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Interpretive Case Studies on the Influence of a Pre-Service Contextual Science Research Course on Novice Science and Mathematics Teachers

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INTERPRETIVE CASE STUDIES ON THE INFLUENCE OF A PRE-SERVICE CONTEXTUAL SCIENCE RESEARCH COURSE ON NOVICE SCIENCE AND MATHEMATICS TEACHERS

By

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I dedicate this dissertation:

To my son, Will, for his love and patience and for understanding his mother’s interests in learning and “finding out things.” I hope to inspire him and to help nurture his own love of learning, especially in science. He is my heart.

To my parents, Bill and Connie, for the constant love and encouragement they have given me. They have always taught me to never give up.

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LIST OF ABBREVIATIONS

BNL Brookhaven National Laboratory

CO-LEARNERS Collaborative Opportunities: Learning Environments And Research uNiting Educators and Researchers of Science

DAST Draw a Scientist Test

DEP Department of Environmental Protection

DOE Department of Energy

EPA Environmental Protection Agency

ECUA Escambia County Utilities Authority

FCAT Florida Comprehensive Achievement Testing

FCETP Florida Collaborative for Excellence in Teacher Preparation

GPS Global Positioning System

IISME Industry Initiatives for Science and Math Education

MCETP Maryland Collaborative for Excellence in Teacher Preparation

NRC National Research Council

NSES National Science Education Standards

NSF National Science Foundation

NYU New York University

ORNL Oak Ridge National Laboratory

PCK Pedagogical Content Knowledge

PPCP Professional Practice Community Project

QSR Qualitative Software Research

RET Research Experiences for Teachers

SAETS Southeastern Association for Educators of Teachers of Science

SERC@SERVE Southeastern Eisenhower Regional Consortium @SERVE

Science FEAT Science For Early Adolescence Teachers

SFP Scientific Fellowship Program

STARS Science Teachers as Research Scientists

SWEPT Scientific Work Experience Programs for Teachers

TIMSS Third International Mathematics and Science Study

TRUE Teacher Research Update Experience
ABSTRACT

I conducted a follow-up, qualitative evaluation to help me understand how participation in a contextual science research course influenced two pre-service science and/or mathematics teacher participants as they begin to teach in their own classrooms as novice teachers.

My specific questions for this dissertation were:

1. What are the beliefs towards the culture of science and the culture of science in the classroom of a novice science and a novice mathematics teacher after completing a constructivist-based, contextual science research course?
2. What are the classroom practices of these novice teachers after completing a constructivist-based, contextual science research course with respect to:
   a. implementing constructivist-based, contextual science methodology in their own classrooms?
   b. forming collaborations with scientists and the science community?
   c. integrating science and mathematics in the classroom?
   d. implementing inquiry-based, hands-on science activities?
3. After completing a constructivist-based, contextual science research course, what are the influences on the novice teachers’ constructions of (a) science content knowledge and/or (b) pedagogical content knowledge?

The theoretical framework for this study is that of a constructivist epistemology, using the genre of interpretive case study. I utilized cultural-historical activity theory to look at the contradictions and coherences, to see how these influenced the participants’ ability to transfer their experiences from the contextual science research to their own classrooms. To insure fairness and trustworthiness criteria of this study, I utilized fourth generation evaluation and the QSR NVivo software program to categorize and analyze the qualitative data.

Findings show that participants learned science content, enhanced their beliefs about the culture of science and the image of the scientist, increased their pedagogical content knowledge with respect to understanding constructivist-based teaching, and integrated science and mathematics. Their practices, however, did not always match their beliefs. While participants
were enthusiastic about the idea of forming collaborations with scientists, implementing contextual learning, and implementing the use of inquiry-based, hands-on, instruction, these practices were limited. Reliance on the use of the textbook and lecture were still very apparent. Pressures faced by novice teachers during their induction years could help explain these contradictions. I make suggestions for how to improve the program.
CHAPTER 1: INTRODUCTION TO THE STUDY

It is of great importance that the general public be given an opportunity to experience—consciously and intelligently—the efforts and results of scientific research. It is not sufficient that each result be taken up, elaborated and applied by a few specialists in the field. Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty.

Albert Einstein (1948), from the forward to The Universe and Dr. Einstein by L. Barnett

What Are My Objectives and Questions?

