EDUCATIONAL RESEARCH ABSTRACTS

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Editors' Note: As noted in previous issues of the *Journal of Mathematics and Science: Collaborative Explorations*, the purpose of this Educational Research Abstract section is to present current published research on issues relevant to math and science teaching at both the K-12 and college levels. Because educational research articles are published in so many different academic journals, it is a rare public school teacher or college professor who reads all the recent published reports on a particular instructional technique or curricular advancement. Indeed, the uniqueness of various pedagogical strategies has been tacitly acknowledged by the creation of individual journals dedicated to teaching in a specific discipline. Yet many of the insights gained in teaching certain physics concepts, biological principles, or computer science algorithms can have generalizability and value for those teaching in other fields or with different types of students.

In this review, the focus is on "action research." Abstracts are presented according to a question examined in the published articles. Hopefully, such a format will trigger your interest in how you might undertake an action research study in your own teaching situation. The abstracts presented here are not intended to be exhaustive, but rather a representative sampling of recent journal articles. Please feel free to identify other useful research articles on a particular theme or to suggest future teaching or learning themes to be examined. Please send your comments and ideas via e-mail to gmbass@wm.edu or by regular mail to The College of William and Mary, P.O. Box 8795, Williamsburg, VA 23185-8795.

Action Research in Your Own Classroom

Where the action is! What images from your past does that phrase invoke? For today's senior citizens it might be World War II, a good paying job, and a house in the suburbs. For middle age Baby Boomers that cry may summon memories of social activism, Dustin Hoffman's introduction to "plastics," Woodstock, or carefree summer days at the beach—they might even remember the Dick Clark TV show of the same name! For Generation X, their action expanded from MTV into Wall Street investment banking. And where else could the action be for today's Generation Y but the Internet and Dot Com enterprises?

Yet for all age groups who happen to be in the teaching enterprise, the action is really to be found in only one place—the classroom. From the kindergarten teacher of five-year-olds to the college professor of graduate students, all teachers act in a classroom to enhance the learning of their students. Most typically, that classroom is a physical space where the teacher and students

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interact face to face. However, a "classroom" connection can also be made through teacher-student correspondence (traditional or electronic) and through students' engagements with exciting, informative materials (books, media, labs, and high-tech teaching technologies).

No matter where that classroom is, the dedicated teacher constantly tries to improve that learning link between the students and the subject matter. One systematic way to do that is through a kind of inquiry known as Action Research (also referred to as "teacher-as-researcher," "teacher-researcher," and "classroom-based research"). As David Kember describes it in his book, *Action Learning and Action Research*, "action research is:

- concerned with social practice;
- aimed toward improvement;
- a cyclical process;
- pursued by systematic enquiry;
- a reflective process;
- participative;
- determined by the practitioners." (p. 24)

Essentially, action research is a teacher's careful look at students at work in one particular classroom (usually his or her own!). The teacher-researcher systematically collects data, analyzes it, and reflects on what it says about the teaching-learning process in that class. While such action research is intended to be very personalized to a certain group of students in a specific class at one precise time, it may sometimes provide valuable insights that may prove helpful to other teachers as well.

The following articles describe different kinds of action research carried out by teachers in a variety of classroom settings. What those teachers did and what they discovered may encourage you to try action research in your own teaching. What worked for them might work for you, but remember the old TV commercial caution, "Individual results may vary." Not all research findings about teaching and learning will generalize to the uniqueness of your teaching situation. Yet when it comes to understanding what works best in your own classroom, give action research a chance, for that is truly "where the action is."

Action Research in College-Level Courses

- **How might replacing traditional assessment practices with portfolio assessment affect students in a college physics course?**

The use of student work portfolios to document learning has been one of the main recommendations of the assessment reform movement. Instead of evaluating students' learning through objective paper-and-pencil examinations, these reformers want students to provide a collection of evidence that shows their learning. Such a portfolio might contain student essays about concepts learned, journal entries on the importance or usefulness of course topics, homework assignments, relevant laboratory reports, study guide quizzes, short research reports, in-depth analyses of course-related phenomena, or any student work that demonstrates evidence of learning. Unfortunately, the empirical evidence for using portfolios in college-level science courses has been lacking.

