Examining the Experiences of Three Generations of Teacher Researchers through Collaborative Science Teacher Inquiry

By Brenda M. Capobianco, Susan Lincoln, Donna Canuel-Browne, & Ruth Trimarchi

Brenda M. Capobianco is an assistant professor in the Department of Curriculum and Instruction of the College of Education at Purdue University, West Lafayette, Indiana; Susan Lincoln and Donna Canuel-Browne are science teachers at Northhampton High School, Northhampton, Massachusetts; and Ruth Trimarchi is a science teacher at Amherst Regional High School, Amherst, Massachusetts.

Introduction

The purpose of this article is to examine the teacher research movement from the perspective of three generations of teacher researchers within the context of a unique collaborative science teacher action research group. The question that guided the study was the following: In what ways do three generations of science teachers perceive their experiences as researchers in a collaborative action research project on inclusive pedagogy? In this article we present the personal experiences of three high school science teachers and one university researcher as they join together with eight other secondary school science

teachers to examine and take action in response to addressing issues of equity and diversity in their science classrooms.

When using the term, "generation," we mean a group of teachers who are at a common stage of development in becoming a teacher researcher. In this model, each generation operated as a function of experience and not years. Therefore, each teacher's location within a specific generation was based on his/her own prior experiences with action research via academic course work, district-based professional development, and/or personal inquiry.

In this model for a collaborative action research group, there were three generations of teacher researchers. The first generation included a university researcher who had completed graduate work in teacher action research, conducted action research as a practicing middle school science teacher and as a university instructional consultant, and co-facilitated collaborative action research groups (Capobianco, in press; Capobianco & Feldman, 2002). The second generation included three science teachers who had completed a graduate course in action research where they identified the major components of the research process, examined different models for action research, and conducted action research within their own practice. The third generation consisted of eight science teachers who were new to action research. As a group of multigenerational teacher researchers, we collectively shared the same ultimate goals: (1) to improve our own practice by conducting action research; and (2) to learn more about inclusive forms of pedagogy as a way of making science accessible for all students.

Theoretical Framework

This study draws from two distinct lines of literature: collaborative action research, specifically feminist approaches to collaborative action research, and first- and second-order action research.

Collaborative Action Research

Collaborative action research, as defined and carried out in this study, entails teachers joining together to examine and take action in response to different issues and concerns related to their practice (Feldman, 1994; Hollingsworth, 1994; Sagor, 1992). In this approach, teacher-researchers come together to solve problems, create change, and accomplish some shared goals with regard to teaching and student learning in science.

Models for collaborative teacher action research involve teacher educators working together with experienced and prospective teachers to address problematic issues in their classrooms and schools and to construct new understandings of teaching and learning (Hodson & Bencze, 1998; Pedretti, 1996; Rock & Levin, 2002; van Zee, Lay, & Roberts, 2003). Some models involve a university researcher as a facilitator who encourages and supports teachers (Feldman, 1994; Hollingsworth,

1994; Miller, 1990), while others involve self-initiated and self-sustained teacher inquiry groups (Philadelphia Teachers' Learning Collaborative, 1984; Boston Women's Teachers' Group, 1983). For this study, we drew from three collaborative action research projects that emphasized the role of teachers as collaborators and the role of a university researcher as facilitator (Feldman, 1994; Hollingsworth, 1994; Miller, 1990). These projects influenced the manner in which teachers are perceived as professional curriculum developers, legitimate researchers, creators of knowledge of teaching and learning, and agents of social change.

A Feminist Approach to Collaborative Action Research.

Unlike more traditional approaches to collaborative teacher inquiry, which basically value and measure knowledge as it is transmitted from experts (e.g., educational consultants, administrators, or curriculum resource personnel) to practitioners, the approach we took incorporated and validated the experiences of the teachers. The approach was to establish a process for science teachers to articulate their feelings, viewpoints, and perspectives about teaching science for all students, specifically women and minorities. For this study, our approach to collaborative action research recognized and valued women's as well as men's diversity of experiences and how those experiences contextualize and inform our knowledge for more inclusive practices in our own science classrooms. Emerging from this process was a heightened awareness of the teacher's own educational situations as well as raised consciousness for the personal changes that may accompany the changes in their knowledge and practice (Hollingsworth, 1994).

