eyes. In writing about these students' observations and questions, Doris reflects upon both the students' thinking and her role as the teacher in eliciting that thinking. She notes the importance of extending the initial observations children make, of calling attention to differences in their observations, of recognizing assumptions being made, and of helping children figure out how to go about answering their own questions.

Other books by elementary teachers documenting their own teaching practices include *Nurturing Inquiry: Real Science for the Elementary Classroom* by Charles Pearce (1999), *Talking Their Way into Science; Hearing Children's Questions and Theories, Responding with Curricula* by Karen Gallas (1995) and *Science Workshop: Reading, Writing, and Thinking like a Scientist* edited by Wendy Saul, Jean Reardon, Charles Pearce, Donna Dieckman, and Donna Neutze (2002).

Figure 1

Marty:	They have long feelers that look as if they come out of their eyes.
Beth:	I noticed that my cricket has two eyes.
Jeff:	Some have two little tails on the back and some have the two little tails with one big tail in the middle.
Jackie:	My cricket has four eyes.
Teacher:	Wait a minute! When Beth looked at her cricket, she found two eyes. When Jackie looked, she found four! Did anyone else see eyes on a cricket?
Nicky:	Mine had two.
Maureen:	Mine too!
Lynnie:	I think mine had four.
Jeff:	Mine definitely had two.
Greg:	I think that they have lots and lots of eyes—they have a special kind of eyes.
Teacher:	Compound eyes?
Greg:	That's it.
Teacher:	Claudia, you look puzzled.
Claudia:	But how do you know where the eyes are? I didn't see <u>any</u> eyes!
Douglas:	They're on the head—one on each side—right where the feelers are.
Claudia:	But how can you tell those are eyes? Just because our eyes are on our heads doesn't mean a cricket's are!

Developing Documentary Web sites to Share Findings about Science Learning and Teaching

Teacher research also includes developing documentary web sites to share one's findings about science learning and teaching. A middle school science teacher, Claire Bove, for example, created a web site to show how she establishes a community within her classroom, encourages a playful approach to experimentation, engages students in developing explanations and questions as well as in talking and arguing about science (http://feelingathome.org).

Developed with support from the Carnegie Foundation for the Advancement of Teaching, Bove's web site includes examples of students' writings and drawings with commentary by the teacher as well as video clips of students in action. Also included are video clips of the author and a colleague talking together about their teaching practices.

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In a reflection comparing science discourse in her middle school classroom and the cell biology research lab in which she had worked as an undergraduate, Bove wrote:

> One of the most interesting parts of the [undergraduate research assistant] job was going to the weekly lab meetings … The main difference between the talk at these lab meetings and the talk in a science classroom was that no one in the lab knew the answers to the questions we were asking … It is hard to have this kind of genuine discussion in a middle school classroom …
>
> Because the teacher does know the answer, students are used to trying to figure out what the teacher thinks the answer is. To change this classroom dynamic, and to get students to try and

> figure out what they themselves think the answer is, I try to frame classroom discussions so that I ask about students' experience of, and opinions about, the things we are studying.
>
> For example, to bring in their own experience, I ask them if they have ever felt an earthquake, and what happened when they did … And to encourage them to state their own opinions, I frame questions like this: "Jerrad said that a pinto bean will sprout if you get it wet, but a popcorn kernel won't. Do you agree or disagree?" When the question implies that it is another student who is proposing a science idea, instead of the teacher, it is much easier for a student to put forth his or her own idea.
>
> Before we have the class discussion, I often ask students to find out what the person next to them wrote. And then I ask them to tell what they, or the person next to them, answered.
>
> All of these techniques are attempts to help students practice saying what they think, and to defend what they think, and often to change what they think. In short, to practice discourse as a way to learn to think.

Under construction is an addition to the web site with a detailed presentation of student explorations about density (Bove, 2006).