Slater, Ryan, and Samson undertook action research in two sections of an algebra-based introductory college physics course to measure the impact of portfolio assessment compared to traditional assessment. Both sections were taught by the same instructor (Slater) and contained sixteen and nineteen undergraduate students respectively. The section of sixteen students was randomly chosen to be evaluated using portfolio assessment while the other section had three tests with traditional multi-part problems and short essay questions as the primary assessment procedure. A pre-test/post-test self-report survey of student perceptions of achievement was given to all students, along with a comprehensive final examination of 24 multiple-choice items matched to the 24 course learning objectives. Most of these items involved calculation since the test was given as an open-book, open-note, open-portfolio exam. Analysis of the results showed no significant differences between the two sections of students. Slater, Ryan, and Samson concluded that a portfolio assessment approach supported learning in a college-level physics course at the same level as did more traditional assessment. In a focus group discussion with students after the course, they found that students in the portfolio section felt less anxiety about learning physics, spent more time outside of class reading and studying physics, personalized the course material more, and enjoyed the learning experience more than students in the traditional assessment section.

T. Slater, J. Ryan, and S. Samson, "Impact and Dynamics of Portfolio Assessment and Traditional Assessment in a College Physics Course," *Journal of Research in Science Teaching*, **34**(3) (1997) 255-271.

- **What difference does it make in the way a teacher models physics problem-solving for students?**

A traditional part of every physics course is having students solve problems. Bob Kibble writes about one particular problem he gave his students to solve: "Janet and her brother decided to race along to the end of their street and back again. The street was eighty meters long. Janet ran at 2.5 m s^{-1} while John's speed was 1.5 m s^{-1}. Where were they when they passed each other?" Kibble reports he received correct solutions from eight students, but when he examined their approaches, he discovered six different methods of solution (using a table, using a graph, using relative speed, using ratios, and two different algebraic solutions). He acknowledged that he might generally first think of a mathematical approach whereas others might find pictorial or conceptual methods more effective. A teacher could use action research to monitor and categorize students' problem-solving strategies in order to acknowledge the variety of legitimate ways to think about and solve problems.

B. Kibble, "How Do You Approach a Physics Problem?" *Teaching Physics,* **34**(1) (1999) 16-18.

- **How well does a cooperative learning strategy work with physics students?**

Most experienced physics teachers reluctantly concede that neither an excellent lecture nor a good set of textbook problems will necessarily lead their students to a clear understanding of key physics concepts. So what's a teacher to do? A group of physics professors in Australia have tried a cooperative learning strategy called the Conceptual Understanding Programme (CUP). Three or four students of mixed ability form a group that works on physics concepts in real-life situations. The students first think about the situation on their own and then they work together as a team. Students are encouraged to use diagrams to describe their thinking so that they can represent relative sizes and relationships of physical objects without calculations. During the subsequent discussions, the instructor facilitates communication among teams and helps the students work toward a consensus view of the situation. Four of these one-hour sessions were held throughout the semester.

Students were interviewed, the CUP sessions observed, and a follow-up survey administered as part of an evaluation of this cooperative learning strategy. Mills, *et al* report that students using the CUP approach showed a high level of enthusiasm, a feeling of being recognized as individuals, an awareness of the value of understanding concepts, and an awareness of how they were learning. While these action researchers acknowledge that some students were cautious about the value of the small group sessions—most usually "shy" students, students with insecurities about their physics knowledge, students from different backgrounds than the majority of students, or students who wanted to find a "final answer" through formulas and quantitative calculations—they also affirm the value of these CUP sessions to enhance the conceptual understanding of difficult physics ideas for a majority of students.

D. Mills, B. McKittrick, P. Mulhall, and S. Feteris, "CUP: Cooperative Learning that Works," *Teaching Physics*, **34**(1) (1999) 11-16.

