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ABSTRACT

This study focuses on a professional development program that employs action research as a strategy. The goals of the program include encouraging volunteer teachers to conduct research projects that can inform their understanding of student learning and achievement and increasing teachers' awareness of the value of disciplined inquiry to answer questions and suggest solutions to perceived problems in classroom instruction and student learning. Sources of data for the study include notes on group discussions, a collection of electronic mail correspondences, personal journals, written reports, videotaped presentations, and survey evaluations of the practitioners' action research experiences. Findings suggest that some of the refinements to practice implied by the action research results have longevity and are an effective means of increasing student achievement and understanding. Contains 23 references. (DDR)

Narrowing Gaps and Formulating Conclusions: Inquiry in a Science Teacher Action Research Program

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NARROWING GAPS AND FORMULATING CONCLUSIONS: INQUIRY IN A SCIENCE TEACHER ACTION RESEARCH PROGRAM

Background: A Consideration of Educational Gaps

The Research-Practice Gap

The "research-practice gap" has recently received attention in such varied forums as educational journals (Cochran-Smith & Lytle, 1990; Kenney, 1998; Pekarek et al., 1996; Lytle & Cochran-Smith, 1992; Wagner, 1997), books (Kagan, 1993; Sagor, 1992), and a presidential address (Koballa, 1997). Closer examination of these authors' positions, however, reveals differing conceptions of the research-practice gap. For example, Pekarek, Krockover, and Shepardson (1996) report evidence of the research practice gap in teachers' failure to use research findings in their daily work, because the formal research findings are considered "too generalized" and therefore irrelevant and inadequate for solving problems in unique classroom contexts. After describing the "apparent failure of research to influence teaching," Kennedy (1997) offers similar explanations. These include research's shortcomings in persuasiveness, relevancy, and accessibility for practitioners, coupled with the reluctance of the educational establishment to change.

Acknowledging the complexity and individuality of classrooms, Nixon (1987) views a gap between 'theorists' and 'practitioners' separated by the wedge of traditional research. The balance of power, he says, has been in favor of the theorists, as opposed to practitioners who are considered "purely pragmatic." Koballa's (1997) work with teachers dramatized the research-practice gap through their comments on the impracticality and irrelevancy of research to their "real teaching." However, he defines the research-practice gap as a "discrepancy between what is known about teaching and learning and classroom practice" (p. 3), clearly tilting the power scale to research. Dona Kagan (1993) was of this same persuasion when she began the journey described in her book. Questioning the opposing perspectives of science education researchers and the teachers with whom she worked, she describes the "notorious" gap as "What preservice candidates learn in university course work versus what they see practiced by experienced teachers" (p. 8). Through her study, Kagan began to analyze and appreciate the differences and functional values of university professors' and classroom teachers' perspectives. She concludes that professors of education must "relinquish some of the power they now monopolize: that is, the power to explain and proscribe teaching and the power to decide how novices are to be educated" (p. 150).

Similarly, Cochran-Smith and Lytle (1990) and Lytle and Cochran-Smith (1992) describe the gap as one of domination and alienation - the disenfranchisement and rejection of teachers' voices from the official knowledge base that leads to discontinuity between what is taught in universities and what is taught in classrooms, teachers' ambivalence about the claims of academic research, and a general lack of information about classroom life from a truly emic perspective. The authors attribute the problem to discrepancies in epistemology - "fundamental questions about knowing, knowers, and what can be known" (Lytle and Cochran-Smith, 1992). After summarizing teacher research projects that demonstrate a variety of topics, data collection strategies and interpretive perspectives, the authors assert, "When teachers do research, the gap between researcher and researched is narrowed" (p. 465).

Taking these assertions a step further, Richardson (1994a) distinguishes between the formal research conducted for elaboration of a formal knowledge base, and practical inquiry conducted by teachers to improve practice. In giving both forms of research credibility, Richardson notes that practical inquiry is of more immediate value to teachers, simultaneously validating practitioner voices in the construction of the education knowledge base. Over the past few years, Richardson reports, "conceptions of teaching have shifted from a view of teachers as the recipients and consumers of research to the current view of the teacher as producer or mediator of knowledge" (p. 5). Action research, conducted by teachers and directed toward the improvement of practice, acknowledges the voice of the teacher (Cochran-Smith & Lytle, 1990). Such practical inquiry may even be viewed as "potentially subversive: an attempt to restore a balance of power between theorists and practitioners and, in some cases...to weight that balance in favour of the latter" (Nixon, 1987).