In this research, the group was non-hierarchical in nature and assumed a more enhanced, active, and involved role of the practitioners. Members of the group and the processes associated with facilitating the group remained separate from outside institutions and the power structures associated with those institutions. Thus the framework and operations of this collaborative were not prescribed by district-based guidelines nor were they facilitated by administrators, educational consultants, or science curriculum experts who direct what teachers must do in order to comply with standards for professional development.

The feminist approach we adopted for our group discussions was a process through which we critiqued the norms of teaching science previously claimed through established epistemologies and research paradigms in science education. This involved helping the teachers rethink their connections with science; re-envision what counts as science; and transform their practice so that their students feel empowered to participate freely in science (Barton, 1998; Barton & Osborne, 2001; Brickhouse, 2001; Harding, 1991; Mayberry, 2001; Rosser, 1997).

First- and Second-Order Action Research

Embedded in this collaborative action research study is the construct of first- and second-order action research (Elliott, 1991; Stenhouse, 1975). For the science

teachers in the study, their research 'object' was their own teaching practice (first order inquiry). For the outside researcher (the university researcher), it was her strategies for facilitating the development and interpretation of the 'teachers' reflective capacities' (second order inquiry). This distinction between first- and second-order action research is particularly important in the context of this study because this distinction questions the location of ownership, as research primarily belongs to the teachers. In this study, it was up to the teachers to establish objectives and strategies to achieve them. Hence, first-order action research was driven and directed by the teachers in the context of our collaborative action research group while second-order action research was produced by the university researcher and her cross-generation analysis and interpretation of the teachers' reflective experiences of becoming researchers on integrating inclusive pedagogies.

Setting the Context

The teachers met every three weeks at the university researcher's home, to eat dinner and engage in conversations about learning how to teach science for *all* students. To spark the first after-dinner conversations, the university researcher posited two questions to the teachers, to provide a framework for the teachers to begin thinking about their action research projects. These questions were based upon the first guiding principle of the National Science Education Standards (NRC, 1996): "Science is for all students" (p. 20). These questions were: How do you, as a practicing science teacher, interpret this principle? What actions can you take in your own practice to meet this goal?

In addition to formulating and designing projects, the science teachers were introduced to different models for feminist pedagogies so they could create ways to incorporate this knowledge into their existing practice. As a group, we read, discussed, and attempted to make meaning of research studies related to applications of feminist theories and feminist science teaching (Barton, 1998; Barton & Osborne, 2001; Brickhouse, 2001; Mayberry, 2001; Rosser, 1997; Roychoudhury, Tippins, & Nichols, 1995). The next question was: To what extent do these alternative perspectives inform the actions you can take in your own practice with regard to accessibility?

In the next phase of the research process the science teachers explored a problem related to our main theme for accessibility and one they wanted to address within their own practice. The teachers engaged in productive and meaningful conversations about accessibility in science and science education as a way of clarifying their stated problems. They reviewed alternative science teaching practices suggested by scholars in feminist science teaching and reflected on this new knowledge through journal writing. The teachers then used ideas from the literature and our conversations to develop an action plan and piloted the different strategies within their own practice. In some cases, the science teachers revisited their original

problem and action plan, using information gained to alter their approach (Altrichter, Posch, & Somekh, 1993). Through each stage of development, the science teachers worked together to assist one another in clarifying, justifying, and evaluating their own educational situations through ongoing conversations.

Methods

Participants

The three participants highlighted in this study were part of a family of eleven practitioners from five different schools located in rural, urban, and suburban school settings in western Massachusetts. The eleven science teachers included eight women and three men who were all White from working or middle class backgrounds. What follows is a brief description of the three teachers—Donna, Susan, and Ruth.

Donna was a biology teacher in her 50s with almost ten years of teaching experiences at a rural/suburban high school in western Massachusetts. In addition to teaching honors biology, Donna taught one lower level chemistry course for non-traditional learners. She brought compassion and rigor to her classroom practice as well as a wealth of knowledge for inclusive pedagogy to our group discussions.

