DOCUMENT RESUME

ED 482 915 SE 068 240

AUTHOR	Goodnough, Karen
TITLE	Teacher Development through Collaborative Inquiry: Primary Teachers Enhance Their Professional Knowledge of Science Teaching and Learning.
PUB DATE	2002-04-00
NOTE	22p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (New Orleans, LA, April, 2002).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Curriculum Design; Curriculum Development; Knowledge Base for Teaching; Primary Education; *Professional Development; *Science Instruction; *Science Teachers

ABSTRACT

This study focuses on the nature of professional development. The approach to professional development that emerged in this inquiry was premised on a belief held by the author, a university researcher, and two K-1 teachers that professional development opportunities for teachers need to be ongoing, allow time for teachers to engage in learning, and occur in a collaborative community of learners. Over an eight month period from October 2000 to May 2001, the researchers developed and implemented science curriculum that targeted a K-1 multi- age classroom of 40 students. One of the main objectives of the inquiry was to foster the development of teacher professional knowledge in the context of primary science education. The second objective was to explore the nature of the collaborative inquiry that emerged and its influence on the development of teachers' professional knowledge. Two questions guided this study: (1) How will the participating teachers enhance their professional knowledge as a result of this experience?; and (2) Under what conditions will this approach to professional development be effective? The processes and contextual variables that contributed to the overall effectiveness of the approach are identified and described as well as outcomes related to the development of collaborating teachers' knowledge base for teaching primary science. (SOE)

National Association for Research in Science Teaching (NARST) Annual Meeting

New Orleans, April 2002

Title:

Teacher Development through Collaborative Inquiry: Primary Teachers Enhance their Professional Knowledge of Science Teaching and Learning

Dr. Karen Goodnough
University of New Brunswick
Faculty of Education
P.O. Box 4400
Fredericton, NB
Canada
E3B 6E3

Telephone: 709-754-5277

E-mail: kcg@unb.ca

Introduction

Current educational reform documents in science and technology education (American Association for the Advancement of Science, 1989, 1993; National Research Council, 1996) are calling for changes at many levels in the educational system. The ultimate goal of many of the recommendations for change is attainment of high levels of scientific literacy for all students. Although conceptions of scientific literacy vary and different emphasis may be placed on different aspects of scientific literacy, current conceptions usually expect students to construct an understanding of scientific concepts, principles, and theories; to develop an understanding of the nature of science and the complex relationships amongst science, technology, and society; to acquire the skills necessary for scientific inquiry, problem-solving, communication, and decision-making; and to develop an interest in and an appreciation for science (National Research Council, 1996). Suggested changes target what students should know, understand, and be able to do in science; how science teaching, learning, and assessment should occur; the nature of professional development; and the many systemic components of the educational system that work together to foster student learning.

This study focuses on the nature of professional development. The approach to professional development that emerged in this inquiry was premised on a belief held by me, a university researcher and my collaborators, two K-1 teachers, that professional development opportunities for teachers need to be ongoing, allow time for teachers to engage in learning, and occur in a collaborative community of learners. Over a eight-month period from October 2000 to May 2001, my collaborators, Catherine and Sarah, and I developed and implemented science curriculum that targeted a K-1 multi-age classroom of 40 students. One of the main objectives of the inquiry was to foster the development of teacher professional knowledge in the context of primary science education. The second objective was to explore the nature of the collaborative inquiry that emerged and its influence on the development of teachers' professional knowledge.

Two key questions guided the study: 1) How will the participating teachers enhance their professional knowledge as a result of this experience? 2) Under what conditions will this approach to professional development be effective? Although data was collected from students (observations and student-generated work) throughout the study and used to inform our planning and practice, outcomes related to student learning are not addressed in this paper.

Theoretical Perspective

If all students are to have opportunities to develop high levels of scientific literacy, considerable emphasis will need to be placed on teacher development. Teachers will need to be supported and encouraged to participate in professional development opportunities that allow them to explore their understanding of science and science teaching and learning and to make changes in their practice that are consistent with new reform ideals. As Hargreaves and Fullan (1992) suggest, it is the classroom teacher who plays a significant role in determining the success of any reform. Local school districts and those engaged in pre-service and in-service teacher education will need to adopt new approaches to professional development that cater to the diverse learning needs of teachers. One-size-fits-all approaches to professional development are unlikely to achieve the type of change envisioned in reform initiatives. Commensurate with adopting new approaches to professional development is the need for teacher educators and policy makers to develop an understanding of the characteristics of effective professional development and the conditions under which professional development will be most effective in fostering teacher learning. Effective approaches to teacher development "mirror what we know about learning; they are continuous, build on learners' current knowledge and skills, and include sufficient intensity and practice that new learning can become part of teachers' ongoing practice" (Loucks-Horsley, Kapitan, Carlson, Kuerbis, Clark, Melle, Sachse, & Walton, 1990, p. 130).