- **What reform teaching strategies benefit the higher-order thinking skills of organic chemistry students?**

Higher-order cognitive skills (HOCS) such as question asking, problem solving, decision making, critical thinking, and evaluative thinking have often been distinguished from lower-order cognitive skills (LOCS) such as remembering, comprehending, and applying memorized algorithms. While HOCS is a worthy goal for college science courses, many professors are gratified to see their students reach a proficiency level for LOCS about the subject matter. Zoller argues that higher-order thinking can be achieved if faculty make the effort to teach and assess with an HOCS emphasis. He supports his view by reporting two international efforts in organic chemistry courses in Israel and Canada.

In both the small organic chemistry course in Israel (class size of 31 students) and the large class in Canada (152 students), the instructors used an inquiry approach in which they raised questions rather than simply providing explanations. For example, this is one of the questions used to initiate class discussion, "An acid-catalyzed addition of D_2O to propene would give an alcohol. Do you expect the product to be optically active? Explain." They also used higher-order thinking test items than would be found in a traditional organic chemistry course. For example on the midterm exam, they asked this question, "The hydrolysis of esters is based on the reversibility of the esterification reaction. Which of the following esters do you expect to hydrolyze faster in an alkaline hydrolysis and why? Explain. [Two different chemical compounds were shown underneath the question.]"

Zoller used students' performance on both HOCS and LOCS test questions and conversations with students to evaluate the effectiveness of this inquiry teaching strategy. He concluded that students' exam performance showed the approach to be feasible and effective in both small and large chemistry classes. He acknowledged the legitimacy of faculty concerns that there is insufficient time for full coverage of all course topics using an inquiry approach and that some students will prefer a traditional teaching approach of lecture and test. Zoller also admitted that HOCS assessment in large classes is “a very tedious, lengthy, and time-consuming task.” Nevertheless, he believes that an HOCS orientation in chemistry better prepares students for real life thinking outside the classroom rather than does a LOCS-type final exam. Through instructional innovations such as peer grading, instructor practice with Socratic questioning, and guidance in better test item construction, Zoller believes HOCS-fostering pedagogies can be creatively implemented in college chemistry courses.

U. Zoller, “Scaling-Up of Higher-Order Cognitive Skills-Oriented College Chemistry Teaching: An Action-Oriented Research,” *Journal of Research in Science Teaching*, **36**(5) (1999) 583-596.

- **What is the impact of using concept maps and interpretive essays in undergraduate mathematics classes?**

So draw me a picture? One way students might show what they understand about a topic is to draw a concept map (also known as a “graphic organizer” or “web”). A concept map is a graphical illustration of concepts to form chains of relationships. Typically, each concept is represented by a node with a line and linking words connecting the nodes to indicate specific relationships. In an action research study with her own students, Linda Bolte describes how such concept maps and writing accompanying interpretive essays might be used to assess students' organization of mathematical knowledge.

Bolte taught 27 prospective elementary teachers enrolled in a required mathematics content course, eighteen prospective secondary mathematics teachers in a required geometry course, and 63 students enrolled in two sections of *Calculus I* how to construct concept maps. She illustrated the various steps in constructing a concept map with a variety of familiar mathematical terms and gave students practice in arranging and linking the various terms. Once students had completed their concept maps, they wrote an essay that clarified the relationships portrayed in the concept map.

Bolte evaluated the effect of the concept maps and essays through the use of a holistic scoring criteria that focused on the organization and accuracy of the concept map and the communication, organization, and mechanics of the essay. She discovered that the concept map/essay scores were more highly correlated with final grades than the combined homework and quiz scores in three of her four classes. She also reported that the concept map and essays allowed her to identify student misconceptions and students' mathematical knowledge better than through a more traditional measure on homework and examination problems. Students reported that the concept maps/interpretive essays helped them reflect on their work in a more explicit manner, encouraged them to modify and extend their mathematical knowledge, and allowed them to think about mathematics as a more creative activity. Bolte believes her experience should encourage other mathematics teachers to use concept maps and interpretive essays because they involve significant mathematics, accommodate individual student differences, require effective student communication, and motivate students' best performance.