My Objectives for This Study

My objectives for this study are two-fold. First, I want to share what I already know about the benefits of science research experiences for practicing science and mathematics teachers from my own experiences and from my literature search. I also share what emerges in my study on how such experiences influence pre-service science and mathematics teachers. Secondly, I hope that my study will help contribute in some way to the improvement of science teaching and learning for students. As a mother and educator of young adults, it is very important to me that we teach science in the way that science truly is—dynamic, thought provoking, engaging, and exciting. Science is not static, not mere facts and information, not passive, and not boring.

Throughout my own schooling, I encountered several negative experiences in science that could have very well stifled my love of science. In sixth grade, my science teacher put science words from each chapter on the board every day for us to define and memorize. We would read the book, look up the words, and then have a test. Because of the way my teacher taught, my fellow classmates and I dreaded science every day. Seventh and eighth grade science was somewhat better as there were more teacher demonstrations and field trips. There were still too few hands-on activities and experiments. Fortunately, I designed and implemented my own science experiments at home and became interested in science through my own self-education. In high school, most of my teachers were quite good, and I enjoyed science during my high school years. High school biology and chemistry were all hands-on, and the teachers were as excited as
we were about finding answers to experiments. While these were mainly textbook-generated experiments, they still provided some exciting and enriching experiences.

In college, I had some excellent biology and general chemistry instructors. However, one organic chemistry professor almost destroyed my love of science. The lecture course, typical for organic chemistry, involved endless note taking, total memorization, and recall of excessive information. This lackluster approach was enough to make the course one that invoked great stress in many students, including myself. In addition to the rigorous nature of the course, the professor did not allow me to postpone an examination, even though I had received severe second degree burns on my writing hand from a kitchen fire on the preceding day. This negative experience set the stage for a downward spiral in my avoidance of chemistry for several years.

Not until my participation in a contextual biochemistry course as part of my doctoral program, was I able to re-ignite my love of chemistry. I was able to actually *learn* chemistry because I was immersed in the chemistry. The science researcher with whom I collaborated gave me the opportunity to construct my own learning, as this is part of the culture of science. I had to learn the chemistry in order to do the research, and I wanted to do the research because I wanted to find the answers. I had to find the answers myself, as no one knew them. I had to find the answers like a “true” scientist, through inquiry and experimentation.

With the knowledge that I gain from this doctoral study, I hope to do everything possible to ensure that the K-12 science teachers, with whom I am in contact, teach science by creating opportunities for students to be excited about science. My goal is for these teachers to gain empathy for their students through their own experiences and provide similar experiences that actively engage their students in science. After the completion of my doctoral study, I plan to continue to teach middle school science, as well as teach as an adjunct instructor at the university level. This doctoral research will impact both segments of the populations that I teach, as I will continue to incorporate more contextual, hands-on science experiences for my middle school students. I plan to design these activities in a similar way to how I have experienced science. Findings from this study will help me in developing a contextual science research course, to enable pre-service teachers to conduct science research. My hope is that their future students will enjoy science as an exciting area of inquiry.
My Personal Experiences

The impetus for this research sprung from my own personal experiences working in science research facilities as a practicing middle school science teacher. The feeling of empowerment alone is invaluable to me as a science teacher. In addition to the empowerment, many other factors influence my own teaching and understanding of teaching and learning science.

As a practicing teacher, I was fortunate to participate in several types of summer research experiences in a variety of research areas. In the Florida Keys, I studied coral reefs and environmental science through a contextual experience utilizing snorkeling and diving in Key Largo. I analyzed artifacts collected from the Ais Indian tribe with the Department of Archaeological Research (Tesar, Benton, & Hahn, 1994). In addition, I conducted simple experimental studies using in vitro techniques in a cellular biology course.

These opportunities for practicing teachers to participate in science research were readily available. My science research experiences provided me with a special lens through which to view science teaching and learning. As a novice teacher entering the classroom, I did not have this lens because my teacher preparation program did not offer such research experiences. These scientific work experiences were so influential to my own teaching practices that I became deeply interested in conducting a study on this type of learning experience with pre-service science and/or mathematics teachers as they enter their novice years of teaching.