Research has consistently shown that there is a need for elementary and primary teachers to be afforded opportunities to engage in high-quality professional development. Many primary and elementary teachers often feel uncomfortable and unprepared to teach science (Abell & Roth, 1991; Kahle, Anderson & Damjanovic, 1991; Tilgner, 1990). Many address their insecurities about teaching science by adopting a variety of strategies, including teaching as little science as possible, avoiding difficult topics, relying heavily on textbooks, using outside experts, and overemphasizing practical activity (Harlen & Holroyd, 1997; Lee, 1995). Quality professional development can help teachers acquire knowledge and skills and "bring [this] knowledge and skills into action in classroom practice" (Bőrger & Tillema, 1993, p. 186). Currently, the research base that links professional development directly to improved student learning is weak (Loucks-Horlsy & Matsumoto, 1999) due in large part to the complex relationships that exist amongst factors influencing student learning. Other factors such as teacher participation in professional development and changes in teachers' knowledge are frequently used to gauge the effectiveness of any approach to professional development.

In this study, we assumed that to become a more effective teacher, one's knowledge base for teaching needs to be continually developed and enhanced. In last twenty years or so, teachers' knowledge has been given considerable attention in the research literature (Elbaz, 1981; Grossman, 1990; Leinhardt, 1990; Shulman, 1986, 1987). Several frameworks have been proposed to describe teachers' professional knowledge base for teaching. For example, Elbaz (1981) believes that teachers possess a broad range of knowledge, often tacit knowledge, including knowledge of subject matter; of classroom organizational and instructional techniques; of the structuring of learning experiences and curriculum content; of students' needs, abilities, and interests; of the social framework of the school and its surrounding community; and of their own strengths and shortcomings as teachers. She continues to say that teachers' knowledge is "dynamic" and "is held in active relation to practice and used to give shape to that practice" (p. 47). In reporting the outcomes of this study, I draw upon the Elbaz framework when discussing the nature of the changes that occurred in the participating teachers' knowledge base for teaching science.

Numerous studies have focussed on the development of various aspects of teachers' knowledge base and practice in the context of science teaching and learning. Despite this, more research is needed to explore how particular strategies and approaches to primary and elementary teacher development in the context of science education result in teacher learning and change. According to a review of literature reported by Loucks-Horsley and Matsumoto (1999), important relationships exist among "quality professional development, various kinds of teacher learning, and student learning" (p. 259). The authors also identify four clusters of traits that can be used to assess the quality of professional development. They include the content (what is to be learned), the process (how content is to be learned), the strategies and structures (how content is organized for learning), and the context (conditions under which content is learned) of professional development initiatives and programs. This study explored a particular approach to professional development, a collaborative inquiry approach, that was an amalgam of several specific strategies (curriculum development, curriculum implementation, and collaborative work, see Loucks-Horsley et al., 1998). The processes and contextual variables that contributed to the overall effectiveness of the approach are identified and described, as well as outcomes related to the development of my collaborators' knowledge base for teaching primary science.

Context of the Study

This study was conducted in conjunction with a larger initiative in which a K-5 school was in its first year of becoming a signature school for science, mathematics, and technology (SSSMT). Prior to meeting Catherine and Sarah, my co-collaborators, I had contacted the principal of the school to find out more about their innovative initiative and to offer my assistance as the school became a SSSMT school. In the first year of their three-year implementation plan, the staff targeted five areas: human resources, structural needs, curriculum development, staff development, and technology. In terms of curricular needs, they hoped to align their curriculum in science, mathematics, and technology with New York State (NYS) science standards (Department of State Education, 1996). In terms of staff development, the school hoped to offer a variety of professional development opportunities to teachers in the areas of mathematics, science and technology. As part of this initiative, I was invited to conduct a series of workshops in the Fall 2000 to assist K-2 teachers in exploring inquiry-based approaches to science teaching and learning. At one of these sessions, I met Catherine and Sarah. After getting to know each other, we decided to work collaboratively to develop and implement a K-1 science curriculum based on the new standards. Through this collaboration, Catherine and Sarah hoped to develop a greater understanding of how to interpret NYS science standards and translate them into classroom practice and how to foster inquiry-based learning experiences for K-1 children in learning science. These goals are reflected in the teachers' comments: "That's what excited me, not only your knowledge and expertise in the way you approached colleagues to learn (that was inviting to me), but also the fact that I wanted to take what I am learning and become better at it, especially in the realm of science" (Sarah, Initial Interview) and "I am not totally there on inquiry and I think this was an opportunity to get help from somebody who knows it well " (Catherine, Initial Interview).

According to the notion of scientific inquiry presented in NYS learning standards (1996) for mathematics, science, and technology, "the central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process" (p. 4). Our beliefs about scientific inquiry were consistent with this perspective. We viewed scientific inquiry as a multi-faceted approach to teaching and learning that would help students develop an understanding of scientific concepts, acquire process skills, and develop an appreciation for the nature of the scientific enterprise. Our aim was to structure learning experiences that would allow students to construct their understanding of scientific concepts by connecting new information to prior knowledge and understanding. Other characteristics of inquiry that were a salient part of our conceptualization of inquiry-based teaching are best summarized by Hinichsen and Jarrett (1999, p. 7) as: connecting personal understandings with those of science, investigating phenomena, and constructing meaning from data and observations.

