

DEALING WITH MESSINESS AND UNCERTAINTY IN PRACTITIONER RESEARCH: THE NATURE OF PARTICIPATORY ACTION RESEARCH

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This article reports on the experiences and perceptions of K-12 teachers as they engaged in a participatory action research (PAR) project, *Science Across the Curriculum*. Although the experiences and professional learning of two of the project participants are highlighted, the challenges that all participants experienced as they conceptualized and implemented action research are also reported. The author concludes that messiness and uncertainty are inherent and necessary elements of action research and that these elements need to be explicit for the benefit of those who engage in and facilitate PAR.

Key words: science education, teacher development, teacher inquiry

Cet article présente les expériences et les perceptions d'enseignants de la maternelle au secondaire qui ont pris part à une recherche-action participative (RAP), *Science Across the Curriculum*. Ce sont surtout les expériences et l'apprentissage professionnel de deux des participants qui sont mis en lumière, mais l'article fait également état des défis auxquels ont fait face tous les participants dans la conceptualisation et la mise en œuvre de la recherche-action. L'auteure conclut que la désorganisation et l'incertitude sont des éléments intrinsèques de la recherche-action et que ces éléments doivent être explicites pour le plus grand bien des personnes qui participent et animent une RAP.

Mots clés : recherche-action participative, perfectionnement des enseignants, recherche sur les enseignants

In this article, I focus primarily on the experiences of two middle-school teachers, Ada and Tanya, who were members of an ongoing participatory action research (PAR) project, *Science Across the Curriculum*.¹ Their experiences highlight the myriad challenges that teacher researchers encounter when they engage in PAR for the first time. As well, I have reported challenges experienced by other teachers who participated in this project over a three-year period. The following research questions guided this study: What types of challenges do teachers experience as they engage in PAR? and What are teachers' perceptions of PAR as a strategy for fostering teacher development?

THE THEORY AND PRACTICE OF ACTION RESEARCH

In many educational contexts, researchers (Calhoun, 1994; Carson & Sumara, 1997; McKernan, 1996; Sagor, 1992) promote action research to foster teacher development and educational change. However, these researchers conceptualize and implement action research in a variety of ways. For example, Noffke (1997) describes the personal, professional, and political purposes of action research. Calhoun (1994) describes three types of action research: individual, collaborative, and school-wide. Rearick and Feldman (1999) offer a more elaborate framework for conceptualizing action research based on three dimensions: theoretical orientation (technical, practical, and emancipatory), purposes of the research (professional, personal, and political), and types of reflection (autobiographical, collaborative, and communal). Maruyama (1996) distinguishes between "practitioner-centred" and "Lewinian" action research, with the former focused on the role of the practitioner and the latter primarily concerned with the generation of knowledge about teaching and learning. Despite the variations in conceptions and purposes, action research usually involves a social practice that can potentially be improved – systematic inquiry into practice through cycles of planning, acting, observing, and reflecting; and direct involvement of those responsible for the practice (Grundy, 1982).

Tillotson (2000) views action research as a possible solution to the problem of research failing to inform classroom practice and effect positive change in schools. In science education (the context of this study), action research is gaining in popularity. According to Feldman and

Capo-bianco (2001), educators have used action research in three domains in science education: teacher education, science learning, and curriculum development and implementation.

In the context of teacher education, university researchers use action research methods to enhance and restructure teacher preparation programs (Buck & Cordes, 2005), while other researchers report on how teachers' professional knowledge is enhanced as a result of their working collaboratively within action research groups (Goldston & Shroyer, 2000; Goodnough, 2001; Hewson et al, 1999; Koch & Burghardt, 2002; Tuan, Chin, & Tsai, 2003; van Zee, 1998).

Many studies (Chin & Tuan, 1998; Feldman, Mason, & Goldberg, 1992; Pedretti & Hodson, 1995) report on how action research has been used as a vehicle to transform teaching practices and enhance curriculum. Other action research studies have focused primarily on improving facets of student learning – e.g., student perceptions of alternate assessment (Waters, Smeaton, & Burns, 2004) and the impact of adopting multiple intelligences on a grade-eight science class (Saurino, Saurino, & See, 2002).

