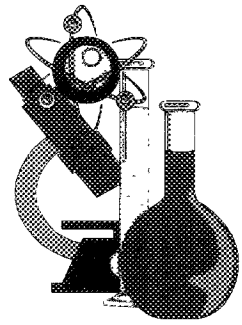

Studying the Game: Action Research in Science Education

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Unlike the highly publicized work of many other professionals, the complexities of the science teaching profession are not widely recognized by the general public. Teachers as a whole have never enjoyed the same professional status as, say, lawyers or doctors. One major difference between the teaching profession and law and medicine involves the process by which new knowledge is generated and used within the profession itself. For example, the research base that informs the medical profession is widely known and highly respected for its utility in helping doctors diagnose and treat illnesses. An equally important research base exists in the field of science education, yet the general public is primarily unaware of that fact. The problem of low professional status is exacerbated when classroom teachers fail to recognize or value educational research in their practice (Clough 1992; Penick 1986; Tillotson 1998).

Sagor (1992) notes that "in education, the worlds of research and practice are both separate and unequal, for the teacher who ignores research is likely seen as anti-intellectual or unprofessional, whereas the researcher who ignores the classroom bears no such label" (4). Why, one must ask, hasn't educational research had more of an impact on practicing teachers?

The reason that teachers lack interest in educational research is that the topics chosen for study seldom have any direct implications for what should occur in real science classrooms. This reluctance on the part of teachers to acknowledge the science education research base is partly to blame for the slow progress in enacting meaningful changes in the way we educate children in science. One doesn't have to look far in most public schools today to find outdated teaching practices and assessment strategies, in spite of ample research findings that suggest more effective alternatives. Noted science education reformer Paul Hurd (1986) said it best: "Current problems in science education do not stem from our inability to discover what should be taking place in the classroom. Rather, our problems stem from our inability to put our knowledge into practice" (1).

The Promise of Action Research

One promising solution to the problem of research failing to inform practice is the expansion of action research at the K–12 level (Calhoun 1994; Cox and Craig 1997; Sagor 1992; Tillotson 1998). Action research is a systematic form of inquiry carried out by teachers and administrators who seek answers to classroom-based problems and issues. The applications of the research results are both immediate and practical.

Choosing the type of classroom-based inquiry to engage in is usually governed by the nature of the topic selected for study. Science teachers interested in examining their classroom practices, and the impact they have on students, typically gather a variety of data throughout the school year that help in that evaluation process. This is known as a reflective form of action research (Feldman 1996). It is continual and ongoing, and often spawns ideas for subsequent action research projects.

Action research can also be geared toward addressing specific school issues through a problem-solving approach (Feldman 1996). In that case, teachers or administrators focus on a specific, significant problem in the school. The action researchers ask questions about the problem, develop a plan for gathering informative data, and carefully analyze the data to make the most informed choices about how to resolve the issue.

The Action Research Cycle

Although there is no single, fixed procedure that must be adhered to in the action research process, there is a

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general pattern that most practitioner-oriented investigations follow. Sagor (1992) offers a five-step model: *problem formulation, data collection, data analysis, reporting results,* and *action planning* (10-11). A sports-coaching metaphor may make for a fruitful comparison as we examine each step in the model more closely.

1. Problem Formulation. A coach prepares for a game by identifying areas of the team's performance that need the most improvement for the team to win. A science teacher does much the same thing. Both coach and teacher consult with associates and review individual and team performances in recent events. In this problem formulation stage, researchers identify what they already know about an issue or problem, what they still need to know about it, and their understanding of the key variables affecting the situation. It is important that the research questions have attainable results and that the phenomena fall within the action researcher's scope of influence (Cox and Craig 1997). The action researcher must be both concerned about and interested in studying the problem that is identified.

2. Data Collection. Once the coach has identified the team's problem (e.g., an inability to defend against the run or disproportionate participation in science classroom discussion by students based on gender), sets of data must be gathered that will help the researcher determine the effectiveness of the strategies used to correct this weakness. In this stage of the process, action researchers must also assemble sets of data from all possible sources. They must determine the sample populations to be accessed; the scope and length of the data collection effort; and the various types of data that will be needed to complete the study successfully. In general, the most reliable and valid results are obtained when researchers gather a minimum of three sets of data for each research question posed to triangulate the findings (Sagor 1992). Appropriate sources of data might include the following:

- Existing sources: student work (portfolios) or archival evidence
- Tools for capturing everyday life: logs, journals, videotapes of lessons, photographs, and shadowing of research subjects
- Tools for questioning subjects: interviews, written surveys, tests and quizzes, and focus groups

3. Data Analysis. After the game, or after the classroom data have been compiled, the researcher/coach analyzes the data, looking for patterns, trends, significance, and correlations. Conclusions are drawn, and suggestions are made, based on that careful analysis. This stage of the process yields the most rewards, as meaningful information on how to improve practice or resolve an issue is uncovered.

4. Reporting Results. Once a researcher/coach has analyzed the team's data, sharing of the results occurs. That sharing step ensures that others know the outcomes of the practitioner-oriented research within the school community, as they may also stand to benefit from this knowledge. Even in the case where the research involves a single teacher gathering data from one classroom, the potential for other teachers to learn from the careful investigation of that problem or issue is very high. The reporting stage also promotes a spirit of risk-taking and innovation within the school community and emphasizes the importance of continual improvement efforts. The sharing of action-research results empowers teachers as both learners and inquirers and leads to a reduction in the research-practice gap in schools (Cox and Craig 1997). In some cases, action researchers may even wish to publish their findings in educational journals as a means of further contributing to the existing research base in education (Richardson 1994).