Such documentary web sites make available examples of inquiry-based instruction, particularly for prospective teachers, who may not experience reform approaches in their placement classrooms. A teacher educator, Anna Richert at Mills College, for example, uses Bove's web site, as well as others, as "texts" in her course on adolescent development. She has documented this use on her own web site (see http://quest.carnegiefoundation.org/~arichert/section2A.html). In a web page entitled "Getting Started: Learning to Learn from the Practice of Others," she reports on her invitation to the prospective teachers in her class to investigate the following questions: "What do these teachers know about their learners? How do they come to know their learners? And how do they use this knowledge in their teaching?" On a web page entitled "Studying Claire's Site," Richert provides links to a lesson plan, study guide, prompt page, and syllabus as well as video clips of prospective teachers discussing Claire's web site. By perusing Richart's web site, interested teacher educators can learn from her experiences in using the K12 documentary web sites to foster learning about teaching.

Known as "snapshots of practice," other web sites developed with Carnegie Foundation support are collected in an online "gallery" (see http://gallery.carnegiefoundation.org). Several of these are discussed in detail in an anthology (Hatch et al, 2005). They represent forms of making public these teachers' "wisdom of practice" (Shulman, 2005).

Contributing to Knowledge Generation at State and National as well as Local Levels

Some teacher researchers contribute to knowledge about teaching and learning not only by conducting workshops in their schools and districts but also by presenting at conferences, publishing their findings, and applying their results at state and national levels. A high school physics teacher, Jim Minstrell, for example, began documenting his students' learning by asking his students diagnostic questions at the beginning of a unit and shaping instruction according to their responses (1982). Funding from government agencies and private foundations enabled Minstrell to devote some of each day to his research as well as to teaching. He viewed his classroom as a research site for studying physics learning and teaching by himself, his students, two mathematics teachers whom he was coaching to teach physics, and university researchers whom he invited to participate in his projects.

Over many years, Minstrell and his colleagues developed a framework of Facets for Thinking that is aligned with Washington State's Essential Academic Learning Requirements and the *National Science Education Standards* (National Research Council, 1996) (see http://www.facetinnovations.com/main/facet-think.htm for middle school science and mathematics and high school physics). For example, the *National Science Education Standards* includes the following content standard for Grades 5-8: "The motion of an object can be described by its position, direction of motion, and

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speed. That motion can be measured and represented on a graph." (NSES p154, grades 5-8). The cluster of facets related to motion includes several ways in which students view a graph:

> **90** Student views a position or speed graph as a map of the actual motion.
> **91** Student interprets an upward (or downward) sloping graph to mean the object is going up hill (or downhill).
> **92** Student interprets a flat line on the graph to mean the object is moving on a flat surface.

The framework of facets of student thinking has served as the basis for building a diagnostic assessment system for promoting learning (Minstrell, 2000, 2001) and development of a computer program, the Diagnoser, that students can use to check their understanding (see http://www.diagnoser.com/diagnoser/).

Focusing on the Needs of "At Risk" Students

College instructors also have been documenting their own teaching practices. A professor of chemistry, Denis Jacobs (2000), for example, developed a web site to share with other faculty ways in which he redesigned a general chemistry course to address the needs of "at risk" students (see http://gallery.carnegiefoundation.org/djacobs/). The web site presents his rationale, ways he implemented cooperative learning strategies, and assessments of the impact of these reforms on students' performance, attitudes, and subsequent success in advanced science courses. One page of the web site compares the traditional and alternative sections of a course in terms of numbers of students enrolled in lectures (about 250 in each), recitations (optional for the traditional section, mandatory for the alternative section), and laboratories (mixed enrollment from both sections). Jacobs describes what he does during lectures as follows:

> Students pair off to discuss conceptual questions in lecture. Periodically during each lecture, I ask a conceptual question to the 250 students in the class. The students vote, through a show of hands on various responses to the question. Then I ask the students to turn to someone sitting next to them and to explain their reasoning. After two or three minutes of one-on-one discussion, the class votes again on the possible answers. Next, I ask representative students who voted on different responses to share their reasoning with the entire class. We often perform a live experiment to test which response is most correct.
>
> Eric Mazur, a physicist from Harvard University, developed this approach to peer instruction and called it 'concept tests.' Faculty at the University of Wisconsin and Carnegie Mellon University have written similar 'concept test' questions for general chemistry.

By providing links to web sites by colleagues at other universities, Jacobs fosters communication of reform practices that he has found useful in the context of the large lecture courses typical of science instruction at major universities. The web site also includes video clips of cooperative learning during recitation sections where students work in small groups to solve challenging problems. In addition, the web site documents dramatic improvement for "at risk" students in terms of their performance on general chemistry exams, performance in related science courses, choice of majors, and attitudes.