Action research has the potential to foster teacher development, which is especially important in view of research that has shown a range of constraining factors – lack of content preparation, of confidence, and of experience in teaching science – that prevent many teachers from teaching science using inquiry-based, constructivist learning approaches (Abel & Roth, 1991; Tilgner, 1990). The research study reported here was empirical in nature, with participants seeking to gain a greater understanding of their classroom practice through individual and group reflection.

In the research I report in this article, teachers used participatory action research (PAR) (Kemmis & McTaggart, 2005) to study their classroom practice. They engaged in continuous cycles of reflection, dialogue, action, and learning as they developed and implemented their inquiry projects. According to Kemmis and McTaggart, in addition to this self-reflective cycle, PAR has other key features: it involves a social process; participants examine their own knowledge and understandings and the research is self-directed rather than other-directed; it is practical, collaborative, critical, emancipatory, and reflexive; and it changes both theory

and practice, viewing the development of theory in relationship with practice and vice versa.

RESEARCH DESIGN

This study was guided by a constructivist-interpretive framework, designed to develop understanding through the collaborative construction of knowledge (Guba & Lincoln, 2005). I studied the experiences of individuals and groups within PAR, making sense of the meanings individuals and groups brought to these experiences.

In 2003-2004, five teachers participated in this project. In 2004-2005, 17 teachers participated, while five of these teachers participated in 2005-2006, as well 12 new teachers. Over the three-year period, most participants were part of school-based teams consisting of two or three teachers. Two levels of support were present during the project – planning, dialogue, and reflection occurred during school-based meetings and during whole-group meetings. Through the involvement and support of local school districts, I invited K-12 teachers of science to join the project. Recruiting occurred in the spring of each year and projects started in the fall of the subsequent school year. Tanya, a French Immersion, middle-school teacher of seven years, and Ada, a 15-year veteran middle-school teacher, were part of the project in its first year. They worked collaboratively to plan and implement an action research project in their respective classrooms. Because they taught in the same school, a rural middle /high school with 350 students, they were able to work closely on-site as the project unfolded. During her teaching career, Tanya's teaching assignments were primarily French, physical education, mathematics, and science. Ada was in her second year teaching science at the middle-school level. Her usual course load included language arts, social studies, and health. Neither teacher had any formal preparation in teaching science. Hence, they viewed this project as an opportunity to "work with knowledgeable teachers from the district, develop a grade-eight curriculum unit on Optics, and explore new teaching strategies" (Ada, planning session). Tanya's French Immersion class had 15 students with high variability in terms of academic aptitude. Ada's heterogeneous English-stream class had 32 students, with 9 receiving program modifications.

Data Collection

Research for this project occurred at two levels – the teachers collected data within the context of their own classrooms and I collected data generated from group discussions and other group and individual activities. At times, these data sources overlapped and were shared. By adopting qualitative data collection methods, I could explore the beliefs, values, ideas, and experiences of the participants as the research unfolded.

To develop an in-depth understanding of the complexity and multi-faceted nature of individual and group experiences, I used several data collection methods and sources:

Participant observation. In each year of the project, the group met on eight occasions, with sessions varying in length from three to six hours. During these sessions, participants engaged in activities that encouraged them to explore the nature of action research, to develop the skills necessary to conduct action research, to consider the nature of science teaching and learning, to structure inquiry-based teaching in science, and to plan for and reflect on all aspects of their action research projects. I recorded field notes after meeting sessions, as well as during and after school visits; all meetings were audiotaped and later transcribed.

Documents. According to Hodder (2000), documents involve a “personal technology” (p. 703) that requires contextualized interpretation. I examined participants’ lesson plans, records, and other materials to enhance data analysis and interpretation, providing another perspective from which to corroborate themes emerging from the data. At the end of the study, each teacher submitted a final report based on what she learned about science teaching and learning and action research.

Journals. Journals, collections of notes or written passages, contain “personal record[s] of insights, beginning understandings, working hunches, recurring words or phrases, ideas, questions, thoughts, concerns, and decisions made during the research process” (Maykut & Morehouse, 1994, p. 68). The participants and I maintained electronic journals throughout the study to foster individual and group reflection, to provide a forum for the exploration of developing ideas, and to better inform our evolving actions.

Semi-structured and informal interviews. I interviewed each participant at the beginning and at the end of the study. Interviews were audiotaped and later transcribed; careful notes were taken after each interview. Informal conversations occurred face-to-face before and after action research meetings and notes were recorded based on these conversations.