The collaborators. Catherine had spent the early part of her 16-year teaching career at the grade five and six levels. She then switched to grade two for four years before moving to her current school district. In her current school, she taught grade two for two years, and then moved into the K-1 teaching context that was part of this study. It is interesting to note that during her assignment as a grade six teacher, Catherine was responsible for teaching science and language arts. In retrospect, she described her teaching of science as extremely uninspiring, content-oriented, and teacher-centred. "I remember it [teaching science] was very book oriented. I did not do any experiments, or it was very rare. I did a couple of projects, but it was mostly out of the book." Catherine's prior experiences in teaching science reflected a transmission orientation (Miller & Seller, 1990)–science is a set of facts and principles to be communicated to students who would learn passively. She completed her Masters in Education degree after teaching for several years.

Like Catherine, Sarah was a veteran teacher in her 24th year. She completed a Masters in Education degree before starting her teaching career. In the first decade of her career, she worked as a speech-language pathologist. The remainder of her career was spent as a regular classroom teacher in grades K-2. With little formal training in science and limited opportunity to consider the nature of science and science teaching and learning, Sarah adopted a more content oriented approach to science. "I do not think I have been as successful at the instruction processes as much as I have been successful at the instruction of the content. I am now learning that there are ways of teaching science that are more far more stimulating in engaging kids as well as teachers."

Although currently a teacher educator and university-researcher, I started my professional career as a high school Biology and Chemistry teacher and later became a consultant for gifted education with a school district. Because of my work in supporting professional development initiatives for teachers, I decided to pursue doctoral studies in education. One of my strong research interests has been and continues to be teacher development in the context of science education. This project afforded me the opportunity to gain practical experience in working with primary teachers and to explore how collaborative inquiry can enhance teachers' practical knowledge of science teaching and learning.

The class. The K-1 class consisted of 40 students with half at the Kindergarten level and the other half at the Grade One level. In this diverse classroom, two Kindergarten students were labelled as special needs (one was classified as cognitively delayed, another had severe speech and language problems) and two were English as a second language students. At the Grade One level, one student had neuromuscular disease, another had autism, and another had attention deficit disorder. Two Grade One students had low cognitive functioning and two others had speech and language difficulties; another was considered to be gifted by Catherine and Sarah. Only one student in the class had a full-time teaching assistant, while two other faculty provided support within the classroom for approximately one hour per day. In the overall school population of 500 students, 35% of them received free or reduced-in-price lunches.

Methodology

Many action technologies such as collaborative inquiry, action science, action learning, and participatory action research, for example, are currently being used in a variety of research and learning contexts. At the heart of these approaches is the recognition that human learning occurs is a social context. This study adopted an approach referred to as collaborative inquiry, defined by Bray, Lee, Smith, and Yorks (2000) as "a process consisting of repeated episodes of reflection and action through which a group of peers strives to answer a question of importance to them" (p. 6). One of the defining principles of this approach to research is doing research with people instead of doing the research on them. Indeed, we shared in all aspects of the co-inquiry including shaping the area of research and the research questions, designing the process for inquiry, and participating in the"experience of exploring the inquiry question, making and communicating meaning" (Bray et al., 2000, p. 7). The study was not only an approach to doing research, but it was also a means to engage in shared meaning-making and learning. As we developed and implemented curriculum, we engaged in continuous cycles of reflection, dialogue, action, and learning.

In this paper, I report on the experiences of the group as we engaged in collaborative inquiry. Several sets of data were collected throughout the study–the data that teachers collected, the data I collected, and the data we collected together that spanned the previous two categories (transcripts from audiotaped meetings, data from students, and field notes). The data collection methods and sources described below were used to report on the experiences of the group.

To ensure triangulation (Guba, 1981), a variety of data collection methods and sources were used, including:

1. <u>Planning meetings.</u> The collaborative group met on a weekly basis for approximately 40-60 minutes over an eight-month period from November 2000 to June 2000-2001. In addition, the group met

for three days in this period for the specific purpose of selecting assessment and learning activities that would support the unit on living things. The meetings were a forum for studying and interpreting NYS standards, discussing and sharing ideas and resources, exploring the nature of science teaching and learning, designing a curriculum unit, and reflecting on the unfolding events as the unit was implemented. All meetings (25 hours of audiotape) were transcribed and later analyzed.

2. Semi-structured and informal interviews. At the beginning and at the end of the project, the teachers participated in semi-structured interviews. All interviews were audiotaped and later transcribed; careful notes were taken after each interview. Informal conversational interviews occurred face-to-face before and after school-based meetings.

3. Fieldnotes. Observation can often reveal insights about a group that would be difficult to ascertain from other methods (Bell, 2000). I visited the teachers' classroom at least three times per week for instructional periods lasting 40-80 minutes. During these visits, I was a participant-observer, acting as a resource, working with small groups of students, and co-teaching with the teachers. Copious notes were taken both while observing and shortly after the observation period. Catherine and Sarah also recorded field notes that became a source of data for the group.

4. Documents. Student-generated documents such as samples of writing, drawings, and other work provided another approach for triangulation. In addition, lesson plans and other material produced by the teachers became sources of data, enriching data analysis and interpretation.