I include both a science teacher and a mathematics teacher in this study, as one of my student participants chose to teach science, while the other chose to teach mathematics. At the university where I conducted my research, the program requires all pre-service middle level teachers to seek certification in two subject areas. Many choose science and mathematics. Combining my own background with the supporting literature on practicing science teachers conducting science research and with the emerging research on pre-service science teachers conducting science research, I chose to conduct my doctoral study on: Interpretive Case Studies on the Influence of a Pre-service Contextual Science Research Course on a Novice Science and a Novice Mathematics Teacher.
My Questions for This Study

After reflecting upon my own experiences as a practicing teacher, as well as those of other practicing teachers, and looking critically at what I learned from the pilot study for pre-service teachers, I developed the following questions for this study:

1. What are the beliefs towards the culture of science and the culture of science in the classroom of a novice science and a novice mathematics teacher after completing a constructivist-based, contextual science research course?

2. What are the classroom practices of these novice teachers after completing a constructivist-based, contextual science research course with respect to:
   a. implementing constructivist-based, contextual science methodology in their own classrooms?
   b. forming collaborations with scientists and the science community?
   c. integrating science and mathematics in the classroom?
   d. implementing inquiry-based, hands-on science activities?

3. After completing a constructivist-based, contextual science research course, what are the influences on the novice teachers’ constructions of (a) science content knowledge and/or (b) pedagogical content knowledge?

What Is Already Known About Science Research Experiences for Teachers?

Because of my prior involvement with the pilot study and science research experiences of my own, I am familiar with some of the literature on this topic. In this section, I will discuss some basic background knowledge about science research experiences for teachers.

“Teachers Teach the Way They Are Taught”

Providing science courses in which future classroom science teachers actually do science in a research setting, as opposed to those that are lecture-driven, textbook dictated, and laden with “cookbook” science experiments, should be the goal of any teacher preparation program. In fact, this is exactly the type of science classroom that current U.S. National Science Education Standards (NSES), published by the National Research Council (NRC), recommend for the K-12 classroom (NRC, 1996). Why are teacher education programs not teaching pre-service teachers in the way that current standards and research suggest?

Macala (2003) discusses how the current educational system exposes generations of future teachers to “traditional” teaching. She criticizes the system of training teachers because it
perpetuates the notion that “teachers teach the way they were taught” (p. 1). Other studies (Adamson et al., 2003) also hypothesize that “teachers teach as they have been taught” (pp. 939–940) and find support for reforming “the way preservice teachers are taught during their teacher preparation program as undergraduates [because it may have] a positive influence on the way they teach when they later become secondary teachers” (p. 951).

It has been my experience, as a middle school science teacher, that many of my teaching colleagues in science and mathematics have previously been elementary teachers or physical education teachers. In general, their work experience and content knowledge in science is very limited. This often leads to science instruction with very little hands-on and inquiry-based instruction. The teachers have a tendency to teach facts and information since they are more comfortable with that type of instruction. This practice is not limited to those science and mathematics teachers who took very few pre-service college science courses. Many science and mathematics teachers who hold degrees in science and/or mathematics related fields teach in much the same way, because they learned science in predominantly lecture-based courses.

Science research experiences could help science teachers of all backgrounds to understand why and how they can introduce similar types of hands-on and inquiry-based experiences into their own classroom. In turn, their students will benefit, as the teachers transfer their experiences into their own classroom teaching.

Teaching

In this section, I describe two types of teaching styles based on teachers’ epistemological frameworks for teaching and learning. I frequently refer to these in my dissertation; one is constructivist-based teaching, and the other is inquiry-based teaching. I choose these teaching styles because the NRC (1996, 2000) recommends inquiry-based teaching of science and my own framework is social constructivism.

Constructivist-Based Teaching

Roth (1994) asserts that the constructivist view of learning is one of an interpretive process in which the learner constructs and reconstructs his or her own understanding, drawing from prior knowledge and combining it with new knowledge. Thus, the learner builds comprehension, rather than receiving it from a more authoritative source such as a teacher.

Considering that the constructivist’s view of teaching would be that a teacher cannot transfer knowledge intact to his/her students, when I refer to constructivist-based I imply that the
teacher is cognizant of the fact that he/she cannot just give students facts and information and expect them to regurgitate them. Instead, the teacher will allow the students the opportunity to construct their own learning by using prior experiences and new information being introduced, fused with hands-on experiences.

I do not imply that the novice teacher will become fluent in using constructivist-based teaching methods because of his/her immersion into science research. I believe the adaptation of the theoretical framework of constructivism takes many years to understand and develop. However, I do believe that by immersing a novice teacher in a constructivist-based course, such as the one in this study, we can help him/her develop a basic understanding of constructivism and encourage him/her to incorporate some constructivist-based practices into the classroom.