Data Analysis

In this study, data analysis closely followed data collection. When analysing the data, I adopted grounded theory (Strauss & Corbin, 1998), using open coding initially to identify concepts. I assigned labels to units of text from transcripts, field notes, journal entries, and interviews, forming the basis for identifying concepts throughout the data set. Simultaneously, I engaged in constant comparison, identifying similar incidents and events for grouping into the same conceptual categories.

Subsequently, I used axial coding to establish larger categories and make connections among large categories and subcategories. To manage the large data set, I used NUD*IST, a qualitative computer software analysis program, to assist with the coding and retrieval of data. In addition, I found that NUD*IST facilitated data analysis by allowing me to generate visual maps of developing categories and their relationships.

To enhance the validity and reliability of data interpretation, I adopted several strategies, such as prolonged engagement at the research site, reciprocity, and member checking. There was considerable interaction among the participants and me over an extended period of time at group meetings, during classroom visits, and through numerous telephone and on-line conversations. To ensure that teachers' voices were represented strongly when reporting the research during and after the completion of the study, I asked teachers for feedback after providing them with summaries of my interpretation of the data.

THE ACTION RESEARCH PROCESS

From September to December of each year of the project, school-based teams explored the nature of PAR (purposes, conceptions, and models), identified areas of focus, formulated specific research questions, and developed plans of action. In addition to learning about action research, teachers shared their beliefs about science teaching and learning, the

prescribed science curriculum, and issues and concerns having an impact on their schools and classrooms. In my role as a facilitator of PAR, one of my goals was to foster the development of a “community of practice” (Wenger, 1998) and to promote individual and group learning and reflection within the context of this community.

In addition to learning about PAR, the initial meetings in each year of the project focussed on building community and trust within the group. At these meetings, teachers shared their reasons for participating in the project: having the opportunity to collaborate with colleagues on an ongoing basis, enhancing various aspects of student learning in science (e.g., student understanding of science topics), developing an understanding of assessment and instructional approaches, and becoming more comfortable with teaching science topics. Teachers also expressed concerns about teaching science. Most of the primary and elementary teachers reported that science was not a curricular focus in their schools, while mathematics and language arts received most of the attention. The following teacher’s comment reflects this problem: “Although I always enjoyed learning science, I often overlooked the importance of science in my classroom, instead focusing most of my teaching on reading and math development. When I did finally get around to the science outcomes, my teaching was mostly direct teaching, supplemented by factual texts” (group planning meeting). Teachers valued science and shared their beliefs about how students should learn in science, although beliefs and classroom practice, according to the teachers, did not always align. Some of their perspectives are reflected in such comments as:

Students are likely not to learn science in isolation. Children do not learn like that. They need to learn language, math, art, and science in an integrated way.” [and] “I believe that constructivism should guide science and learning. Students should take an active role in the learning process, exploring scientific concepts, making discoveries, and learning new concepts. (Teachers’ comments in group meetings)

School-based teams posed a variety of research questions focussed on improving teaching through a technique or strategy, or revising and enriching a curriculum unit. Examples of research questions posed in-

clude the following: "How can we use a worm-composting project in our classrooms to increase recycling/environmental awareness?" (School-based team A, primary), "How will students use the WebCT discussion forum to help them learn during the chemistry unit?" (School-based team B, grade 9), "How will combining art with science enhance student understanding of simple machines?" (School-based team C, grade eight), "How would the adoption of an inquiry-based teaching and learning approach impact our classes in science?" (school-based team D, grade six), and "How would our grade-five students become more engaged in science learning if I changed my approach to an activity-based one?" (School-based team J, elementary)

Teachers developed plans of action by the end of February of each year and implemented them between March and April in each year. All teacher inquiry projects were qualitative, usually involving one classroom. All teachers used their journal entries as a source of data. The teachers adopted their data collection methods and sources such as pre- and post-surveys, student-generated data (e.g., presentations, student self-assessments, journal entries, portfolios, and other written work), and field notes. As implementation occurred, teachers engaged in individual, school-based, and whole group sharing and reflection.