Data analysis and interpretation began very early in the study. Because the study had an evolving design, a grounded theory approach was adopted (Strauss & Corbin, 1990). Most of the data were in the form of free-flowing texts (Ryan and Bernard, 2000). Several levels of data analysis were used, from the most fundamental of assigning tags to short blocks of text to the establishment of categories and then broader themes. As a group we examined much of the data, exploring meaning and reaching consensus on the meaning of the data.

Curriculum Development and Implementation

When Catherine, Sarah, and I started our work together, the teachers were using a science kit on weather that had been recommended by the school district. As they began exploring the NYS science standards, they realized that the kit would not address many of the standards at the K-1 level. Consequently, they adapted the kit materials and adopted other materials to address the standards related to weather. Because of this lack of match between the kits and standards, Catherine and Sarah preferred, in the future, to develop their own unit for implementation that would focus on standards one and four (analysis, inquiry, and design; and the living environment, respectively). Table 1 provides an overview of the specific science standards addressed, while Table 2 outlines the assessment and learning activities adopted in the "Feathers, Fins, Fur, and Friends" unit. The unit focussed on larger animals because we believed that young children would have a natural interest in learning about larger animals and would have considerable prior knowledge about larger animals to bring to the learning context. The design of the unit occurred over a two-month, period followed by implementation over a six-week period.

After identifying the learning outcomes we wished to target, the next step in the curriculum development process was the gathering of materials about our designated topic, so Catherine and Sarah could enhance their subject matter knowledge related to living and nonliving things. In planning assessment and learning activities to support the standards, we adopted a learning cycle model. Students engaged in a series of learning activities that allowed them to explore materials, ideas, and concepts (exploration); to relate their prior knowledge to new learning (engagement and explanation); and to apply their learning to new situations and tasks (extension). Assessment, embedded throughout the unit, included classroom observation, analysis of student-created artifacts, and teacher questioning. The culminating assessment for part one of the unit was performance-based, asking students to classify a group of items as living or nonliving and to explain their choices. Part two of the unit required students to create an imaginary animal that demonstrated their understanding of life processes and functions.

Outcomes

Before starting formal data collection for this project, I had collaborated with Catherine and Sarah for at least three months, exploring the notion of scientific inquiry and planning curriculum using a weather kit that was not aligned with NYS science learning standards. Even in this short period of time, I witnessed changes in their thinking about science and how to teach science. As we continued with the collaboration, planning a unit using NYS standards and later implementing it, the teachers developed many aspects of their practical knowledge including knowledge of instructional and assessment approaches, knowledge of how to structure learning experiences and curriculum content, and knowledge of their own abilities as teachers (Elbaz, 1981).

Enhanced professional knowledge. Early in the collaboration, both Catherine and Sarah expressed beliefs about science and science teaching and learning that were consistent with current notions of scientific literacy (see the Introduction) and how to foster high levels of scientific literacy for all students. Sarah, in her teaching in the past, had attempted "to make the natural world an important part of what [students] do" although she acknowledged, as mentioned previously, that she was always better at the "instruction of content" rather than the "instruction of processes." Catherine believed in adopting student-centred approaches to learning science that would foster the development of inquiry skills. "I think inquiry skills are key at this time because that will help students continue their learning in science" (Catherine). She continued to emphasize the importance of fostering a "curiosity in and love for science" in students. Early in her career, Catherine had considered inquiry and discovery to be the same concepts. She admitted she was still exploring the whole concept of inquiry as an approach to teaching, and stated in the initial stages of this study that she was "getting more comfortable with inquiry" but was still structuring inquiry experiences that were "teacher-directed." She wanted her classroom to become more child-centred, encouraging students to pose some of the questions and problems for exploration.

Throughout the study, both Catherine and Sarah enhanced classroom skills that are necessary to foster student learning through inquiry. This is reflected in some of their comments:

> Before, I did not provide as much opportunity for students to extend their thinking. I am now more focussed on fostering thinking and communication. I am listening to their responses and knowing what my next open-ended questions will be to keep the inquiry going. (Sarah)
>
> I think there has been enhancement in my practice. I think generally what I do is not question-based, but I think the support you have given us has helped me become more aware [of questioning]. It is something I think more about in my planning. Sarah and I try to think of what the kids will say after we have talked about an activity. (Catherine)

Catherine considered the development of her questioning skills as an ongoing challenge.

Of course, closely linked to instructional practice is assessment. As a curriculum planning team, we believed it was necessary to offer students variety in assessment, including student choice in assessment options as well as assessments ranging from contexualized to decontextualized formats. Ongoing observational assessment of student learning, performance-based assessment, and product-based assessments were an integral part of the unit. The teachers experienced two areas of growth in terms of assessment. Sarah focussed on making her observational assessment more consistent, recording it on a regular basis. As she commented: "I need to get better at that piece–listening to children, being able to quickly write down what they say and make those conversations ongoing observations." Conversely, Catherine believed she was fairly adept at collecting and using informal assessment. However, she concentrated on "using more formal assessments that were not paper and pencil" (Catherine). She found herself reflecting more on assessment and on how to ensure that accountability for each student was built into group collaborative work. During one of our planning sessions, she asked this question: "How can we encourage each kid to be accountable for his/her work, so that no one is sitting back and letting everyone do the thinking and work?"