Susan was a biology teacher from the same rural/suburban high school and taught introductory chemistry during the course of this study. As a self-proclaimed feminist, Susan brought a wealth of experience and knowledge of feminist praxis. She grew up in a working class environment and later became a lab technician and worked in both rural and urban settings. Susan, in her 50s, recently entered teaching and often grappled with the politics associated with the invisible role scientific literacy played within her school community. She brought an enlightened perspective on the social, historical, and political nature of science that allowed us to engage in interesting and serious conversations about what we teach and why.

Ruth, also in her 50s, was a biology teacher from a suburban school and taught both honors biology and human anatomy and physiology for over ten years. Ruth brought her talents as an experienced research technician into her classroom and frequently provided students with rich stories and experiences of real-world applications of scientific research. She, like Donna and Susan, welcomed the chance to talk with other science teachers concerned about their students and teaching and interested in transforming their practice.

Interestingly, Donna and Susan were two teachers who had prior knowledge of and experience with conducting action research and therefore, represented members of the second generation of teacher researchers. Both Donna and Susan expressed a strong interest in learning more about feminist pedagogy. Ruth, on the other hand, was new to action research, and consequently, represented the third generation of teacher researchers.

Data Sources

There are two separate components to our model for collaborative action research. The first component consists of the science teachers conducting action research. The second component consists of the university researcher examining the science teachers and how they engage in action research. This required the science teachers to employ their own methods for gathering data, including journal keeping, observations of their own and other teachers' classroom teaching, interviews with students, formative assessment, and student work. The university researcher gathered data via three semi-structured interviews per teacher (total 9 interviews), whole group discussions (8 three-hour meetings; total 24 hours), classroom observations (3 per teacher; total 9 observations), and review of supporting documents (i.e., lesson plans, curriculum materials, personal research journals, action research papers). Unlike more traditional models, our group met every three weeks over the course of six months. Each meeting was recorded and later transcribed by the university researcher. Between meetings, the university researcher conducted classroom observations, interviews, and consulting sessions with individual teacher researchers.

Data Analysis

Once all the data were collected, the university researcher began the preliminary analysis using grounded theory (Strauss & Corbin, 1990). The first step entailed open coding of the transcripts from interviews, group meetings, and teachers' action research papers (Miles & Huberman, 1994). During this phase, emphasis was given to identifying indicators of concepts and categories that fit the data. Repeatedly appearing categories and concepts helped to construct themes based on the lessons the teachers learned on becoming researchers. The viability of the construction of themes was then tested against other relevant data sets (i.e., field notes from classroom observations and other supporting documents).

To ensure trustworthiness (Lincoln & Guba, 1985), the university researcher employed peer debriefing, member checking, and triangulation. The university researcher reviewed the data with the teachers individually and collectively. Subsequently, the teachers and university researcher used member checking by taking the narrative accounts back to one another to ensure they were representing their personal ideas accurately. Lastly, the university researcher and teachers triangulated the different data sources comparing and contrasting "different accounts of the situation" (Elliott, 1991, p. 82). The final phase of analysis involved the continued interpretation of each source of data with particular attention to the stories each teacher shared throughout the course of the study. Through construction and reconstruction of the teachers' stories (Clandinin & Connelly, 1995), the teachers created their own narratives grounded in the data to make sense of how each science teacher transformed her practice using inclusive methodologies.

Findings

What follows are the teachers' personal and reflective first-order narratives of their experiences in becoming researchers of their own practice. In these narratives, each teacher describes: (1) why she joined the collaborative action research group; (2) how she devised an action plan for making science more accessible for her students; (3) what dilemmas she encountered; and (4) what she learned as a result of engaging in action research. In addition, the university researcher presents her second-order account, describing her roles as the facilitator of the collaborative action research group, university researcher of the study, and experienced teacher researcher.

Third Generation—Ruth

I joined the collaborative action research group to fulfill a specific professional development requirement for my district. I had not heard of collaborative action research before I joined the group and it took several meetings and conversations before it became clear to me just what action research was and what it entailed. I soon learned that this was to be a group of teachers meeting every few weeks to talk about our practice. This was an unheard of luxury, and I became very excited as I realized the potential that was opening up for all of us. We were not going to be lectured at nor force-fed ideological pabulum from someone else's agenda. In contrast to most professional development activities, we were considered "experts" in the area of improving our own teaching practices, and we could look to one another for support through sharing of our ideas and comparing our experiences.