THE EXPERIENCES OF ADA AND TANYA

Although I did not know this until later, Ada and Tanya started the project with their own notions about the purpose of the project and how the process would work. Based on a discussion after completion of the project about how the confusion arose, the teachers reported that they misinterpreted the information that was sent to the school district and had not paid careful enough attention to what was stated in the consent form, although I had explained the nature of the project and participant expectations. In post-study interviews, both Ada and Tanya retrospectively reflected on these notions, explaining how they had originally conceptualized the research:

Somehow I thought this would be a place to test out ideas. You would come here on one day and this is what we would learn [a new teaching strategy or approach]. Then, we would go to our schools, teach it for a month or so, and then

we would come back, do a new scenario and teach it again for another month. (Tanya, post-study interview)

Early in the project, there were times when I felt I was lured under false pretence. There was considerable trepidation on my part. It was not what I expected. (Ada, post-study interview)

I intended to foster individual and group ownership of the project by supporting a forum to allow collaborators to guide their own professional development, based on their available time and classroom needs. I devoted the early group sessions to examining the characteristics of action research, comparing action research models, and exploring how to develop a plan of action. For example, on one occasion, after examining several conceptions of action research, two questions arose: "Does action research have to focus on a problem?" and "Isn't this what we always do?" The following dialogue that occurred during a planning session provides insight into how Ada, Tanya, and other group members grappled with the issues raised by the questions.

Karen [researcher]: Yes, action research is systematic; it's intentional, and requires considerable commitment. You first have to find an area of focus and then develop a focused research question. Once you focus, you need to do some reading. And then you come up with strategies for answering your research question. For example, "What can I try in my classroom to encourage more girls to participate in my science classes?" You try something new. You collect data. Did it work? Did it not work? So there is a cycle involved in action research.

Ada: So, does action research have to be a problem?

Karen: From my perspective, no. Sometimes action research can stem from a problem in your own classroom. Not always, but it can. For example, when I did my small action research project last year in my preservice classroom, I had read a lot about problem-based learning, as an instructional approach. Based on the research at post-secondary level that's been done, it seemed to be a very effective form of instruction. It could also add variety. So for me it wasn't that I perceived a problem, I just wanted to try a new approach and ascertain the outcome.

Tanya: I think this is a lot of what we do now. Plan a lesson, take action, teach it. See what works and does not work. You evaluate what works and does not work. What we do in our classroom is a cycle.

Ada: Yes, I think we do this all the time.

Karen: So how is action research different?

Tanya: I guess we are formalizing the process – putting ideas on paper. (group planning session dialogue)

These teachers had identified a critical difference between action research and “what they do all the time.” In formalizing the process, they were suggesting that action research moves beyond reflection and involves “systematic, intentional inquiry by teachers” (Cochran-Smith & Lytle, 1993, p. 5) that allows teachers to examine and interrogate what they do in classrooms and why they do it.

As the group learned more about the nature and process of action research, Ada and Tanya gradually came to the realization that most of the onus for structuring the project would rest with them. They would have to choose their own research area and develop and implement a plan of action. Some resistance to this notion persisted, even as they formulated their research questions and developed a plan of action. Eventually this resistance dissipated, only to be replaced with feelings of frustration and apprehension.

Planning for Action

For several months, Ada and Tanya struggled with formulating their shared research question. From a broad perspective, they wanted to gain more insight into their students’ thinking as they engaged in inquiry-based activities. After exploring possibilities and getting feedback from the group, Ada and Tanya decided to use student journals in their Optics unit to probe student thinking and understanding. Their research question at the outset was: “How can journals be used to evaluate students’ understanding of scientific concepts and their transfer of knowledge to new situations?” As Tanya stated in a journal reflection, “We struggled with this question all the way through the planning and early implementation stage of the project. We were not convinced that the question reflected the true needs of our classrooms.” Furthermore, it became evident to me that although other group members were enthusiastic about their research questions and plans of action, Ada and Tanya did not exhibit the same level of enthusiasm. Their enthusiasm was dampened by feelings of insecurity about their plan of action: “I am still very unsure about what we are doing. What do I know? I want kids to think

and figure things out without being spoon fed . . . inquiry . . . but it is messy. They make a lot of mistakes and as a result, draw poor conclusions. Is that really wrong? Isn't that how science develops anyway?" (Ada, journal entry).

To compound feelings of uncertainty, Ada and Tanya, interpreting a new science curriculum framework, lacked the content knowledge needed to teach a unit on Optics.² They shared their uncertainty with the group at a planning session: "We just don't know the material. We have had to put a lot of time into learning it. It's all so new" (Ada). Furthermore, time became another challenge. In the context of teaching, it is often difficult to separate the personal and professional dimensions of one's life. As Ada commented at one point, "Finding time is almost impossible right now. Between my children's commitments and my work commitments, I am overwhelmed. I need more time for me; I need to set priorities, and my time on task needs to be more efficient."