As we engaged in curriculum-building activities (interpreting learning standards, developing assessment and learning activities, implementing curriculum, and reflecting on practice), we adopted a backward design process (Wiggins, 1998). Catherine had become familiar with backward design–a sequence for curriculum planning that identifies learning outcomes first, selects assessment approaches, and then follows with the design of learning activities–during another professional development initiative. After exploring the backward design process, we adopted it as a framework for our approach to curriculum development. This necessitated a shift in thinking since previous to this project neither Catherine nor Sarah had done very little planning using learning outcomes (standards) in science. As well, Sarah commented on how this new way of approaching planning was a challenge: "One of my challenges has been how to think of starting at the assessment piece first and then working backwards to the actual things students are doing. That is a real piece of learning for me." In reality, planning for assessment and instruction occurred simultaneously, reflecting the close interconnectedness of these elements.

Our interpretation of the standards guided our curriculum development activities. This project afforded Catherine and Sarah the opportunity to become more comfortable with the standards and how to translate them into classroom practice. They believed that the standards provided them with a guide, giving them insight into what students should know, understand, or be able to do in science at the K-1 grade level. As Catherine commented, " They [standards] help us in our teaching, not just in the sense of our grade level, but also in the broad sense of what these kids are going to need to be able to do as they move through years of learning." Examining the standards over a range of grade levels allowed us to view science and how students would engage in science from a more holistic perspective.

The project resulted in positive changes in Catherine and Sarah's thinking about the nature of science teaching and in their classroom practice. Both teachers, during one of our final planning sessions, shared their thinking about the project. They believed the entire collaboration had been extremely valuable, but emphasized the need for them to continue to build upon what they had learned in this study. For Catherine and Sarah, this was the beginning phase in developing their abilities to interpret and use the NYS standards and to foster student learning in science that would be student-centred and inquiry-based. This is reflected in their comments:

> I think I now approach my teaching differently, and I will continue, now that I have a base from which to work. I think it will take several years however. (Catherine)
>
> Catherine and I were both saying that we will never go back to a traditional classroom. I know I could not go back to thinking of science as content only. It is so much more. I want to move further along the continuum of developing my skills and how to facilitate student thinking, but I am at the beginning baby stages of learning how to do that. (Sarah)

Catherine and Sarah attributed many of the positive outcomes that resulted to the nature of this collaborative inquiry. Subsequently, I will identify the characteristics of this collaboration that we believe made it a productive and meaningful approach to teacher development.

The nature of collaborative inquiry. As a collaborative inquiry group, we believed we were fairly successful and productive. We attributed this success to several important aspects of the project. One important element that fostered group learning was related to who controlled the research. All aspects of the research were negotiated to meet all participants' needs. We functioned as a group of peers who shared ideas, offered constructive feedback, reflected on events and actions, planned classroom events jointly, and collected and interpreted data to better inform future action. In many forms of research, teachers have little control over the goals of the research, how the research will be conducted, the interpretation of data collected, and how the outcomes of the research will be used. In this inquiry, co-initiation occurred. Through informal discussions about our work, beliefs, and interests, the project evolved. Although we brought different forms of knowledge and expertise to the study, we all shared, through consensus-building, in developing shared goals for the research. In addition, the design and implementation of the project were negotiated. Catherine, Sarah, and I shared in interpreting classroom data as it was collected. Ownership and control of the project did not reside with me, the researcher, but with the group as a whole. Although they were invited to share in the writing of this paper, Catherine and Sarah both declined because of time restraints.

A second element critical to the success of this project was the support and involvement of school-based administrators. The three-person administrative school team (principal, assistant principal, and administrative assistant) provided financial support by obtaining supply teachers so Catherine, Sarah, and I could have long periods to plan–three full planning days. In addition, weekly ongoing planning occurred outside of the instructional day. Sarah described the support offered by the school administration at a planning meeting: "Our administration has been extremely supportive and complimented us on tackling this initiative without receiving any financial reimbursement. They pursued financial support so we could get supply teachers and they visit our classrooms, wanting to see what we are doing and how we are doing it . . . .it makes you feel like you are being valued." The administrators' support contributed to the overall ability of the group to engage in ongoing inquiry and learning. Catherine and Sarah's perceptions of this collaborative inquiry approach to teacher development are shared below:

> The fact that I can do this with a group of colleagues makes me motivated and excited. I think that is really important for myself as a learner. I need to be able to share with other people and get ideas from them, and build my confidence as I reflect with them . . . .Over the last 25 years, there are only three professional development initiatives [this initiative being one] I apply because of how they were approached. I really wish more professional development could be like this. (Sarah)
>
> The professional development experiences that I have gotten the biggest benefits from are the ones where I am actually doing something. I am not just listening to theory or seeing examples of what other teacher have done. Being able to work closely with other educators is a huge way to grow professionally . . . . I have gone to workshops, where you just sit and listen, but you get no followup. You need other people to work with. I would rather do this, even though it is a lot more work, but in the end you grow tenfold. (Catherine)

Catherine, Sarah, and I had the opportunity to develop rapport, learn about each others' abilities and aptitudes, engage in group reflection, and construct meaning through shared experiences.