**Inquiry-Based Teaching**

Dewey (1938) indicates that using inquiry, as an instructional strategy, is just as important as learning the scientific subject knowledge itself. Inquiry is in many ways equivalent to immersion experience, as described previously by Melear (2000). According to the NSES (NRC, 1996) science inquiry involves:

1. students recognizing and identifying problems,
2. students asking their own questions,
3. students deciding the processes and reaching a conclusion, and
4. teachers acting as facilitators.

These are the processes that science teachers (as students) may encounter in a contextual science research course. While teachers learn about the importance of inquiry, there is little evidence that they have actually experienced inquiry themselves. Yager (1997) states that there are too few in education who have practiced science—who have experienced first hand “the richness and excitement of knowing about and understanding the natural world” (p. 2). Likewise, there are too few educators of science who have practiced education in a reflective manner.

The NRC (1996) also states that the professional development of science teachers should include involving teachers in scientific investigations by examining both the content and processes of science. According to the NRC (1996), the following description characterizes good science teacher development, “integrating knowledge of science, learning, pedagogy, and students” (p. 62), and as experiencing a “coherent and integrated” (p. 70) pre-service or in-service program.
Learning

I now look at the different ways of facilitating the learning of science. These pedagogical methods are among those that the NRC (1996, 2000) recommends as those that promote student understanding in science. This includes experiential learning, hands-on learning, learning through immersion, and contextual learning.

Experiential Learning

Experiential learning is learning that actively involves the learner. Kolb (1984) describes the first stage in the learning cycle as coming from a concrete experience and defines learning as the process whereby a person creates knowledge through the transformation of experience. This definition places emphasis on the process of learning, rather than on the outcome or content gained from the learning. Content learning does occur in the context of process learning, however. I interpret this to mean that process learning empowers the learner to take control of his/her own learning in the process, thereby experiencing content learning.

Dewey (1958) believes that experience connects the mind and consciousness and keeps one’s thinking alive. When consciousness stagnates, he believes that interest declines. I interpret this to mean that when teachers give a student the opportunity for experiential learning activities, the student’s mind and consciousness become completely involved in the process. However, when the teacher dispenses facts and information, the students become less involved; and, therefore, the learning is much more limited than in an active experience.

In his Pedagogic Creed, Dewey states the following:

I believe that one of the greatest difficulties in the present teaching of science is that the material is presented in purely objective form, or is treated as a new peculiar kind of experience that the child can add to that which he has already had. In reality, science is of value because it gives the ability to interpret and control the experience already had. It should be introduced, not as so much new subject matter, but as showing the factors already involved in previous experience and as furnishing tools by which that experience can be more easily and effectively regulated. (Hickman & Alexander, 1998, p. 232)

Dewey’s statement written over 100 years ago could be interpreted as his recommendation for the need for more experiential learning. Today, in the year 2004, many classroom science teachers continue to teach science as just facts and information. Could it be that their teachers taught them that way, and thus they have never truly experienced science? I believe that the lack of experiential opportunities could be remedied in our pre-service teachers preparation programs through the offering of science research experiences.
Hands-on Learning

The term hands-on implies that one learns by doing. According to Bettencourt (1993), “[u]nless hands-on science is embedded in a structure of questioning, reflecting, and re-questioning, probably very little will be learned” (p. 48). Therefore, when I refer to hands-on science in this dissertation, I am generally referring to a teaching style in which teachers implement hands-on activities, as well as questioning and reflecting.

Learning Through Immersion

Melear (2000) suggests that placing pre-service science teachers into the culture of science, such as in science laboratories, will create an immersion experience in the culture, especially if the pre-service teachers are with persons who practice that culture or who “speak the language” (p. 10). Melear also asserts that people can speak the language if they are no longer “foreigners in a foreign land” (p. 10). A science teacher should not be a foreigner to science. Therefore, having the experience of working in an authentic scientific research setting may serve to give the pre-service teacher a boost toward being more comfortable and more competent as a “scientist” and thus being able to teach more easily.

Contextual Learning

Gilmer (1999) defines contextual learning in science as “learning in the context of doing, thinking, speaking, and experiencing science” (p. 13). In an ideal contextual learning environment in science, one learns within the culture of science with other practitioners and uses the equipment and language of science. S/he uses the logic, the creativity, the analytical reasoning, and the communication skills needed to conduct scientific research. In other words, the learner immerses his/herself in the context of science. Unfortunately, this immersion is difficult to do within the constraints of a traditional university classroom or laboratory.