Ada and Tanya had completed their plans of action by the end of January and started implementation in early February. During the planning process of interpreting curriculum outcomes, designing and modifying learning and assessment activities, and determining how they would collect data, the teachers worked collaboratively at their school site. Some planning occurred during whole-group meetings, while I provided support and feedback during visits to their school and through online communication using e-mail.

Taking Action and Reflecting on Action

At the end of this project, Tanya reflected through a journal entry on the overall process: "It has been frustrating, exhilarating, and thought-provoking." The real excitement and exhilaration for Ada and Tanya did not become evident until close to the end of the project. At one of our later group planning sessions, Tanya entered the room stating, "I can't wait to tell you our news. We have changed our research direction." As our session started, Tanya and Ada informed the group that they had attended a professional development session on differentiated instruction (Tomlinson, 1999, 2001), an approach to organizing teaching and learning that offers students a variety of learning options that cater to different readiness levels, interests, and learning profiles. Students are

provided with different avenues to develop their understanding of content, to process ideas, and to show what they have learned. Adopting a differentiated approach to teaching and learning incorporates a variety of classroom organizational, instructional, and assessment approaches and principles (e.g., flexible grouping, tiered assignments, learning contracts, cluster grouping, thematic units, curriculum compacting, student choice, multiple intelligences, and learning styles) that allow teachers to move away from teaching to the middle. Subsequently, they decided to modify their research plan. Continuing to assess students' work through journal writing using three key areas (explanation of new concepts, use of scientific vocabulary, and formulation of research questions), they would now deliver their Optics unit using a new instructional lens: differentiated instruction. Their final research question was, "How can differentiated instruction be used to improve the quality of student journal entries?" In other words, they expected students to write about their developing understanding of science concepts and how they felt about learning activities as they engaged with them. Tanya commented in her journal on this shift: "The new direction allowed us to modify the presentation of the unit; we felt this new approach was more appropriate for our mixed ability classes."

Their rationale for this change was consistent with the learning needs of their students. I commented on this observation in one of my journal entries:

Ada and Tanya were extremely excited throughout the day. They re-focused their research question. This notion of using a range of strategies to differentiate instruction really resonated with them. They have students with such diverse abilities that this approach seems promising. They now have a clearer focus and seem more grounded. (Goodnough, journal entry).

Ada and Tanya adopted tiered activities as a starting point to differentiate their instruction. They designed learning activities such that students could choose activities from a selected or assigned ability level; they designed rubrics for all tasks. For example, in one learning activity students were asked to choose one of the following options:

- (a) Green level: What are the mathematical symbols for angle of refraction, angle of reflection, and angle of incidence? Draw and label a ray diagram with an angle of incidence of 45 degrees.
- (b) Gold level: Use a ray diagram to explain how to use the laws of reflection in playing one of the following games: pool, ping pong, baseball, or basketball.
- (c) White level: You are an interior designer. Design a room using three different sources of diffused lighting. Explain your choices. (Ada and Tanya's reformulated research question)

Students were assigned a particular level but could choose to complete an activity at a higher level of complexity. In moving from green to gold to white, the specified activity became more complex and more open-ended. In addition to adopting a tiered assignment approach, Ada and Tanya used Gardner's (1993, 1999) multiple intelligences (MI) theory inventory to help their students explore their unique intelligences profiles. Moreover, MI theory provided a lens for them to examine their own teaching beliefs and approaches and how they aligned with students' strengths and weaknesses.

Although Ada and Tanya reported that their students liked this approach, the teachers felt some of their activities (lower level) did not foster student engagement. "A lot of kids chose not to do the lower end activities because they were more text-oriented. The higher activities were more challenging and motivating, even though some of the students' writing and explanations were not good" (Ada, journal entry). Ada and Tanya hoped in the future to redesign some of the learning activities and to get to know their students better by using ideas from the learning styles literature. By catering to the different ways that students process information, they hoped to enhance students' understanding of science and to make learning more relevant for them. In using journals with their students, Ada and Tanya reported two challenges: first, students did not have enough class time to complete their guided journal entries, and second, many of their students struggled to articulate their thinking when writing in their journals.