L. Bolte, "Using Concept Maps and Interpretive Essays for Assessment in Mathematics," *School Science and Mathematics*, **99**(1) (1999) 19-25.

- **How might a special problems physics course be used to introduce pre-service elementary students to the practices and discourse of science they would later use with their own students?**

Smith and Anderson designed a physics course in which future teachers would have a real opportunity to: (a) invent models and theories to explain and predict phenomena; (b) design, gather, and interpret data; (c) consider authoritative sources and evaluate their validity claims within a community of discourse where knowledge claims are publicly debated. Nine seniors in a five-year elementary teacher preparation program were enrolled in the course. A semi-structured interview about these students' science learning experiences and their views about science was conducted with all nine students either at the beginning or end of the course. During the course, the instructor and students kept journals and all class sessions were videotaped. Two graduate research assistants met weekly with the instructor to discuss students' progress and class experiences.

Using the physics of light as the focal topic in the course, the instructor had students read storybooks which raised interesting scientific questions. They would share ideas about the physics involved in the story situation and discuss ways to find out answers and test out student ideas. In small groups, they would design specific experiments and make models to represent or explore emerging theories. The whole class would come together to share their work and discuss outside readings and the validity of scientific claims. A central theme in the course was the role of discourse in scientific practice. Stories about scientists' disagreements about models of light highlighted the roles that discourse, publication, and the larger scientific community played in validating claims (p. 758).

At the beginning of the course, Smith and Anderson discovered that students started the course with different attitudes about science and science learning. The "knowers" were successful science learners who focused on facts, getting the right answer, and conformity with the trusted authority of textbooks and professors. The "wonderers" were unsuccessful science learners who valued their personal experiences and beliefs and seldom made appeals to scientific authorities. By the end of the course, both sets of students had expanded their views of the roles of models, data, and authority in the generation and validation of scientific knowledge. The students also showed a decline in faith in authority and a more complex understanding of the nature and value of authoritative sources. The search for logical connections among the models and data replaced students' habitual acceptance or rejection of authoritative scientific knowledge. Smith and Anderson argue that providing such reform-based course experiences can result in "elementary teachers who bring solid conceptual understanding as well as sophisticated sociocultural views of science to their work with children." (p. 774)

D. Smith and C. Anderson, "Appropriating Scientific Practices and Discourses with Future Elementary Teachers," *Journal of Research in Science Teaching*, **36**(7) (1999) 755-776.

Action Research in K-8 Classes

- **What experiences prepare fifth grade students to understand the multiplication of fractions?**

How can a teacher best help students understand "taking a part of a part of a whole" in a meaningful way? Nancy Mack suggests a three step approach any teacher can use in her own class: "What mathematics do I want students to learn?; What informal knowledge do students have?; How might I help students build on their informal knowledge?" (p.34) With respect to multiplication of fractions, a teacher might want her students to be able to solve problems such as, "You have one-half of a giant chocolate chip cookie. You give your friend one-fourth of the piece you have. How much of the whole cookie did you give your friend?" [Mandated grade-level curriculum guides or a school system's learning objectives will often identify the mathematics you are supposed to teach. Nevertheless, the revised NCTM standards, as well as your own classroom wisdom, should broaden your decision about what mathematics students need to know to accomplish the state standards!]

Mack suggests a series of questions to assess the informal knowledge of students about multiplying fractions. "There are eight cookies on a plate. Three people want to share all the cookies. How many cookies will each person get?" Look how each child tries to solve that problem. Let them draw diagrams. Let them act out the answer with "pretend" cookies. Let them even work with numbers if they want. Next, ask students to explain the meaning of a fraction. Then, give them the problem of finding one-fourth of one-half of a cookie. Mack believes all these approaches will give the teacher a more accurate diagnosis of each student's informal knowledge that can guide her instructional decisions.