Forming Collaborative Research Communities

Teachers in a school may collaborate with one another and/or with university researchers on long-term research projects. In *Creating Scientific Communities in the Elementary Classroom,* for example, Maureen Reddy, Patty Jacobs, Caryn McCrohon, and Leslie Rupert Herrenkohl (1998) report upon their collaboration as teacher and university researchers. Their book includes sections written by the teachers as well as by the university researchers in interpreting what was happening during implementation of a new science curriculum in two second grade classrooms. Caryn McCrohon, for example, reflected upon her disappointment with the curriculum's worksheets and subsequent shift to using dialogic journals:

For both research scientists and teacher researchers, acts of research begin with curiosity about phenomena observed.

> For the most part the worksheets were coming in filled out, but I quickly discovered that they did not help me assess what the children were learning. The worksheets required the children to record results, or answer one or two factual questions. They did not ask the type of questions that stimu-

> lated descriptions of procedures, explanations, or even children's general thinking about the activities …

With advice from her principal, she shifted to having the students write journals:

> Once we were finished with our wrap-up my students had about thirty minutes to write a journal entry and draw a picture to go with the entry. At first I was a bit wary. Science was taking longer than expected out of our seven-hour day. My principal said not to worry because science journals are part of language arts and she was excited to see writing across the curriculum. (p.94).

Following Caryn's reflections is a section written by the university researchers that provides examples of many kinds of journal entries by the children and their teacher. The collaborative construction of this account of the use of dialogic journals makes available to interested teachers both the perspective of the classroom teacher and the detailed analysis developed by university researchers. Other accounts of collaborative research communities include *Changing Schools From Within: Creating Communities of Inquiry* by Gorden Wells (1993) and *Teacher Research for Better Schools* by Marion Mohr, Courtney Rogers, Betsy Sanford and Marion Nocerino (2002).

Getting Started with Teacher Research

For both research scientists and teacher researchers, acts of research begin with curiosity about phenomena observed. A good way for teachers to get started is to listen closely to what their students say, to watch what their students do, and to record any questions that such observations prompt them to wonder. By writing reflective journals, teachers can begin documenting what is happening in their classrooms.

Interested teachers should consult with their principals about the need for district approval of more formal studies. Although obtaining permission from parents involves some effort, placing an audio- and/or video- camera unobtrusively in the classroom and taping instruction can capture interesting conversations about science for later reflection and analysis. Making copies of a variety of student work can trace students' growth and document various ideas they generate.

School administrators can foster teacher research by providing equipment, supplies, journals, and most importantly, time during the school day for teacher researchers to meet regularly to discuss their studies with one another.

Teacher researchers can learn from one another by meeting regularly to discuss video clips of their students in action or a set of student work. Taking the next step to share findings through school and/or district workshops can deepen one's own understandings as well as communicate insights and experiences. Presenting at conferences and writing for publication can inspire others to begin improving their practices through such inquiries.

School administrators can foster teacher research by providing equipment, supplies, journals, and most importantly, time during the school day for teacher researchers to meet regularly to discuss their studies with one another. District and state administrators can assist by designating resources for teacher research and by sponsoring teacher researcher workshops and meetings. In addition, funding for travel to present at conferences can help interested teachers become part of a broader research community. County funding, for example, made possible participation in a NSTA national conference of a teacher researcher who described his experiences there as follows:

> Teacher Researcher Day allowed me to stand in one room (literally), look around, and say, 'Wow! Here's a group of individuals dedicated to teaching/learning. It doesn't get any better than this!' I felt as though it elevated what I do as an individual and lends credibility to me, the classroom teacher. We had a ballroom full of excited individuals talking about student thinking and what that thinking meant. [teacher researcher, NSTA national conference, April 2003]

Through experiences such as these, teachers can learn from one another how to formulate questions about science teaching and learning, collect data as they teach, develop interpretations of these data, and share their findings with others. Such classroom-based research has the potential to inspire teachers to improve instruction through learning about, trying out, and adapting practices advocated in reform documents.

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