Learning and Transformation through PAR

One of the obvious outcomes of this project for Ada and Tanya was the enhancement of their pedagogical content knowledge (Grossman, 1990;

Shulman, 1986, 1987). Shulman (1986) refers to pedagogical content knowledge as “the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word the ways of representing and formulating the subject matter that makes it comprehensible for others” (p. 9). According to Ada and Tanya, they developed a much greater understanding of how to differentiate science instruction for their mixed ability science classrooms, which resulted in a change in how they designed and implemented the science curriculum.

Although teacher research can result in learning and the transformation of practice for individual teachers, unfortunately the outcomes of teacher research initiatives are not widely disseminated (Cochran-Smith & Lytle, 1993; Gore & Zeichner, 1995). To contribute to the professionalization of teaching, it is critical that practitioner research outcomes be shared with others. In this study, I encouraged all participants to consider sharing the outcomes of their research in a public format – through staff meetings, local or national conferences, or publications in a district newsletter or practitioner journal. Ada and Tanya decided to share their research through a workshop presented during a local district professional development day. This decision allowed local dissemination of their work, thus increasing the possibility that other teachers might benefit from what they learned. This workshop also provided a culminating, synthesis experience for them to crystallize their thinking and reflect on what they had learned during the first year of the project.

Most of the action research journey was frustrating for Ada and Tanya; yet, from the untidiness and uncertainty, learning occurred. Both teachers highly endorsed action research as a feasible approach to teacher development.

Action research is a messy, yet exciting concept. Selecting a specific area of your teaching to improve and concentrating on that area helps to bring about change in your classroom. It allows you to research current methods and evaluate activities on an ongoing basis, deciding what works and does not work, and adjusting for the next activity is an important step in this research method. (Ada, interview)

Action research is a method that offers a researcher the flexibility to make changes and adjustments as situations occur. This was a very positive learning

experience . . . our students are benefiting as we incorporate new ideas into our current and future science units. We are also incorporating differentiated instruction into and using action research in other subject areas. (Tanya, interview)

The messiness and uncertainty within action research challenged Ada and Tanya, but they were able to garner many insights about their own teaching and student learning from the experience. And more importantly, they did not view this action research project as the end but as a beginning. "The most interesting thing for us is that as we come to the end of this year, we are really at the beginning. We are looking forward to the future" (Tanya, journal entry).

CHALLENGES ENCOUNTERED BY ALL PROJECT PARTICIPANTS

Teacher inquirers encounter a range of challenges when they engage in PAR which can vary from teacher to teacher and group to group. For example, for many action researchers, finding an area of focus and formulating a research question is the most demanding aspect of action research. In other instances, data analysis presents the biggest challenge.

Table 1 presents an overview of the challenges identified by teacher researchers who engaged in action research in this project over a three-year period. The most prevalent concern expressed by teacher researchers was finding enough time to devote to all stages of the action research. Although several days were provided for release time for teachers, they felt this was not enough. Most teachers reported that the demands placed on their daily professional lives had become more and more demanding, and consequently, they had less time to devote to all aspects of their professional practice. One teacher shared her concerns about the business of teachers' lives:

This [action research] takes time and the demands of every day teaching are multiplying – we were cut back on preparation time this year, the demands of committee work have increased, the extras associated with teaching have increased; and the actual teaching in all of my classes and the administrative things have taken on more time. (project teacher)

Table 1
Challenges Experienced by Teacher Researchers
during Action Research

Challenge	Number of teachers who identified this challenge (total participants = 39)	Brief description of the challenge
Time	39	More time for developing plans of action prior to implementation, library research, and meeting with school-based colleagues to collaborate
Area of Focus/ Formulating a Research Question	22	Identification of the topic of the inquiry and the development of an appropriate research question
Data Analysis/Interpretation	20	Uncomfortable with how to analyze and interpret data
Journal Writing	20	Finding time to make regular journal entries
Logistics	17	Difficulty with adhering to implementation time lines, accessing computer technology, avoiding daily classroom interruptions imposed externally
Resources	14	Lack of resources to support the implementation plan
Support	7	Lack of school-based support

Teachers cited lack of time during the regular teaching day as a significant barrier to making regular journal entries and holding regular meetings with school-based colleagues during implementation. Over one-half the teachers struggled with finding an area of focus and formulating a

research question, while many did not feel comfortable with how to go about data analysis and interpretation. Other challenges focused on logistics, resources, and school-based support.