Once a student's current level of understanding is assessed, the teacher can introduce a sequence of activities to build on that knowledge. Mack suggests starting with equal-sharing situations such as sharing eight cookies among three people. Then students can be asked to find a fraction of a whole number before tackling the "part of a part of a whole" situation such as finding one-fourth of four-fifths of a cookie. Throughout her article Mack encourages teachers to apply action research to their lessons. Keep track of what children do to solve your problems. Look at the kinds of diagrams they use to explain their ideas. Keep a notebook of their responses and your observations. Use the diagrams they draw to help the students connect to number sentences involving multiplication of fractions. Assess the effectiveness of your instructional activities with students having different informal knowledge of multiplying fractions.

N. Mack, "Building a Foundation for Understanding the Multiplication of Fractions," *Teaching Children Mathematics,* **5**(1) (1998) 34-38.

- **How can you enhance the geometry concept learning of elementary school students?**

Geometry is a course that some states are now requiring for high school graduation, but geometric understanding does not start in ninth or tenth grade. NCTM standards stress that the conceptual basis of key mathematical ideas begins in the early elementary grades. Fuys and Liebov recommend two different ways to teach geometric figures and suggest teachers systematically examine the effects of these different instructional practices with their own students.

One approach to geometry concept learning is the use of "best examples." Students are shown examples that clearly demonstrate variations in the attributes of the selected concept. For instance, equilateral triangles or hexagons can help students understand regular polygons, especially if these geometric figures are presented in multiple ways (everyday objects, manipulatives, diagrams, verbal definitions).

Another concept learning instructional approach is to use "concept cards" in which examples and non-examples of two-dimensional and three-dimensional geometric shapes are shown to students. Students can use either a prototype strategy (their "average representation"of key features) or a rule-based strategy (their understanding of key properties of figures) to categorize new examples. Students can do this individually, in small groups, or in a teacher-led whole class lesson.

Fuys and Liebov encourage teachers to undertake action research when using different concept learning strategies. They believe both approaches have value whether taught in expository or inquiry lessons, but they more strongly believe that teachers must discover for themselves which students learn better with which method. Teachers should try both a "best example" and "examples/non-examples" approach with their students. If they keep accurate records of each student's progress, they should be able to discover whether one teaching method is generally more effective or whether individual differences among their students result in both methods helping different types of students to learn their geometric shapes.

D. Fuys and A. Liebov, "Concept Learning in Geometry," *Teaching Children Mathematics*, **3**(5) (1997) 248-251.

- **How are middle school teachers doing "action research" like seventh grade students doing "authentic science?"**

Almost sounds like a riddle, doesn't it? Bencze and Hodson however are very serious when they make that analogy. They believe certain myths about scientific inquiry are still taught in school:

- Science starts with observation
- Science proceeds via induction
- Experiments are decisive
- Scientific inquiry is a simple, algorithmic procedure
- Science is a value-free activity

Now substitute "curriculum knowledge" for science, "student activities" for experiments, and "curriculum development" for scientific inquiry. The resulting statements are still myths. What does it take to help teachers become curriculum makers rather than just curriculum implementers?

A Canadian researcher (Bencze) and two teachers collaborated to develop and implement a more authentic seventh grade science curriculum. The researcher encouraged the teachers to repeat cycles of: (a) reflecting on and challenging each other's beliefs and practices; (b) seeking and critiquing alternative views to develop new approaches; and, (c) field testing and evaluating these approaches in their classrooms. The teachers developed more open-ended scientific investigations for students where designing a variety of scientific inquiries, thinking about variables, and interpreting findings were more important than merely duplicating the textbook-derived "correct answer." Both the students and the teachers became more independent thinkers about the scientific process and less accepting of the common myths about science.