In summary, the research-practice gap is conceived in terms of voice, relevancy and power. Whose voice is heard? Whose experiences, questions, data and conclusions are relevant to improvement of practice and enhancement of learning? Who maintains the power over the educational knowledge base and its practitioners?

The Racial/Ethic/Gender Achievement Gap in Math and Science

The Department of Defense Education Activity's Community Strategic Plan (1995) was designed to help all DoDEA schools improve education for their students. The Education Reform Bill, or Goals 2000, sponsored by the Clinton Administration, set forth ten goals that provide the framework for the strategic plan. Benchmarks related to each goal are intended to ensure standards and accountability measures for all DoDEA schools. The system-wide strategic plan emphasizes eight goals for school improvement plans. In the area of science, schools are challenged to develop strategies and action plans to meet the following benchmark:

> **Goal 4: Math and Science Achievement**
> *Benchmark 4.2: By the year 2000, the achievement gap in Math and Science between racial/ethnic/gender student groups and the DoDEA total student body will be narrowed by 50% as measured by a standardized achievement test based on 1994 disaggregated data.* (DoDEA, 1995, vol II, p iv)

Gaps in systemwide disaggregated NAEP and CTBS scores were identified in 1994. In response, the Strategic Plan calls for: 1) analysis of gaps to determine possible causes, 2) dissemination of technical assistance in the form of promising practices, 3) incorporation of methods for instructing minority students in math and science, and 4) monitoring implementation of NCTM and NSTA curriculum standards and teaching practices and 5) facilitation of staff development for "multiple teaching strategies..to make math and science more meaningful" (DoDEA, p. 4-2).

Zeichner (1996) presents a review of literature related to closing the achievement gap. He lists key elements of high expectations for all students, cultural congruence in instruction, teacher knowledge and teaching strategies. Although methodologies such as collaborative learning environments, teaching for higher level thinking skills, and incorporation of meaningful tasks are recommended, Zeichner emphasizes the importance of preparing teachers who culturally sensitive, free of negative attitudes, and committed to maintaining high standards. Translating these ideas into concrete classroom pedagogy is the crucial task delineated by the DoDEA Strategic Plan.

Purpose of the Research

As the Science Curriculum Liaison in the Department of Defense Dependents Schools Japan district and a recent Ph.D. recipient, Larson was cognizant of both the research-practice gap and science achievement gaps. She reasoned that the DoDEA Strategic Plan indicated both technical assistance and teaching methods for bridging the gap could be transferred from research to a practice base. However, she was also committed to a staff development program that encouraged teachers' voices in enriching the knowledge base on practice with respect to the Strategic Plan. She hoped to inspire them to generate questions, research designs and analysis that would constitute meaningful contributions to improvement of practice and bridging racial/ethnic/gender gaps in science achievement.

Therefore, to address both gaps, Larson planned and conducted the Science Teachers Action Research (STAR) program in the Japan district in spring, 1997. The objectives were a two-pronged effort to: 1) encourage volunteer teachers to conduct research projects investigating their ideas of meaningful ways to improve practice and narrow science achievement gaps in their classrooms, and 2) increase teachers' awareness of the value of disciplined inquiry to answer questions and suggest solutions to perceived problems in classroom instruction and student learning. What she proposed fit Richardson's (1994) conception of the two forms of research on practice - she would conduct formal research as a researcher-teacher, and practical inquiry would be undertaken by a group of teacher-researchers. The format embraced by this project matched descriptions of collaborative action research (Sagor, 1992) developed in a "clinical partnership" as defined in Wagner's (1997) discussion of three forms of direct researcher-practitioner cooperation. As the researcher, Larson would be outside the schools, reflecting on the individual projects as well as the collaborative process. The practitioners would be in the schools engaged in action and reflections, investigating specific classroom contexts through disciplined inquiry.