PERSONAL REFLECTIONS ON FACILITATION

At the core of the approach to action research conceptualized in this study is the recognition that human learning occurs in social contexts. One of the defining principles of this approach is doing research *with* people instead of doing research *on* them. Hence, I assumed a variety of shifting roles (facilitator, supporter, challenger, and teacher) in supporting teachers throughout the project (Goodnough, 2003). I attempted to foster ownership by encouraging all collaborators to take responsibility for the process. For example, the group planned agendas at the end of a meeting day in preparation for the next meeting. In this way, the group was better able to assess its needs formally and plan appropriately.

Initial meetings were devoted to learning about the nature and process of action research (e.g., formulating research questions, conducting data collection and analyzing data, examining other accounts of teacher research). My initial role of teacher changed as the needs of the group changed. Later, my role shifted to facilitator, and often I acted as a sounding board, as did other groups members, providing feedback on teachers' developing ideas and insights.

Based on my previous experience in facilitating inquiry groups, one of the dilemmas I regularly encounter is judging the amount of support teachers need at different stages of the action research. For example, in reflecting on my role in the first year of this project, especially at the problem formulation stage, I questioned how I could have better assisted Ada and Tanya as they struggled with their research question.

Although they [Ada and Tanya] have formulated a tentative research question, they still seem frustrated and less than content with how the process is unfolding. The group brainstormed ideas for sources of research questions and issues, we completed a reflective tool that encouraged teachers to answer questions about their practice, the teachers collected some preliminary data from their students about their learning needs, and we read other reports by teacher

researchers. Am I providing enough support in helping group members identify a research area? [Author's journal reflection]

Although I was providing guidance to help Ada and Tanya identify a research area, I believe the activities I adopted were not focused enough. When I asked Ada and Tanya at the end of the study for input about my role in the action research, they suggested that a more exhaustive exploration of ideas occur up front. For example, Ada said, "If we had known about differentiated instruction at the beginning, things may have proceeded differently. Perhaps future groups could explore teaching approaches in more detail."

In the second and subsequent years of the project, I used the work of Dana and Yendol-Silva (2003) to enhance my ability to support teachers when they are identifying areas of focus and formulating research questions. Based on their own work and the work of Hubbard and Power (1999), these authors suggest the following guidelines to help teachers pose and refine research questions:

1. Look at teaching using eight lenses (the child, curriculum, content knowledge, teaching strategies, beliefs and practice, personal/professional identity, social justice, and context).
2. Be prepared for research questions to change as an inquiry progresses.
3. Explore questions that do not have answers.
4. Develop open-ended questions as opposed to closed questions.
5. Eliminate jargon.
6. Ensure the question can be supported and explored by the methods adopted.
7. Share question ideas with colleagues.
8. Be patient with articulating a research question. (p. 47)

These ideas have become an integral part of my work in facilitating teacher inquiry groups. Dana and Yendol-Silva (2003) present a comprehensive approach with a series of built-in exercises that I use to provide a more structured exploration of potential issues and problems. For example, in exploring the relationship between teacher beliefs and classroom practice, one of eight lenses, the authors suggest that teachers generate a general teaching philosophy and then a teaching philosophy about their discipline areas; share it with a friend; and then identify how

the philosophy is or is not being enacted in the classroom. The information gathered from this exercise can then become the essence of a research issue.

Of course, helping teachers find an area of focus and formulate a research question is only one facet of facilitation. Teachers need support at all stages of action research. I have found the design principles of Wenger, McDermott, and Synder (2002) to be very helpful in cultivating productive action research communities of practice.³ Table 2 provides a brief overview of each design principle and its application in cultivating communities of practice.

This multi-layered study of teacher inquiry provided a forum for a small group of teachers to engage in professional development in the context of science education. Although it is difficult to separate process and product when exploring the nature of action research, the primary focus of this article has been on process – the experiences of Ada and Tanya as they engaged in collaborative action research. Because teacher research is contextual research and begins with teachers' beliefs, knowledge, and understanding, the problem or issue they research cannot be held in "place while it is researched" (Loughran, 2003, p. 182). Rather, as teachers inquire into their own practice, their problem and research plans are continually shifting, developing, and being revised as ideas are translated into classroom practice. In essence, the experiences of Ada and Tanya reflect, in a vivid way, the nature of the action research cycle, described by many as involving a recursive spiral of planning, acting, observing, and reflecting. Intertwined in this process is the element of human learning, a process of negotiating meaning as new insights are garnered.