Discussion

Through participation in this project, Catherine and Sarah enhanced many aspects of their practical knowledge (Elbaz, 1981) including their knowledge of instruction and assessment, how to plan standards-based science curriculum, and how to integrate content and pedagogy. Starting with learning outcomes (standards), we adopted a backward design (Wiggins, 1998) to curriculum development. Although not a new concept (Ralph Tyler provided a rationale for the backward design process in 1949), backward design was a new way of thinking for both Catherine and Sarah. As Wiggins suggests, backward design is backward to how many teachers typically plan curriculum. For many teachers, curriculum planning entails the selection of a series of learning activities or the coverage of textbook topics. Both Catherine and Sarah had adopted both approaches in the past. This shift in thinking about how to plan curriculum forced them to reflect more intensely upon the relationship between assessment and instruction. Instead of planning assessment at the end of a unit, it was done at the beginning, followed by the design and selection of learning activities. Although Catherine and Sarah struggled with this shift in thinking, it forced us to be more focussed in our planning and in determining what and how students should learn.

In planning assessment, a variety of approaches were adopted, ranging from paper-and-pencil tasks to more authentic, performance-based assessments and tasks. This is consistent with many current theories such as Gardner's theory of multiple intelligences (1983). This pluralistic view of human ability has been interpreted in a myriad of ways by educators. In terms of assessment, it has been used as a framework to offer students multiple pathways to demonstrate what they have learned (Campbell, 1997). The use of only de-contextualized forms of assessment may limit the development of students' understanding and may prevent teachers from ascertaining students' cognitive and affective development in science.

In terms of instruction, it was evident from the teachers' interpretations of inquiry teaching that they conceptualized inquiry as occurring on a continuum (see Figure 1). Teacher-directed inquiry can be highly structured; the student is engaged in investigations where the teacher makes all the decisions–what the question will be and how the inquiry will be investigated. In the middle (guided inquiry), the teacher may select the problem and ask students to determine how to carry out the investigation. At the other end of the continuum, student-directed inquiry, students determine the problem and how they will carry out the investigation. Although Catherine and Sarah had not moved to the far end of the inquiry continuum by the end of the school year, they had progressed from offering students highly teacher-directed inquiry experiences to offering them experiences that reflected guided inquiry.

The instructional and assessment approaches adopted in the study reflect a constructivist view of learning. In the constructivist view of knowledge, there is an assumption that a reality exists but it is beyond the capability of humans to know that reality (von Glaserfeld, 1989). The individual constructs knowledge by interacting with objects and events through the senses (Tobin & Tippins,1993). In other words, individuals construct meaning that is socially mediated. In our planning, careful attention was given to creating experiences that would allow students to work collaboratively to share ideas and give each other feedback.

We believed the changes that occurred in teachers' knowledge and practice were directly attributable to the nature of the collaborative inquiry that emerged in the project. Ascertaining the effectiveness of any form of professional development entails identifying how learning occurs (processes) and the conditions under which the learning occurs (context). For example, having time during the regular instructional day to plan, provided through teacher release time, and making time to meet regularly outside the instructional day were critical to the inquiry. Without the commitment of the participants to scheduling time and making this initiative an ongoing, integral part of their daily teaching, many of the positive teacher outcomes may not have occurred.

Because of the availability of time, the presence of strong school-based support, and the commitment of the group, collaboration emerged readily. At times, the terms cooperation and collaboration are used interchangeably when referring to groups of people who work together. In this study, we moved beyond simply helping each other out with a focus on individual learning (cooperation). In contrast, group functioning reflected a notion of collaboration espoused by Peters (1997). In this view, people work together to create and produce knowledge that can benefit the individual, group, or both. Community and trust are present and individuals can express differing viewpoints in an atmosphere of respect.

Another factor that contributed to the emergence of collaboration focussed on control of the research. As mentioned previously, this research was co-initiated and all aspects of the research design resulted from mutual negotiation amongst group members. Although we brought different forms of expertise to the situation, the group shared common goals. Ownership resided with the group, and not with any one individual.

Another important factor that contributed to the effectiveness of this collaborative inquiry approach to professional development was the relationship that emerged between theory and practice. The inquiry was not decontextualized, but embedded in the teachers' everyday classroom practice. We used and applied educational theory to practice, but also generated new knowledge and understanding about teacher development and teaching primary science. There was a dialectical relationship between theory and practice in which "neither thought nor action was pre-eminent" (Carr & Kemmis, 1986, p. 34); theory informed practice and, vice versa, practice informed theory.

Conclusions

In this study, collaborative inquiry provided a structure for fostering adult learning and engaging in research. The group became the primary conduit through which learning occurred. Ongoing dialogue, individual and group reflection, systematic action, mutual respect, and shared decision-making became the essence of how the group functioned. Several conditions were necessary for creating this collaborative community of learners–group ownership of all aspects of the research, contextual support (release time and moral support from school-based colleagues), and a strong commitment to learning. This study does not suggest that collaborative inquiry, as designed in this study, should be the only approach to professional development. Each approach to teacher learning will require a unique design to meet the individual and group needs of those involved. Nevertheless, the characteristics of this inquiry and the conditions under which it occurred contributed significantly to its effectiveness and can offer guidance for those who plan for and support teacher development.