Design and Procedures

The formal research on the Science Teachers Action Research Program was conducted with a group of twelve volunteer teachers whose classroom experience ranged from two to 26 years. Areas of responsibility included a media specialist, physics teacher, and teachers of kindergarten, first, fifth and sixth grades. The group met for a two-day orientation on research methods, constructivism, and analysis of racial/ethnic/gender gaps in disaggregated data from district students' standardized test scores. By the end of the session, teachers completed a research problem statement, research questions, and a data collection plan (Sagor, 1992). In the following weeks teachers began their investigations, guided by frequent telephone or email communications between Larson and the schools. Next, the group met for a day of discussion and sharing on data collection and analysis and report writing. They were encouraged to engage in collaborative sessions at their schools as they checked results and formulated conclusions, then prepared written and oral reports. A STAR symposium, at which they shared their projects, was held in May, 1997.

Data sources for the formal research project on STAR included notes on group discussions, a collection of email correspondences between me and the teacher-researchers, their personal journals, written or Power Point reports, videotapes of the presentations, and survey evaluations of practitioners' action research experiences. Data were analyzed in relation to 1) the effectiveness of action research as a professional development initiative to bridge the research-practice gap by increasing teachers' regard for, and employment of, the process and products of disciplined inquiry, and 2) the degree to which teachers' projects contributed to narrowing gaps in their students' science achievement and attitudes.

Eight practical inquiry projects were generated from this program, encompassing such diverse topics as student use of information resources, decoding directional skills, increasing science activities in the kindergarten curriculum, promoting organizational skills, using science books to develop specific reading skills, developing critical thinking skills. Two of the projects are selected for discussion in this report because of the similarity of their research problems, the uniqueness of design, and depth of conclusions. The first, by two collaborating first grade teacher-researchers, is entitled "Umm..I Think...: Student Formulated Conclusions to Science Activities" (Mayer and Kight, 1998). Teaching an integrated curriculum based upon science, Mayer and Kight began the school year summarizing science concepts introduced through hands-on activities, guiding their students to record these identical conclusions in science journals. Their project explored their students' growth in formulating conclusions, asking, "Will students be able to formulate and state conclusions in their own words, conveying their understanding of the concept?" Triangulating data from surveys, student journals, and student interviews, Mayer and Kight examined the success of their efforts to increase students' facility to independently question, discuss and summarize science concepts.

Golson, a fifth grade teacher-researcher who also emphasized science in the classroom, had a similar question. She believed her students failed to refocus on the purpose and reflect on results of hands-on experiments when writing conclusions. As a result, she theorized the scientific knowledge they constructed was not as elaborate as was possible. Her project, "Wrap it Up: Increasing Student Understanding of Experimentation in Science" (1997), documented the effects of the class developing and using a rubric to evaluate and improve written conclusions of experiments. Data sources included pre- and post-intervention self assessments of scientific knowledge, student journals, and science grades, as well as Ms. Golson's personal journal.

Practical Inquiry: Findings and Conclusions

Mayer and Kight (1998)

First, in the area of language, Mayer and Kight noted that some children had difficulty summarizing results of experiments and recording them clearly in their journals. However, when questioned by the teacher, the children were often able to construct an accurate conclusion. Similar findings were reported by Roth and Roychoudhury (1994) and other researchers when probing student science understandings, and have led to cautions about exclusive reliance on written answers when assessing student conceptions.

A second conclusion formulated by Mayer and Kight was the importance of using "a series of activities" in developing student understanding of concepts such as the water cycle. By closely monitoring student explanations for phenomena, then choosing activities to challenge the conceptions and lead students to more scientifically acceptable understandings, the teachers observed that students could more clearly construct and record accurate conclusions in their journals. This was a cogent example of the teacher-researchers' 'discovery' of the conceptual change process described in formal research reports (Posner, et al., 1982; Watson & Konicek, 1990).

The teacher-researchers' third conclusion is based on differing perceptions on the necessity of having the correct answer. Mayer and Kight were surprised that even first grade students demonstrated fear and frustration if they could not express a conclusion. "The fear of being wrong overwhelmed their abilities." This was interpreted as a lack of self-esteem and need for perfection not promoted by the teachers. In formal research circles, this is related to conceptions of the nature of scientific knowledge, the realist belief that science is a set of truths to be learned and stated in exact language. (Lederman, 1992). If students believed only one correct conclusion for an experiment was possible, their fear of error would be palpable. Mayer and Kight's recognition of the difference between their personal relativist positions and their students' realist conceptions became the basis for adjustments in their instructional language and techniques.