One of the main goals of this authentic science curriculum is to help students and teachers expand their idea of scientific inquiry from pure experiments to correlational and practical field-based studies. Bencze and Hodson report that this new kind of science curriculum helped students "reflect on what causal relationships may exist in a system, plan appropriate action to bring about a desired change, implement that action, and evaluate its effectiveness. Within the action research group, teachers behave similarly. Action research is also based on the premise that understanding can result from action." (p. 536) While Bencze and Hodson admit the teachers felt they never had enough time to accomplish all the curriculum reform they wanted, these researchers also proclaim that systematic action research during everyday teaching does allow teachers to reassess their own views and practices in the most meaningful way.

L. Bencze and D. Hodson, "Changing Practice by Changing Practice: Toward More Authentic Science and Science Curriculum Development," *Journal of Research in Science Teaching*, **36**(5) (1999) 521-539.

Action Research in College Courses for Pre-Service Teachers

- **What are the advantages and disadvantages in using an oral performance assessment in a mathematics methods course?**

Write it or say it? What is the best way to determine what your students have learned? The reform movement in mathematics and science recognizes that changes in instructional techniques and pedagogical strategies must be accomplished by changes *in assessment* procedures. If classroom teachers are expected to use a variety of assessment techniques with their students, then college professors should model these procedures in college level teaching methods courses.

Denisse Thompson believes so strongly in that philosophy that she implemented an oral performance assessment into her mathematics methods course. Because much attention was given in her methods courses to the development of mathematics concepts through the use of manipulatives, she wanted to go beyond written exams in assessing her students' ability to explain those concepts. At the beginning of the year, students were given guidelines for the oral performance with a list of tasks (e.g., "Illustrate the meanings of perimeter and area using pattern blocks"; "Demonstrate congruence and similarity using a geoboard"; "Illustrate the meaning of surface area using blocks"; "Illustrate the Triangle Inequality Theorem using straws.") At the end of the semester, each elementary methods student was scheduled for a twenty minute interview in which she would be given five randomly chosen tasks to demonstrate. Each task was graded on a ten-point scale to reflect both appropriateness of each student's answer and need for prompting from the instructor.

Thompson used both her students' and her own reflections about this oral performance assessment. She believes it has the advantage of allowing the instructor to probe for greater depth of student understanding than on written tests, to remediate misconceptions during the oral interview, and to prompt students for more explanations of a given concept. Students identified the ability to demonstrate mathematical knowledge with manipulatives, the importance of practicing effective communication skills, the one-on-one feedback from the instructor, and the ability to determine their strengths and weaknesses in that interview as the biggest advantages. Students identified being nervous during the interview as the biggest disadvantage. Thompson saw the biggest disadvantage as the amount of time needed to conduct the interviews. However, she believes it is comparable to the instructor time needed for grading essay exams or lesson plans. For Thompson, the advantages far outweigh the disadvantages, and it has the added benefit of modeling alternative math assessment techniques while encouraging pre-service teachers to use such techniques with their own elementary school students. "Educators must practice what they preach or run the risk of having their message fall on unbelieving ears." (p. 88)

D. Thompson, "Using Performance Assessment to Engage Pre-service Teachers in Mathematical Discourse," *School Science and Mathematics*, **99**(2) (1999) 84-92.

- **How might a methods of teaching science course be used to introduce pre-service students to becoming a "teacher as researcher?"**

Action research does not just happen. The seed of the idea to do it must be planted, nourished, pruned, and admired. Emily van Zee describes what she did in her methods of teaching science courses between 1995 and 1997 to help students learn how to do research. While her main course goals were to increase the competence and confidence of prospective teachers in teaching science, she also wanted to incorporate research experiences in her courses. Van Zee began her course by having students describe their prior experiences learning science. The students analyzed those experiences that fostered the most positive science learning experiences (e.g., interesting subject matter; hands-on experiments; enthusiastic teacher; allowed to make mistakes). Each week, the students wrote a reflective journal entry about a science learning event they had observed or experienced. They would later reflect on these entries to identify common themes and factors that promote effective science learning. Finally, in their take-home final, the students would recommend science teaching methods based on their observations, connect these claims to science teaching standards, and formulate a research question that could be explored in their own classrooms after they graduated.