In negotiating new meaning during action research, participants, especially novice teacher researchers, frequently experience challenges as they conceptualize and implement projects (Elliott, 1991). However, often the inherent messiness and uncertainty of action research is not reported in accounts of action research. One notable exception is the work of Cook (1998), who reports on the experiences of a group of novice researchers and their dissonance around reconciling the messiness of

Table 2
Seven Design Principles for Cultivating
a Community of Practice

Principle	Characteristics
Design for Evolution	Communities need to be dynamic and flexible, redesigning and making changes in how they operate and what they do over time.
Open a Dialogue Between Insider and Outsider Perspectives	Only insiders can understand the nature of knowledge that is relevant to a community and the challenges that members of a profession or domain encounter. However, communities need to capitalize on outsider perspectives and knowledge to strengthen community functioning and evolution.
Invite Different Levels of Participation	Individuals participate in communities of practice for varying reasons. Not all will have the same interest or involvement in a community. Participation should not be forced. Rather, the contributions of all individuals, whether at the periphery of a community or at the core, should be valued.
Develop Both Public and Private Space	The successful functioning of a community is dependent on the intricate web of relationships among its members. Members need many informal opportunities to interact and share. Strengthening community member relationships also allows public events such as meetings to be more productive and inviting.
Focus on Value	The value of a community may not be apparent in the early stages of its existence. Its value needs to emerge over time, and members need to explicitly reflect on how to harness the community's potential.

Combine Familiarity and Excitement	Community members need to have regular events and structures, while simultaneously having opportunities to participate in new events, interrogate new ideas, and welcome new members. Routines and structure foster relationship building; new ideas and events foster excitement and are more likely to engage members.
Create Rhythm for the Community	Wenger et al. (2002) refer to rhythm as the “beat” of the community. If participants do not have enough time to reflect on their learning, they can become overwhelmed. Likewise, if the pace is too slow, then interest can wane and members may become less engaged. A balanced rhythm is needed to create a vibrant community and enhance its value.

Source: (Wenger et al., 2002)

action research with the necessity of having a model to structure and guide their work. She suggests that PAR researchers need to “describe the action research process more expansively and candidly . . . and to allow it to be critically scrutinized for its intrinsic worth and what it has to offer” (p. 107).

Tanya referred to the messiness and uncertainty in action research as “there-and-back-again,” an apt description of the bumpy road that many novice action researchers experience (Gilbert & Smith, 2003). Garnering more than superficial insights into this “there-and-back-again” process will necessitate, as Cook (1998) suggests, reporting in the literature that is frank and comprehensive. Making the process of action research explicit has implications for both practitioners who engage in action research and those who support and facilitate action research.

From a practitioner’s perspective, being able to study and read about other accounts of action research can facilitate an understanding of the process and hence, inform how others engage in action research. Like-

wise, those who facilitate action research and become “critical friends” to teacher research groups can benefit from gaining more insight into action research. Facilitators assume myriad roles, face a range of facilitation challenges (Burchell, 2000; Goodnough, 2003), and make decisions about how to best address those challenges. For example, having a greater understanding of the action research process and the potential challenges that may arise for novice action researchers can assist facilitators to examine their roles and how they are fulfilling those roles. Facilitators of action research need to engage in second-order inquiry, “constantly deliberating about their own practice and its relationship to the nature of the activity they are trying to facilitate” (Elliott, 1985, p. 259).

Messiness and uncertainty are inherent, and often necessary, elements of action research. Those who engage in action research need time to grapple with new ideas, to make sense of an emergent process, and to construct shared meaning within PAR communities of practice.

NOTES

¹ The action research project was sponsored by the Social Sciences and Humanities Research Council (Initiative for the New Economy).

² The Optics unit, in which students explored the properties of visible light, included investigations of the reflectioning and refractioning technologies of light.

³ According to Wenger, McDermott, and Synder (2002), communities of practice are “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis” (p. 4). Communities of practice are ubiquitous and individuals are often members of a variety of these communities. These authors believe that communities of practice can be cultivated through thoughtful attention to creating learning environments that value learning and provide support through resources, time, and the removal of organizational barriers.

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