This study raises two broad issues that have implications for teacher education: the role of the teacher in curriculum development and the role of the teacher in generating knowledge. The approach adopted in this study was predicated on the notion that teachers can become curriculum makers, rather than simply technicians who implement curricula developed by others, often considered outside experts (Connelly & Clandinin, 1988; Grundy, 1987). Professional development programs and initiatives should afford teachers the opportunity to engage in a broad range of curriculum building activities. The language of teachers should be paramount; action should be interpreted from the perspective of teachers; and educational theory and practice should be reflected as an integrated praxis.

The other broad issue pertains to the role of the teacher in educational research. In their book, *Inside, Outside: Teacher Research and Knowledge*, Cochran-Smith and Lytle (1993), argue that teacher research should be a legitimate research genre for generating significant knowledge about teaching. They define teacher research as a "systematic, intentional inquiry about their own school and classroom work" (p. 23-24). This collaborative inquiry encompassed both teacher research and research on teaching. Both forms of research merged and overlapped, generating knowledge about teaching and teacher education, while supporting a rich context for adult learning. I advocate an approach to teacher learning and educational research that brings teachers and researchers together in a mutualistic relationship that can benefit all involved.

I strongly encourage teachers, researchers, school and district curriculum leaders and policy makers to consider collaborative inquiry as a viable approach to adult learning and educational research. Collaborative inquiry is inclusive and equitable, and has the potential to enhance teacher education and educational research, and ultimately, student learning in science.

References

American Association for the Advancement of Science (AAAS). (1989). *Science for all Americans: Project 2061.* New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy: Project 2061.* New York: Oxford University Press.

Abell, S., & Roth, M. (1991, April). *Coping with constraints of teaching elementary science: A case study of a science enthusiast student teacher.* Paper presented at the National Association for Research in Science Teaching, Lake Geneva, WI.

Bell, J. (1999). *Doing your research project: A guide for first time researchers in education and social science.* Philadelphia, PA: Open University Press.

Borger, H., & Tillema, H. (1993). Transferring knowledge to classroom teaching: Putting knowledge into action. In C. Day, J. Calderhead, & P. Denicolo (Eds.), *Research on teacher thinking: Understanding professional development* (pp. 185-197). London: Falmer Press.

Bray, J. N., Lee, J., Smith, L. L., & Yorks, L. (2000). *Collaborative inquiry in practice.* Thousand Oakes, CA: Sage Publications.

Campbell, L. (1997). Variations on a theme: How teachers interpret MI theory. *Educational Leadership, 55*(14-19).

Carr, W., & Kemmis, S. (1986). *Becoming critical: Education, knowledge and action research.* London: Falmer Press.

Cochran-Smith, M., & Lytle, S. L. (Eds.). (1993). *Inside/outside: Teacher research and knowledge.* New York: Teachers College Press.

Connelly, F. M., & Clandinin, D. J. (1988). *Teachers as curriculum planners: Narratives of experience.* Toronto, Canada: OISE Press/Ontario Institute for Studies in Education.

Department of State Education. (1996). *Learning standards for mathematics, science, and technology.* Albany, NY: Author.

Elbaz, F. (1981). The teacher's 'practical knowledge': Report of a case study. *Curriculum Inquiry, 11*(1), 43-71.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences.* New York: Basic Books.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education.* New York: Teachers College Press.

Grundy, S. (1987). *Curriculum: Product or praxis?* London: Falmer Press.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal, 29*(2), 75-91.

Hargreaves, A., & Fullan, M. G. (1992). *Understanding teacher development*. New York: Teachers College Press.

Harlen, W., & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: Impact on confidence and teaching. *International Journal of Science Education, 19*(1), 93-105.

Hinrcihsen, J., & Jarrrett, D. (1999). *Science inquiry for the classroom: A literature review.* Northwest Regional Educational Laboratory. Available: http:// [2002, February 13, 2002].

Kahle, J., Anderson, A., & Damjanovic, A. (1991). A comparison of elementary teacher attitudes and skills in teaching science in Australia and the United States. *Science Education, 21*, 208-216.

Lee, O. (1995). Subject matter knowledge, classroom management and instructional practice in middle school science classrooms. *Journal of Research in Science Teaching, 32*(4), 423-440.

Leinhardt, G. (1990). Capturing the craft knowledge in teaching. *Educational Researcher, 19*, 19-25.

Loucks-Horsley, S. *(1998). Ideas that work: Science Professional development.* Columbus, OH: Eisenhower National Clearinghouse.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1999). *Designing professional development for teachers of science and mathematics*. Thousand Oakes, CA
Corwin Press.

Loucks-Horsley, S., Kapitan, R., Carlson, M., Kuerbis, P. J., Clark, R., Melle, G. M., Sachse, T., & Walton, E. (1990). *Elementary school science for the '90s*. Alexandria, VA: Association for Supervision and Curriculum Development.

Loucks-Horsley, S., & Matsuma, C. (1999). Research on professional development for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*(5), 258-270.