Van Zee also used this inquiry approach in exploring science content by focusing on one topic in depth throughout the semester on phases of the moon. Early in the semester, students again indicated what they already knew about the moon and what they would like to discover about it. Throughout the course, students summarized observations, shared patterns observed, and described their models to explain these patterns. The conclusion of this process required students to communicate their current understanding of the phases of the moon as well as the process by which they had reached this opinion. Van Zee also expanded this inquiry technique through field-based assignments where the prospective teachers interviewed children and adults about a particular topic. The students then designed "conversation" (rather than "lesson plans") that could be used to initiate, facilitate, experience, and assess these science ideas in their school placement settings.

Through instructor reflection, students' written work, and informal student questionnaires, van Zee concluded that students agreed her teaching methods were a good match to the national standards for science teaching. Many students expressed appreciation for her student-centered approach and its positive impact on their attitudes toward science and science teaching. However, many students complained about the amount of student-centered work and asked for more of the "standard teacher lecture." Some students do prefer learner-centered teaching; other students prefer teacher-directed instruction. There is no one best way to induce a love for and understanding of science learning in prospective school teachers. Yet through a commitment to action research, the classroom teacher can connect her teaching beliefs to real life outcomes and find personal meaning in both the product and the process of that research effort.

E. van Zee, "Preparing Teachers as Researchers in Courses on Methods of Teaching Science," *Journal of Research in Science Teaching*, **35**(7) (1998) 791-809.

- **Still not convinced to try some action research? Why else would you conduct action research in your own classroom?**

Lederman and Niess argue that action research can and should be a significant component of both pre-service and in-service teacher programs because it is the most direct route to helping teachers become reflective practitioners. They believe systematic, classroom-based inquiry helps teachers develop a critical eye about their own instructional practices. Investigating classroom instructional and learning actions can sensitize the teacher to the multitude of variables and relationships that impact successful teaching. It also may help teachers see educational research as a valuable contribution to their own understanding, rather than just journal articles of esoteric, theoretical, impractical, over generalized, jargon-filled pages with nothing to say to them. Action research in your own classroom is aimed at the questions you want answered, the issues that will help you become a better teacher with students who become better learners. Action research can speak louder than textbook words when it comes to understanding what works in your own teaching.

N. Lederman and M. Niess, "Action Research: Our Actions May Speak Louder Than Our Words," *School Science and Mathematics*, **97**(8) (1997) 397-399.

Next Steps!

For other ideas about the kinds of action research you might try with your own students, look at any research article on a topic of personal interest. What did those researchers do that you might want to try in your own classroom? For example, White and Frederiksen provide an extensive description of the reform teaching strategies of student inquiry, teaching modeling, and metacognitive thinking applied to science. Why not take one aspect of their approach to try in one of your own lessons or units? What do you think might happen? What kinds of data can you collect to test out your expectations? What did you find and what does it mean? Don't wait. Action Research today means Better Teaching tomorrow.

B. White and J. Frederiksen, "Inquiry, Modeling, and Metacognition: Making Science Accessible to All Students," *Cognition and Instruction*, **16**(1) (1998) 3-118.

Sample Books on Action Research and Teacher-Researcher Research

G. Burnaford. J. Fischer. and D. Hobson (eds.), *Teachers doing research: The power of action through inquiry*. Erlbaum, Mahweh. NJ. 2001.

Z. Donoahue. M.van Tassell. and L. Patterson (eds.). *Research in the classroom: Talk. texts. and inquiry*. International Reading Association. Newark, DE. 1996.

D. Hopkins, *A teacher's guide to classroom research,* Open University Press, Buckingham, 1993.

R. Hubbard, and B. Power, *Living the questions: A guide for teacher-researchers*, Stenhouse, York, ME, 1999.

D. Kember, *Action learning and action research: Improving the quality of teaching and learning*, Kogan Page, London, 2000.