In describing contextual learning, Gilmer (1999) continues with, “contextual learning is a step beyond ‘hands-on’ and ‘minds-on’ science. It is actually doing, thinking, speaking, and experiencing science” (p. 13). For this study, I use the term contextual to refer to when the teachers experience the context of the science that they are studying. While the experience is an immersion experience, rich in inquiry and experiential learning, I will limit my use of terminology and use only contextual scientific research within my research title.
Research Experiences

My Own Immersions into Science

My first immersion into science research took place during the second summer of the National Science Foundation (NSF)-funded Science For Early Adolescent Teachers (Science FEAT) program in 1994 with the Bureau of Archaeology in Tallahassee, Florida. The Science FEAT study involved 66 middle level science teachers who participated in a summer research experiences. Spiegel, Collins, and Gilmer (1995) report that the teachers learned to question the scientific method as traditionally presented in the first chapter of every science textbook. They learn that science does not always follow a systematic or step-like manner. Spiegel et al. (1995) profess that the teachers gain understanding through experiencing science research as active participants and contributors.

In my study, I became involved in an actual study of the Ais Indians. Based on our findings from the artifacts, an archeologist researcher, a fellow teaching colleague, and I collaborated on producing a scientific report on the lives of the Ais Indians (Tesar et al., 1994). We also created a simple booklet to be given out at the museum for children’s groups. This feeling of accomplishment within a previously unfamiliar area of science gave me confidence in teaching this subject to my own classes.

My second science research experience influenced my beliefs largely because I was able to completely immerse myself in an investigation from start to finish. This particular research dealt with studying the causes behind the deaths of a large number of a certain species of Florida fish. The researcher with whom I was working was asked to determine if an algal toxin, microcystin, caused the fish mortality. For the investigation, I learned to utilize several procedures which were previously unknown to me. These procedures included using organic solvents and a sonicator to induce cell lysis. I also utilized equipment for high performance liquid chromatography (HPLC) to determine if the microcystin were present based on the standard given for the toxin from this species of algae. I believe that I understand and remember what I learned because I constructed my own learning. This experience yielded more knowledge of chemistry than all of my other chemistry courses combined (Hahn, 1999).

Palmer (1998) discusses factors that will test the teacher’s identity and integrity. To focus on integrity, Palmer states:
Integrity requires that I discern what is integral to my selfhood, what fits and what does not—and that I choose life-giving ways of relating to the forces that converge within me: Do I welcome them or fear them, embrace them or reject them, move with them or against them? By choosing integrity, I become more whole, but wholeness does not mean perfection. It means becoming more real by acknowledging the whole of who I am. (p. 13)

This brings me to the notion of an experience being powerful enough to allow the teachers to bring forth their integrity. This was the exact type of emotion that I experienced during the summer I participated in the contextual biochemistry course and research experience.

The epiphany, so to speak, occurred when I sat outside the laboratory writing up a report on a chemical analysis. I watched a school of dolphins swim by the research facility. At that moment, I realized that I did science and immersed myself in science in the truest sense. As I sat by a beautiful body of water and watched the magnificent animals playing and jumping in the water, while simultaneously studying the cause of fish mortality through chemical analysis, I said to myself, “I am a scientist!” Why at this particular moment? I cannot really explain this, but I do know that from that moment on, I could no longer let political factors and classroom constraints prevent me from practicing my beliefs about teaching science. My integrity would no longer let me think it was acceptable to teach students mere facts and information and call that science. I must do all that I can to ensure that my students experience science by doing science, immersing themselves in science, and being scientists!

**Blending Research Experiences with Constructivism**

Based on my own personal scientific research experience (Hahn, 1999) and blended with the work of Tobin and Tippins (1993), I believe that an experiential science course for the pre-service science teacher working in a contextual learning environment within the constructivist framework:

1. involves a process of personal learning;
2. becomes empowering;
3. becomes a tool for critical reflection;
4. allows for the culture and language of science to be experienced, versus the presentation found in a science textbook;
5. calls for the teacher (the research mentor) to take on the role of provocateur;
6. connects teachers to science;
7. allows each stakeholder (i.e., the teachers, the research scientists, and university staff), through the interpretive process, to have a voice and make decisions as opposed to just one side or another doing so;
8. creates the research to be more analogous to learning rather than truth seeking;
9. generates frustrations, unsolved problems and unanswered questions, which are part of the learning, not failure; and
10. becomes a catalyst for teacher change with respect to channeling such beliefs and practices into his/her classroom.