I decided to focus my inquiry on improving my approach to lecture in my honors biology classes. In spite of the criticism and negative valuation placed on lecture in science education, it still remains a mainstay in my classroom practice. What I did observe though, was that select groups of students in my classes were clearly not getting as much out of lecture as others were. Therefore, I decided to re-examine my model for lecture and attempt to improve the overall effectiveness of my approach by making it more accessible for these groups of marginalized students.

I felt that I was a pretty good lecturer, but I knew that there were always a handful of students in each class who I could not seem to draw into the give-and-take during my lectures. My lectures have always been an interactive process of presenting material and questioning students on it as we go. Even so, there were students who would not participate in whole-class verbal exchanges. I talked to the other members of our action research group about these "silent voices," and clarified for my colleagues and myself that these students often were second-language learners, students of color or low-income students in my honors classes, and girls in any level of science that I'd teach.

I independently surveyed each of these groups outside of the classroom and discovered a range of reasons for their relative lack of engagement in lectures. The

ESL students said the classes went too fast for them to follow. The girls said they often felt intimidated by gregarious males who would raise their hands quickly or try shouting out responses. Lastly, students of color and low-income students said that they found it difficult to take notes in this kind of setting.

With the support of the other teachers and Brenda, I assembled a collection of techniques that I would later integrate into my "interactive lectures." Examples of these techniques included the following: instructing students to write reflective responses to questions posed throughout a lecture, assessing students' understanding formatively via quick check in's, and asking students to compose a letter to the teacher depicting the main points of the lecture.

One of the difficulties I encountered while conducting my action research was determining how I would evaluate the effectiveness of these techniques. Additionally, I was not sure as to whether or not the results I did collect would serve as a valid indicator of my work. As an experienced research technician, I had set up controlled experiments, run multiple trials, and collected clear-cut, obvious data. I found it difficult to transfer my empirical and experiential knowledge of scientific research to that of my own action research.

In light of this dilemma, I decided to administer a subjective survey to my students. This survey enlisted students' self evaluation of their own participation in class. I administered this survey on two occasions—at the beginning and at the end of my action research work. The results were consistent with my own observations. Student participation had increased significantly with the use of the interactive lecture model.

The support I gained from the other science teachers in the group was very rewarding. The teachers listened to my ideas and asked questions. They challenged my assumptions by offering observations from their own experiences and encouraged me to think critically about what I was doing. In return, I also asked questions, probed for understanding, and offered my own suggestions in response to how we were each attempting to transform and improve our practice.

Reflecting on my own experience with action research for the first time, I can honestly state that there is no doubt this process has profoundly changed the way I teach. I now pay much more attention to the "quiet voices" in my classes. I am constantly tinkering with new ways to draw these students out. And in some way nearly every student is a "quiet voice" from time to time, so I feel that these approaches directly benefit nearly every student. Additionally, I have become an advocate for action research within my own school community. Earlier this school year, I approached my administrator and made the suggestion that our faculty consider forming action research teams and explore the multiple ways in which our school could be restructured into "smaller professional learning communities." This could prove beneficial for departments such as guidance and alternative support programs, who can better attend to the diverse developmental needs of their students by closely re-examining and improving upon their current systematic practices.

With encouragement from Brenda, I later published an article on my work with interactive lectures (Trimarchi, 2002). This was wonderfully rewarding, as were the emails that I've received from readers saying that they are using these techniques. With this kind of success it is exciting to return to the classroom and my students, knowing that I have a particularly satisfying way of continuing to improve my teaching for them.

Second Generation—Donna

At a trying time in my career, I welcomed the opportunity to join this group of science teachers looking to reflect upon their practices. I hungered for the opportunity to discuss the nature of science and how that applied to all of the students I serve each day.

After the earlier meetings, I knew that most of my expectations would be met. The group of teachers had diverse backgrounds and pedagogical methods that would color our conversations and prompt all of us to reexamine our points of view. Brenda, the facilitator of the group, made all of us feels welcomed and valued, while maintaining a low profile and letting the group develop its own momentum.

I had learned about action research during a course I had taken about eight years before, which was based solely on how to do action research. I had taken it as part of the requirement for my master's degree. At that time, I completed an in-depth review of literature on heterogeneous grouping and conducted an action research project on heterogeneous grouping in the science classroom. The goal of my research was to study ways to formulate cooperative learning groups and to devise a model for building groups that promoted maximum success for students at all levels of achievement in science.