Golson (1997)

Although Golson's (1997) use of rubrics did not stimulate the dramatic improvement in "more thoroughly written conclusions" that she had hoped for, she noted a general improvement in quality and "fewer poorly written ones." After consulting a published research article on rubrics, Golson became aware of a need for revision of the rubric and an adjustment in its use to a multiple step process of self-, peer-, and teacher-evaluation. She was encouraged by the research suggestions to continue her work with rubrics in the following school year and expand their implementation to additional content areas.

Next, Golson discovered an unplanned benefit in the use of student journals. "It seems that writing about what they learned in the experiment was an effective way to get them to re-focus on the purpose of the experiment, even though this was not explained to them as a purpose for writing" (p. 8). Originally included simply as a reflective instrument for students to discuss experiments, Golson discovered the effectiveness of the journal as a reliable tool for assessment of scientific understanding. Golson plans incorporation of journals on a more regular basis in her students' science investigations in the coming year.

A third conclusion relates to students' self assessment of scientific understanding. Most students rated their level of understanding higher than their grades indicated, leading Golson to reflect on the accuracy of letter grades as indicators of conceptual understanding and to seek alternative means of assessment.

Formal Research: Findings and Conclusions

Whereas practical inquiry is "more likely than formal research to lead to immediate classroom change," formal research is designed to produce generalizations and "contribute to an established and general knowledge base." (Richardson, 1994a). What can we learn about practical inquiry as a result of the STAR Program?

Bridging the Research-Practice Gap

Through data collected in our interactions, written and oral communications, research reports, journals and surveys the following assertions are posited in relation to the objective of increasing practitioner use of, and regard for, disciplined inquiry in education:

A) From their unique vantage points, the teachers <u>generated</u> educational knowledge as they conducted their research projects. In some cases, as noted above, their conclusions matched those of formal research in the areas of student learning, pedagogy, and data collection methods.

B) When teachers <u>used</u> formal research, it served to guide and enrich their research design, data collection and data analysis. The formal research gave validity to practitioners' conclusions and steered them to additional steps, questions, or methods they could employ to extend their inquiry.

C) STAR participants rated their efforts as meaningful. A list of positive aspects includes:

- *applying science strategies for studying about student learning and achievement; the sharing of information and ideas*

- *using the classroom as a basis for research; discovery that students' perceptions are very different from teachers'*
- *I learned to question my techniques, carefully watch them over a period of time and make changes. The program gave me the tools in which to assess my techniques.*
- *I found the experience valuable. Teachers are researchers. My findings were interesting to me as a teacher.*

D) Teachers readily extended themselves in terms of time and effort. The requirements of disciplined inquiry were often mentioned ("it's a lot more work than I thought"), but the benefits appeared to outweigh the demands.

E) Action research inspired positive changes of a constructivist nature in practice across curricular areas.

- *I continue to use science journals.*
- *Maybe because (of the research) or maybe because of Literacy Place, or both. I'm using a lot more literature in all disciplines.*
- *I have provided time for students to reflect, explain and write their thinking.*
- *I have incorporated daily use of computers as well as a more hands-on approach to learning.*
- *I try to let students create their own learning.*
- *(I use) more prediction/hypothesis-forming before activities and discussion of findings after.*

Bridging Racial/Ethnic/Gender Gaps

How successful were the teacher-researchers in narrowing racial/ethnic/gender gaps? This was a more elusive objective to track, because participants' perceptions of the gap differed greatly. From the beginning, the group had questions about the "ethical justifiability" of the concept as one of four quality criteria for action research : "Is the research process compatible with the educational aims and does it correspond with principles of human interaction?" (Feldman, 1994). Some interpreted our effort to support those on one side of the gap as a corresponding lowering of expectations and/or challenges for those on the other. The general consensus at the outset, then, posited that gaps would be narrowed by the improvement of science instruction for the benefit of all students.