**Why Is This Study Significant?**

I believe that my study is significant in that it seeks to transform the traditional science courses taken by pre-service science and mathematics teachers. This transformation involves blending the ideals of existing programs for practicing teachers’ scientific work experience with the offering of content course credit for pre-service science and mathematics teachers. This is a unique collaborative effort among: the pre-service science or mathematics teacher, a practicing science teacher, and a science researcher, working together toward this blending of cultures and backgrounds.

**Pre-service Teachers Doing Research**

There are many examples of practicing teachers having the opportunities to become involved with scientific work. School districts, educational organizations, and private industries have sponsored such experiences (Alters, 1998) for many years. However, pre-service teachers typically do not have the opportunity to conduct scientific research within the context of science research.

The type of research associated with my study is unique in that the pre-service teachers collaborate with the practicing teachers and the science researchers. I believe the addition of the pre-service teacher into the learning community brings a new, critical element to the scientific research collaboration. When I began my pilot study in 1999, I could not find any data about programs similar to my own concept called, Collaborative Opportunities: Learning Environments And Research uNiting Educators and Researchers of Science (CO-LEARNERS), which has pre-service teachers, practicing teachers, and scientists doing scientific research together in a collaborative effort in which the pre-service teachers receives undergraduate course credit.
While I was aware that there were many such opportunities for practicing science teachers to participate in such research, I had seen very little research on teacher preparation programs with implications for pre-service science teachers participating in authentic science research. I strongly believe that if there had been an opportunity to participate in such a learning environment in my own teacher preparation program, my early teaching experiences would have been much less stressful and more productive. I believe that I would have had more confidence, as I would have been not only a science teacher but also a scientist as well.

In a survey of practicing science teachers, Melear (1999) reports that practicing teachers believe that they would have benefited from science research experiences in their teacher preparation programs. As Melear (1999) states:

Science education reform at the K-12 levels will not occur without major revisions of the preparation programs for the teachers of K-12 students. Pre-service teachers need mentoring by scientists in unique ways. Science teachers must not be the underserved in science any longer. (p. 11)

In their study of pre-service teacher apprenticeships with scientists, Brown, Bolton, Chadwell, and Melear (2002) assert that in order for pre-service teachers to comply with the inquiry-based state and national standards, teacher preparation programs “must consider more avenues in giving teachers opportunities to perform some kind of authentic research experience” (p. 22).

Research as Undergraduate Course Credit

The U.S. Department of Energy (DOE) currently sponsors the Energy Research Undergraduate Laboratory Fellowship program in which a practicing science teacher, a pre-service teacher, and a research scientist conduct a summer science research project. The DOE initially designed the program for college science majors. However, in the summer of 2001, the NSF Collaborative for Excellence in Teacher Preparation initiated the Pre-Service Teachers (PST) pilot program. Participants spend the summer working with a science researcher at one of several participating national laboratories. While the experience is rewarding and beneficial, the pre-service teacher participants do not typically receive undergraduate course credit. Often, it is possible to arrange this through the university the participant attends. Despite its limitations, the program is mutually beneficial; the participant gains knowledge and experience, while the research facility gains an eager volunteer.

One of the pre-service teachers, who had participated in a project at the Oak Ridge National Laboratory (ORNL), writes of her experience:
My summer at the ORNL changed my perspective on teaching. I experienced the life of a research scientist. When I combine my knowledge of science and teaching methodology with my hands-on experience at the ORNL and my teaching internship, I feel I will be able to blend the theoretical with the practical. Eventually, as an experienced teacher, I hope to design a classroom environment that combines the best of both of my experiences. (Brockwell, 2002, p. 46)

It is evident that this pre-service participant has learned a great deal from her experience. This program, however, is not a college-based course such as the one in my study. Because it is a summer program, usually located in a specified DOE location, it might be difficult for many pre-service teachers to participate. In fact, this participant mentions a “nine-hour drive” (p. 41) to her laboratory. Conducting the research in a university laboratory or local research facility, as well as gaining course credit, is much more conducive to student participation and convenience.