I was eager to incorporate action research again into my professional growth strategy. As a scientist, my initial exposure to action research did not come without its struggles. Qualitative research is often dismissed in science. Aspiring scientists are grilled for quantitative data. During my first experience with action research, it took me weeks to come to terms with using qualitative data, and yet with some reluctance, I found a way to address my concern. I used scores from student tests and quizzes to lend credibility to my concern for quantifying my data. I just had to have some graphs in my results!

During my second experience with action research, my concern for generalizability was much less important to me. I felt I had much more freedom in choosing my research topic. In my initial experience, I felt that I had to choose a research topic that would lend itself to some degree of quantifying my results. During this second experience, I felt free to research the topic that was most pressing and could be most rewarding. I chose to research a dilemma that I was currently experiencing in one of my science classes. My dilemma was with trying to assess the achievement of a group of students in a "special needs" chemistry class.

Many of the students in this class worked with major physical handicaps,

learning disabilities, psychological problems, legal problems, and substance abuse problems. All of these problems interfered with their ability to succeed in school. Many could not read or write at a level that allowed them to communicate effectively. Many others had attention problems or comprehension problems that mandated drastically modified testing. So I decided to focus my research on how I could most effectively assess students in this class given the limitations of the situation.

I selected several assessment models grounded in inclusive pedagogy which are based on process and student performance, as opposed to recall and written manipulation of facts. Throughout the course of the semester, I assessed students' work on a weekly basis. After each assessment session, the class discussed how they felt about the assessment tool and if it showed me what they understood about the week's lessons. Through formative assessments I could also correlate the accuracy of the summative assessments based on the students' displayed level of understanding during the week's lessons. These two factors helped me to gauge the accuracy of each assessment tool.

As a result of my research, I learned that a performance-based assessment was more accurate in determining the student's level of understanding. The exception to this finding is that the performance-based assessment needed to have only a few simple steps or to have the steps clearly outlined. Many performance assessments ask students to formulate steps as part of the assessment. These types do not work with these students, for some of the same reasons that the more traditional types of testing do not work.

During the course of my research, I sometimes lost focus on the purpose of my research. I remember one particular moment, when I became very concerned with my research. My action research felt too overwhelming—as though there were too many parameters that I needed to explore. During one of our group meetings, one of the members, an experienced science teacher and novice teacher researcher, simply asked me "Who are you doing this for?" At that moment, I instantly realized that I had lost track of my initial intent for my action research. I neglected to keep in mind that I was doing it for myself. At that pivotal moment, the point of my research fell into place again. I stopped worrying about my imaginary "audience" who wanted quantitative evidence and remembered that this research was for my benefit and hopefully that of my students.

What I learned from my second experience with conducting action research was that I can trust myself and my instincts as a teacher. My instincts have been honed based on my years of reading, practice and expertise. Action research provides me with the tool necessary to formalize my findings so that I can research the non-quantifiable and use that research to improve my practice.

Second Generation—Susan

I chose to join a collaborative action research group to earn graduate course credits towards my master's degree in secondary science education. The nature of

the group was not clear to me at first. However, the theme of feminist pedagogy and science education presented at the onset of our meetings did interest me immediately. The description of the meetings also appealed to me, in that we would gather in each other's homes over dinner for our meetings. After a day of teaching, this alternative to a traditional classroom setting was very attractive. In addition, I was pleased to be able to work with the facilitator who was coordinating the group. Having taken another graduate course with Brenda, I knew of her teaching experience, organizational skills, and familiarity with recent topics in science education.

At our first meeting I learned that we would engage in action research as a means of investigating our practice and examining aspects of feminist pedagogy. I was interested in this approach because I had completed an action research project earlier in my graduate program that provided time to closely examine an aspect of my teaching and the opportunity for receiving useful feedback from others in that group. This model for study places value on an educator's experience and knowledge to examine questions and problems that are at the core of her own practice, and I was curious to learn about feminist pedagogy in this personal context. I was also interested in the opportunity to learn about the other teachers' experiences teaching science in their respective schools.