At the symposium, each presentation was followed by a discussion of the research's effects upon the proposed bridging of racial/ethnic/gender gaps. In most cases, it was concluded that only standardized test results can inform us. In another case, the efforts of the research project appeared to widen the gap. Teacher-researcher comments on their increased understanding of the gap include:

- *I have found that if science and the scientific procedure are introduced in kindergarten and first grade, then we have more of a chance at narrowing the gap.*
- *Narrowing can't start until we truly understand causes.*
- *By providing hands-on activities and allowing students to test, discover, explain, and collaborate, the gap should be reduced.*

- *Just keep encouraging/ promote equity*
- *I think the most important realization is to understand that every student has a different life experience. The key is to find a learning platform which facilitates science .. on a level which can be understood by the student at their current level of ability.*

Summary

> *There is room for 'layman-oriented' research in education. Those in the trenches have real contributions and ideas to offer*
> (teacher-researcher comment on action research)

The general consensus of both researcher-teacher and teacher-researchers was that the Science Teachers Action Research program was beneficial to both teachers and students. In an NSTA theme paper, Kyle et al. (1991) set forth recommendations for the role of research in science education. Their recommendations are:

1 - Research should be a Collaborative Endeavor
2 - Teachers should be Action-Researchers
3 - Research must be Close to the Classroom
4 - In Investigative Society Should be Created
5 - Research Should Inform Policy (pp. 416-417).

The STAR program accomplished recommendations 1-4. However, the program does not have the impact nor the status to inform policy. This will be discussed below in the section on the political dimension of action research.

Noffke (1997) distinguishes personal, professional and political dimensions of action research, and her framework is appropriate for analyzing the effects of the STAR program as well as suggesting changes for future endeavors. First, in the personal realm, we look at the impact of the action research process on individuals. The comments above provide evidence that teachers were positively affected by their work. As McKernan (1988) states, the teacher-researchers have become "self-monitoring researchers," carefully examining their practice and students' science conceptions. Reflection on the conclusions of the studies was translated into revised objectives and modified practice. In addition, our conversations and written evaluations expressed teachers' growing confidence in, and desire to, conduct research and present it to their peers. With this comes enhanced feelings of the "prestige and power" society usually reserves for school district personnel and academics (Richardson, 1994b). Increased self esteem and knowledge contribute to the "process of personal transformation" (Noffke, 1997). However, in terms of personal reactions to the program, time was often mentioned as a constraint to further practical inquiry projects. It is the goal of the district science liaison to develop means to support future action research endeavors so that demands on personal time are not overwhelming.

The STAR program created action research as a professional development experience. As a result of their participation in disciplined inquiry, teachers' experiences and status were validated. Richardson (1994b) sees this as an affirmation of "teachers' ways of knowing" through their experience. The teacher-researchers have contributed to a growing knowledge base on instruction to improve instruction and increase science achievement. In addition, they have developed a personal understanding of the impact of educational research on teaching and learning. In looking to the future, professionalization should also include publishing the work of the STAR program, and this has become a prominent objective for the district.

It is in the political arena that the STAR program displayed shortcomings. Noffke (1997) defines the political aspect of action research as "issues of social justice, especially over racial and gender inequality" that play a role in the selection of research topics. Racial/ethnic/gender gaps in science test achievement created the impetus for the STAR program. However, as mentioned above, general misunderstandings about gaps, and, in some cases, refusals to admit the existence of gaps in classrooms or schools, resulted in what a colleague terms "a cop-out" in the research program. By assuming that what is good for one is good for all, we disregarded issues of culture, gender, learning styles and preferences. We took the safe way out. We should consider "the social and political implications of ..practices and act on them" (Noffke, 1997) more deeply. To this end, formal research would be helpful in identifying factors that cause or exacerbate the gap in science students' learning and achievement. Future STAR programs will attempt to research and confront these political (and public) issues more directly.

In conclusion, action research became an effective form of staff development (Richardson, 1994b) that served to narrow the research-practice gap and improve classroom teaching and learning. Discussions with the teacher-researchers, however, have led to questions about our understanding of racial/ethnic/gender gaps and how to overcome them, about the ethics of targeting certain segments of the population, and the types of classroom practice that are most effective in improving the academic achievement of diverse student populations. We await reports of disaggregated data on standardized test scores to evaluate the effectiveness of the practical inquiry. However, to answer nagging questions about ensuring quality education for all students, narrowing achievement gaps and promoting scientific literacy, it appears that we require a combination of both formal research and practical inquiry.

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