*The Practicing Teacher “Bridging the Gap”*

Many of the programs that offer research experiences for pre-service teachers (Brown et al., 2002; Melear, 2000; Raphael, Tobias, & Greenberg, 1999) do not include the practicing teacher component, which serves to bridge the gap between novice teacher and science researcher. While Melear (2000) and her graduate students (Brown et al., 2002) have contributed greatly to the study of the immersion of pre-service teachers in science research, her work does not involve the collaboration of the practicing teacher. However, Brown et al. (2002) report that the pre-service teachers have difficulty in replicating their scientific research methods into their secondary science classrooms. At the beginning of my research, I predicted, however, that the addition of the practicing teachers to my study would help to remedy this situation.

*Opportunities for Learning Pedagogical Content Knowledge*

Shulman (1986) coined the term pedagogical content knowledge (PCK) for the synthesis of teachers’ pedagogical knowledge, what they know about teaching in general, and their subject matter, for this study, in science. A major consideration of adding the practicing science teacher to the pre-service teacher and research scientist, relates to PCK (Van Driel, Verloop, & De Vos, 1998). PCK is the knowledge of how to effectively present particular concepts and ideas to students, or how to teach the subject. The concept of PCK refers to teachers’ interpretations and transformations of subject-matter knowledge in the context of facilitating student learning.

In summarizing their research on science teachers’ PCK, Van Driel et al. (1998) report that a familiarity with a particular content topic in combination with teaching experience positively contributes to PCK. The immersion into the science research, combined with the
mentoring from the practicing teacher, allows the pre-service teacher to become familiar with science while simultaneously getting ideas from the practicing teacher of how to teach it.

PCK is a form of knowledge that distinguishes science teachers who teach science from scientists who do science (Gudmundsdottir, 1987a, b). Teachers differ from scientists, not necessarily in their subject matter knowledge, but in how they organize and use that knowledge. The practicing and experienced science teachers organize their knowledge of science from a teaching perspective and use it for helping students to understand specific science concepts. Scientists, on the other hand, organize their knowledge from a research perspective and use it as a basis for developing new knowledge in the field.

Hauslein, Good, and Cummins (1992) compare the organization of science subject matter knowledge among groups of experienced science teachers, experienced research scientists, novice science teachers, subject area science majors, and pre-service science teachers. Hauslein et al. (1992) find that undergraduate science majors and pre-service teachers both show loosely organized subject matter knowledge. They also report that the science subject matter knowledge of the experienced teachers and the research scientists is much deeper and more complex. The science researchers show a flexible subject matter structure, while the practicing, experienced teachers show a more fixed structure. The authors believe this to be due to the curriculum constraints that teachers encounter.

Therefore, bringing the practicing teacher into the learning community with the pre-service teacher and the science researcher could remedy what Brown et al. (2002) describe as the pre-service teachers’ limited ability to replicate their scientific research methods in their classrooms. I can envision the science researchers bringing the science content knowledge and the culture of science to the learning community, while the practicing science teachers bring how to teach the science content within the culture of science in the classroom, as well as how to deal with the barriers associated with implementing changes in the classroom. This could help the pre-service teacher learn how to blend the two cultures for a more effective classroom practice, in terms of bringing more hands-on, inquiry, and constructivist-based science instruction into the classroom.

Beliefs to Practice

My study is also unique because it follows the teachers from their pre-service participation in the contextual science research course through their second year of classroom
teaching. This allows for the exploration of the transition from beliefs to practices, which I will discuss later in terms of catalytic and tactical authenticity (Guba & Lincoln, 1989).

My prolonged engagement with the teachers for five years also allows a glimpse into what Palmer (1998) calls identity and integrity of the teacher. In other words, this extended opportunity gave me a chance to see if and how the teachers put their beliefs into practice. My hope was to see if an immersion into a contextual science research experience might influence the teachers to put their beliefs into practice. In summary, Palmer (1998) states:

Good teachers possess a capacity for connectedness. They are able to weave a complex web of connectedness among themselves, their subjects, and their students so that the student can learn to weave a world for themselves. The methods used by these weavers vary widely: lectures, Socratic dialogues, laboratory experiments, collaborative problem solving, creative chaos. (p. 11)

*Breaking the Cycle*

My research also builds upon the studies edited by Kielborn and Gilmer (1999), in which practicing teachers experienced scientific research. These studies examine how the scientific work influences the practicing teachers’ beliefs about science. One case examines the influence of the scientific work experience on how the teacher teaches science and how their students learn science (Greenspan, 1999). In my own chapter (Hahn, 1999) from the Kielborn and Gilmer (1999) study, I discuss how my immersion into science research influences my own praxis in teaching. I discuss this feeling of emancipation that leaves me with a change in both beliefs and practices. This change is powerful enough to inspire me to conduct my doctoral research on contextual science research for pre-service science teachers.