As the facilitator of the group, Brenda made clear that she would provide a supportive role for the projects that we chose to investigate. By providing readings from the science education literature focusing on feminism and the teaching of science, Brenda helped to create a framework that would guide us in our inquiry. Although she was particularly interested in this topic, Brenda worked to maintain a sense of balance within the group to ensure that each action research project held meaning for each investigator.

At the time I joined the group, I was teaching a lower level high school chemistry course and I was concerned with my ability to present the material to the students in a manner that would engage them. Many students enter high school with the attitude that they can't do science because it is too difficult, not interesting, or not useful. I was searching for ideas to help me present the subject material in a more holistic and engaging way. Reviewing the literature on feminism in science education and discussing ideas within the group, I was able to create a framework of inquiry to begin my action research, which would focus on students' negative attitudes about chemistry and how to bring about change in those attitudes using feminist pedagogical methods.

To determine the attitudes of the students in this class, I chose to use qualitative measurements in the form of surveys of students' feelings, third party observations, and my own observations as sources of data for this action research project. My plan was to use the information gleaned from these sources to change the presentation of the material in the course to suit the interests of the class and to collect follow-up data to assess the effectiveness of the modifications. The result of the first round of inquiry led to the development of a unit in which we would examine the water

quality of a nearby river by performing several different assays on a regular basis. We included discussions about the historical use of the river and contemporary issues dealing with different aspects of water resource management as well. The students seemed to appreciate the effort I made to consider their interests when planning the units that we would cover.

I felt fairly comfortable with most of the aspects of this investigation, although the outcomes were not as dramatic as I had hoped they would be. Unlike some of the other teachers in the collaborative group, I was not overly concerned with the "quality" of my data. We spent much time questioning the validity of small and often subjective data sets in our group meetings. I remember having similar concerns with my first action research project. In this project; however, I viewed the data more as a formative tool that helped me to monitor the attitudes of the class, rather than evidence that must withstand public scrutiny.

One dilemma that did arise for me over the course of the investigation stemmed from the political nature of feminism. Several members of the group appeared to be uncomfortable with the initial feminist perspective of the group, and the language that we used in our discussions focused less on feminism and more on accessibility over time. It seemed to me that the pairing of action research with an examination of feminist practices in teaching is a dynamic one, in that each aspect strongly supports the other. I felt as though we missed the opportunity to examine this relationship, which was one of my reasons for joining the group. Other members of the group had similar feelings, and we were able to have those discussions in a more informal manner at meetings outside of the group.

The collaborative nature of this group was generally effective at providing support and feedback for the individual action research projects. Members of the group listened to each other's stories and concerns and provided feedback that included many useful ideas regarding classroom management, lesson plans, and action research. The group also provided an opportunity for in-class observations that proved to be a valuable data source.

Overall, the implementation of action research, conducted in a collaborative manner, with a focus on feminist pedagogy has helped me to identify aspects of power and authority in the teaching and learning of science that I had not yet considered. By incorporating opportunities for students to express their feelings and concerns about the material to be covered in class, existing curriculum can be modified or enhanced to suit their interests along with meeting the standard expectations laid out by departments of education. This may provide the access to science that many students feel never existed for them in the past.

First Generation—Brenda

I established the collaborative action research group for two main reasons. First, I was interested in learning whether or not collaborative action research could be an effective way for assisting science teachers in finding new methods, strategies,

or curriculum to meet the needs of all students. Second, this project was my dissertation. I examined and analyzed closely the teachers' participation in this project for the purpose of conducting productive qualitative research.

I entered this study with a wealth of knowledge, experience, and level of expertise in teaching science as well as with conducting action research. Through our interactions, the teachers and I successfully established a professional relationship that provided multiple opportunities for us to engage in collaborative conversations about our own professional lives. I helped the teachers respond to unanswered questions that fostered their own thinking about their work.

As an experienced teacher researcher, I shared with teachers my earlier experiences of learning how to conduct research on my own practice. I shared issues I grappled with such as conducting school-based action research vs. classroom action research (Calhoun, 1993); not having enough time to reflect on my practice (Saurino, 1996); and organizing and presenting my data to appear legitimate for a wider audience (i.e. administration, other faculty, and parents). The exchange of these experiences not only helped clarify and validate their own concerns for what they were trying to do but also allowed the teachers to re-think their essential goals for their action research. For some teachers, it meant re-evaluating who they were doing action research for and why. For other teachers, it meant delving further into the meaning behind their goals for their students and their own teaching.