Miller, J. P., & Seller, W. (1990). *Curriculum perspectives and practice*. Toronto, Canada: Copp Clark Pitman.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Peters, J. M. (1997). Reflections on action research. In B. A. Quiley & G. W. Kuhne (Eds.), *Creating practical knowledge through action research*. San Francisco, CA: Jossey-Bass.

Ryan, G. W., & Bernard, R. H. (2000). Data management and analysis methods. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research: Second edition*. Thousand Oaks, CA: Sage Publications.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-15.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1).

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. London: Heinemann.

Tilgner, P. J. (1990). Avoiding science in th elementary school. *Science Education, 74*(4), 421-431.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 23-38). Hillsdale, NJ: Lawrence Erlbaum.

Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. Chicago: University of Chicago Press.

von Glaserfeld, E. (1993). Questions and answers about radical constructivism. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 23-38). Hillsdale, NJ: Lawrence Erlbaum.

Wiggins, G., & McTighe. (1998). *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Scientific Inquiry Occurs on a Continuum

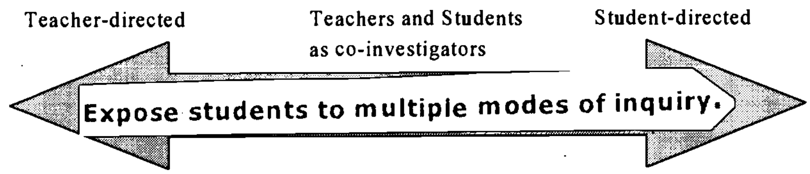

Figure 1. Scientific inquiry can occur on a continuum ranging from teacher-directed to student-directed.

Table 1
New York State (NYS) science standards addressed in the *Feather, Fins, Fur, and Friends* unit

Standard One	**Performance Indicator**
Analysis, Inquiry, and Design Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.	Observe and discuss objects and events and record observations.
	Articulate appropriate questions based on observations.
	Accurately transfer data from science journals or notes to appropriate graphic organizers.
	State, verbally or in writing, any inferences or generalizations indicated by data collected.
	Explain their [students] findings to others, and actively listen to their [other students'] suggestions for possible interpretations and ideas.
Standard Four	
The Living Environment Students will understand and apply scientific concepts, principles, and theories pertaining to the physical and living environment and recognize the historical development of ideas in science.	Describe the characteristics of and variations between living and nonliving things.
	Describe basic life functions of common living specimens.
	Describe some survival behaviours of common living specimens.

Table 2
Assessment and Learning Activities Used in the *Feather, Fins, Fur, and Friends* unit.

Section I Assessment	**Teaching and Learning Activities** Characteristics of Living and Nonliving Things
Ongoing informal assessment through classroom observation and the examination of children's work. Performance-based assessment: Given a collection of living and nonliving things, students classify items as living or nonliving and explain their choices.	Exploration: School yard walking tour. Using a t-chart, students identify things they think are living and nonliving. After returning to the classroom, teacher explores students' ideas. Engagement: Students continue to explore the differences between living and nonliving things. Using a Venn Diagram, students compare a stuffed animal and a fish. Explain: Guided instruction follows in which the teacher and students identify the characteristics of living things. Extension: At a learning centre, students reinforce their understanding of what organisms need to live through creating collages, making drawings, and playing games. Students keep ongoing journals as they observe the behaviours of classroom animals. Students take turns, on a daily basis, caring for animals.
Section II Assessment	**Teaching and Learning Activities** Life Processes/Survival Behaviours
Ongoing informal assessment through classroom observation and the examination of children's work. Culminating assessment: Project Habitat Students create an imaginary animal and its surrounding habit. Students need to identify the life processes and life functions of their imaginary animal . Each student chooses one of four formats (Big Book, Diorama, Shoebox Theatre, or Puppet Show) for the product.	Exploration: Viewing a short video about animal life processes, life functions (growth, consumption of food, breathing, reproducing, and eliminating waste) and survival behaviours. Engagement: Students sing a song, developed by the teacher, that incorporates hand symbols for each of the life processes. Explain: Guided instruction about each of the life processes. Extension: Four animal research groups (kangaroos, sharks, turtles, owls) are established in the class. Students select a group based on interest. After guided reading and research using books, magazines, and web sites, students and the teacher build a model habitat for their designated animal group.

SE068240

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Teacher development through collaborative inquiry: Primary teachers enhance their professional knowledge of science teaching & learning	
Author(s): Dr. Karen Goodnough	
Corporate Source:	Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1 ☐	Level 2A ☐	Level 2B ☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Signature: Karen Goodnough	Printed Name/Position/Title: Karen Goodnough	
Organization/Address: University of New Brunswick	Telephone: 506-447-3060	FAX:
	E-Mail Address:	Date: June 30/03

Faculty of Education
P.O. Box 4400
Fredericton, New Brunswick, Canada E3B 6E3
kcg@unb.ca

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
4483-A Forbes Boulevard
Lanham, Maryland 20706

Telephone: 301-552-4200
Toll Free: 800-799-3742
FAX: 301-552-4700
e-mail: ericfac@inet.ed.gov
WWW: http://ericfacility.org

EFF-088 (Rev. 2/2001)