5. Action Planning. Having studied the problem—whether it's a poor run-defense or uneven discussion participation—the teacher/coach uses the information to generate a new game plan. (The revised game plan will be modified later as new information is uncovered after each game/classroom discussion.) The action plans can include

- changes in current teaching and assessment practices;
- alterations in existing school and/or classroom policies; and
- new mechanisms for studying problems or issues within the school community.

It is critical that action research be recognized as a cyclical process (Calhoun 1994; Cox and Craig 1997; Sagor 1992; Tillotson 1998). Each stage of the action research model directly informs the others, leading to new studies' being born from existing ones. That cyclical process occurs in all types of action research, regardless of whether it follows the teacher-as-researcher, collaborative action research, or schoolwide action research model. Figure 1 provides an example of an action research study that demonstrates the process.

The Benefits of Action Research

The climate in most of our nation's schools is strained. Teachers and administrators are struggling to achieve new mandates while dealing with factors such as limited financial resources, teacher shortages, and a population of students whose educational and emotional needs are greater than those of any past generation. Action research represents one powerful tool for improving the quality of teaching and learning within a school community.

Past research on school effectiveness has shown that

FIGURE 1
Action Research: A Practical Example

SETTING
The setting is a rural elementary school in upstate New York that qualifies as a high-needs district. Two fifth-grade science teachers are collaborating on an action research project geared toward helping students achieve the New York State math, science, and technology standards. They have created a hands-on unit on weather that involves students in collecting real data, analyzing data, communicating their findings, and applying this knowledge to new situations. The teachers decide to teach parts of the unit in a traditional lecture/notes format and the other part in a more student-centered, inquiry format. They then compare student outcomes in both cases.

RESEARCH PROBLEM
- How will students react to nontraditional styles of instruction during the new, realigned weather unit?
- Will student-centered lab investigations assist students in applying their knowledge to new situations?

DATA COLLECTION
- A pre- and post-instruction student questionnaire that measures students' attitudes toward learning science, learning style preferences, and preferred teaching style is administered.
- Observational data are collected throughout the teaching of the weather unit.
- Interviews are conducted with a sample of students from class.
- Assessment data are gathered on students' conceptual understanding via a brief quiz.

DATA ANALYSIS
- The teachers compare pre- and post-results on the surveys and quizzes.
- The teachers look for patterns and trends in the observational data that both had collected.
- Interview responses are categorized and grouped by type.
- The findings suggest that students routinely had better attitudes toward science learning during the inquiry activities. Students preferred to have hands-on experiences as opposed to notes and lectures. The quiz scores showed that students were successful in applying the knowledge they had learned in the realigned weather unit to novel situations. Some students needed more teacher guidance than others during the inquiry activities.

REPORT
The teachers jointly author an action research report that they share with the teaching staff, district curriculum coordinator, building principal, superintendent, and board of education. In the report, they emphasize what they investigated, what they collected as evidence, and what they learned from the process. They also identify what the next phase of the action research cycle will examine.

ACTION PLANNING
The teachers decide that students need additional opportunities to practice with inquiry-oriented activities that require them to organize their own data and apply problem-solving strategies. A revised plan for gathering research data is also developed.

in the most successful schools teachers are likely to (*a*) discuss teaching and learning issues with one another on a regular basis, (*b*) collaborate on the preparation of materials, (*c*) critique each other's work, and (*d*) jointly design lessons (Little 1982). Similarly, other research has shown a set of norms that typically distinguish schools where student growth and development are likely to occur. These norms are the following:

- Collegiality
- Experimentation
- High expectations
- Trust and confidence
- Reaching out to the knowledge base
- Tangible support
- Appreciation and recognition
- Caring, celebration, and humor
- Involvement in decision making
- Protection of what's important
- Traditions
- Honest, open communication (Saphier and King 1985, as quoted in Sagor 1992, 6)

Although the benefits of action research are well documented, its success in any given school community depends on a number of conditions' being met. First, faculty and administrators must be committed to changing the status quo. Second, there must be a clear understanding about how decisions will be made and implemented, based on what is learned from each action research initiative. Third, study groups or small teams of researchers should spearhead the effort and should meet often to consider progress and review the objectives of the investigation.

The Link between the University and the Classroom

Our understanding of the complexities of teaching in schools can only be enhanced by collaborative efforts that join university faculty and classroom practitioners in applied action research. Such efforts provide practitioners with technical support and offer university researchers a dose of practical reality concerning school-based issues (Calhoun 1994). In fact, no longer is it possible, or wise, for universities to conduct educational research that serves no one other than themselves and other researchers. Classroom science teachers can no longer ignore current knowledge on effective practice and continue to use outdated and ineffective techniques.

Action research provides a vehicle for bridging the gap between research and practice. Substantial evidence exists that "when teachers have the time and opportunity to describe their own views about teaching and learning, to conduct research on their own teaching, and to compare, contrast, and revise their views, they come to understand the nature of exemplary science teaching" (NRC 1996, 67).

Just as coaches must continually modify and adjust

their game plans, so, too, must science teachers commit to providing their students with the most effective learning experiences possible. That can only happen when the lines between classroom teachers and university researchers become so blurred that we value equally the contributions each group makes to the knowledge base.

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