The conflicts I faced in the group were often associated with the multifaceted roles as the university researcher and facilitator. The first dilemma that I faced as a university researcher was that of being an outsider. Some researchers have discussed the pivotal role an outsider can play in a group of teacher researchers (Lieberman, 1988) while others draw attention to the dangers associated with the imbalance of power inherent in the relationship, especially if the outsider is from a university (Collins, 1991; Goldstein, 2000; Lather, 1991; Patai, 1991). There is a sense in which the outsider could be considered a threat to teachers' autonomy and authority as experts.

With this in mind, it was important for me to be aware of the balance of power associated with establishing and maintaining my collaborative relationship with the teachers. Some feminist researchers claim that sharing my expectations might be a less-than-welcomed discussion (Stacey, 1991). This was the case with my earliest interactions with the teachers. At the beginning, the teachers and I shared our own expectations for the group. By asserting my interest in exploring feminist pedagogies, I observed an immediate uneasiness on the part of some teachers. Several teachers did not converse, while other teachers probed for further understanding of what it meant to teach science from a feminist perspective. Other teachers joined in the conversation and shared their interpretations of what I meant by a feminist agenda (i.e., Susan and Donna).

To resolve this dissonance, the teachers and I employed Feldman's model for equitable collaboration through separation (Feldman, 1993). In this sense, the

teachers and I shared our own personal interests and expectations then negotiated an overall theme or mission for the group. The teachers then devised their own individual inquiries based on this theme. As Susan mentioned in her reflective vignette, my recommendation for a feminist agenda was soon replaced with an interest in "accessibility and making science accessible for all students" (transcript from group meeting # 3, March 1, 2001). However, I did not completely relinquish my research goals. I learned from the teachers that this would be an opportunity for me to inform them of feminist methodologies and to let them choose whether or not to make connections between feminist models for science teaching and their practical models for accessibility. In the interim, I learned to model feminist methodologies by attempting to de-center myself as the expert; incorporating and validating the different voices, experiences, and viewpoints of all the teachers; offering solace to teachers who felt confined by the challenges associated with transforming their practice; encouraging the teachers to devise creative and personal interpretations of the literature on feminist pedagogy and action research; and empowering the teachers to redefine the roles science and action research played in their professional lives (Harding, 1991; Lather, 1991; Mayberry, 2001; Rosser, 1997).

I also observed early on that each teacher came to the group with different experiences with action research. A large majority of teachers in the collaborative (eight teachers, including Ruth) did not have prior experience with action research. A smaller cohort (three teachers, including Donna and Susan) had completed graduate course work in action research where they designed and conducted an action research study in their respective classrooms. Reflecting on this phenomenon, I concluded that there were three distinct groups or generations of teacher researchers present in the group. Each group was at a particular stage of development in his/her learning and practice of action research. As an experienced teacher researcher, I provided insight, literature, prior knowledge and experiences to those teachers new to action research. The teachers in the second generation provided support and encouragement while simultaneously engaging freely in the process. Lastly, the teachers in the third generation asked questions, probed for understanding, and challenged the validity and reliability of action research as a technical endeavor.

This became most apparent during our discussions on how to collect data and how to measure the effectiveness of their strategies. Several teachers often asked: "How do I know what I am doing is effective?" and "Is this data really valid?" (Transcripts from group meetings #4-6, March-April, 2001). With the help of the second generation teachers as well as supporting literature on action research, the teachers in the third generation began to recognize the inherent connection between their students' feedback and their interest in improving their practice. However, several teachers still remained somewhat skeptical of the process and continued to seek ways to quantify their data.

Feldman (1994) expressed this conflict in his discussion of "Erzberger's dilemma" and what he referred to as the "need to know" (p. 93). To resolve this

conflict it required a re-examination of our views of the nature of research and a re-newed perspective that the validity in teacher research relies heavily in the discourses within teachers' own educational situations. From those new understandings comes a transformation toward the shared revisions of the situations or what Lather refers to as, "coming to know reality in order to transform it" (Lather, 1991, p. 61).

Discussion

The Professional, the Personal, and the Political

Understanding the role of action research in this particular model requires looking carefully at the three areas that frame each teacher's purpose for engaging in the process. Noffke (1997) best describes this as the professional, the personal, and the political dimensions and/or tensions situated within the domain of action research. For Ruth, engaging in action research served as a means of knowledge production, professional development, and status. Action research served as a vehicle for gaining new knowledge about how to employ effectively her model for lecture to all students. In addition, action research provided an alternative means of staff development. Like many of the other teachers in the group, Ruth welcomed the opportunity to be a researcher and student of her own practice. She welcomed the freedom of choice, voice, and space to explore one or more aspects of her science teaching not yet uncovered in previous inservice experiences. Making her work public via a national science teacher journal, Ruth enhanced her own status as a professional as well as enhanced the profession of science teaching itself.

Donna's increased confidence and renewed faith in her work as a science teacher embodied Noffke's second dimension - the personal. The idea of teachers questioning the basis of their work is an essential element to the efforts of action research (Noffke, 1997). Donna's inquiry and in depth reflections constituted rich explorations of the complexity of the "self" in action research. As a result Donna gained confidence and insight in her way of being a reflective teacher and effective researcher.

For Susan, engaging in action research stemmed from the personal and the political dimensions. Her practical inquiry allowed her to critique implicit power structures situated within her own educational context. She challenged the goals of the mandated curriculum and reinvented a curriculum that empowered her students to construct their own knowledge for learning chemistry. Susan also questioned the complex nature of science and science teaching and furthermore, made visible the marginalized voices of her students as a way of altering traditional models of science learning.

Lessons Learned from Each Generation

Each generation of teacher researchers in this study experienced collaborative action research differently. For example, the first generation (university researcher) learned that this particular forum served as a vehicle for teacher researchers to pursue

significant intellectual questions, challenge existing beliefs about research and science teaching, and argue for more self-sustaining collaboratives in order to bring about educational reform in science education. Having prior experience and knowledge in action research helped the university researcher gain legitimacy as both a researcher and as a facilitator of the collaborative.

The second generation of teacher researchers (i.e., Susan and Donna) learned that their prior experience with action research was invaluable. They were able to engage in the teacher inquiry process freely, confidently, and with less judgment with regards to validity of action research. In addition, they learned to be very supportive of newcomers to teacher inquiry and assisted one another in the process. It was the second generation of teacher researchers who played a pivotal role in effectively instructing and facilitating the process of action research. In other words, they were teachers teaching teachers about teacher research.

The third generation (i.e., Ruth) learned a great deal about the practical and professional aspects of action research. In this article, Ruth explained the ways she challenged the validity of action research and argued that action research was inadequate in meeting her needs for valid and reliable data. She learned how to overcome her anxiety with collecting and analyzing data by reviewing and discussing literature about action research as well as listening to the experiences of second and first generation teacher researchers. She generated new ways to gather data, analyze the results, and make meaning of her action research. For some, becoming a teacher researcher is one of the more productive and powerful experiences in their teaching career. For others, it sparks a new level of enthusiasm and appreciation for teaching and student learning in science. In the case of Ruth, action research was both personally and professionally rewarding.

Conclusion

The significance of this study hinges upon the voices, viewpoints, and experiences of a distinct family of science teacher researchers. Engaging in action research empowered the teachers from each generation to take the role of active participants in the research process and helped them develop and critically analyze their own knowledge about teaching diverse groups of students. While engaging in this work, teachers "come to trust their own ability to construct knowledge, to be meaning-makers, and to improve their practice. Buoyed by trust in themselves, they gather confidence to take new risks. The impact expands like concentric circles around the stone thrown in water" (Glesne, 1991, p. 11).

Findings from this study suggest that for collaborative action research to be effective at empowering teachers, teachers need to join with other passionate teachers to explore ways to voice freely their concerns, develop action plans, and enact their plans for change. Groups must be configured so that they include teachers who have alternative thoughts, ideas, and perspectives on teaching and learning.

Lastly, teacher researchers must be given collective authority to establish routines, negotiate an agenda, question different methodologies, and explore concerns related to coming to know the value of action research. By providing these conditions, collaborative action research will have a significant and lasting effect on professional practice.

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