We must teach future science teachers in the ways that current research suggests that teachers should teach within their own classrooms. We tend to “…teach the way we are taught” (Macala, 2003, p. 1), and “teachers teach as they have been taught “ (Adamson et al., 2003, p. 939). If we teach pre-service science teachers using only textbooks, lecture, and cookbook-type laboratories then can we truly expect them to allow students to experience science inquiry or provide contextual, constructivist-based lessons in their classrooms?

**Organization of the Dissertation**

*Chapter 2*

In Chapter 2, I discuss the *apprenticeship model* because I base my ideas about the collaborations for the pre-service teacher with the practicing science teachers and the science
researchers on this model. I also discuss collaborations and learning communities in Chapter 2, as they are critical parts of my study. A brief section on teaching for inquiry is included in this chapter, as well.

In Chapter 2, my Literature Review, I discuss, in more detail, several of the many different science research programs currently available for practicing science teachers. I also include existing research on programs that immerse pre-service teachers into a learning community with practicing science teachers and/or science researchers. My study focuses on a follow-up to a program in which pre-service teachers were part of a community of learners with practicing science teachers and science researchers working together within the context of science research. Chapter 2 includes a review of current research on novice teachers and the first few years of teaching. I also address teacher beliefs, teacher empathy, and teacher change in Chapter 2.

Chapter 3

Chapter 3 details my theoretical perspective and methodology. Constructivism (Tobin & Tippins, 1993), combined with cultural-historical activity theory model, forms the framework for this study. To help explain the dynamics of my study, I use cultural-historical activity theory, developed by Engeström (1999), to search for coherences and contradictions related to the components of my study. To assist with analyzing the data, I utilize a qualitative methodology of interpretive design (Denzin & Lincoln, 2000; Erickson, 1998; Guba & Lincoln, 1989; Lincoln & Guba, 2000). To narrow my focus to two of the participants, I choose to use a qualitative case study genre (Denzin & Lincoln, 2000). In this chapter, I introduce the quality criteria for a qualitative study. For the evaluation, I implement the hermeneutic dialectic circle described in Fourth Generation Evaluation (Guba & Lincoln, 1989). I explain how I consider the four types of authenticity involved within a fourth generation evaluation. Chapter 3 also includes a section on the limitations of my study.

Chapter 4

In Chapter 4, I describe my pilot study entitled, CO-LEARNERS. I would like to consider my pilot study as part of my Literature Review because the Southeast Eisenhower Regional Consortium for Mathematics and Science Education @SERVE (SERC@SERVE) published part of my findings in a publication entitled, Experiential Learning for Pre-Service
Science and Mathematics Teachers (Gilmer, Hahn, & Spaid, 2002). In addition, in Chapter 4, I explain how findings from my pilot study evolved into the doctoral research for this dissertation.

Chapter 5

I introduce my participants and the context of the study. I detail my research activities with respect to my research questions, theoretical framework, methodology, the observations and interviews, and an analysis of the data using the QSR Nvivo qualitative software research tool (QSR, 1999).

Chapters 6 and 7

Chapters 6 and 7, include writings from two of the novice teacher participants in this study “Cathy” and “Rob,” respectively. Cathy and Rob are pseudonyms, as I wish to protect their anonymity. Cathy and Rob turned these papers in to me, the instructor of record, as a requirement for a constructivist-based, contextual science research course entitled, Experiential Science/Mathematics in Middle School. In these chapters, the participants discuss their summer research experiences, both the positive and negative aspects. Their writings offer a critical and reflective account of their experiences and provide some glimpses into their first year of teaching.

SERC @SERVE published the student teacher participants’ papers in the monograph under my guidance and assistance. Cathy and Rob have given me permission to include their chapters in my dissertation. SERC @SERVE has also given me permission to use these chapters as well. My major professor, SERC@SERVE staff, and I edited these papers for the monograph entitled, Experiential Learning for Pre-Service Science and Mathematics Teachers (Gilmer et al., 2002). I served as a co-editor of this monograph, as well as a contributor. I also submitted a chapter on the evaluation of my pilot study entitled, CO-LEARNERS (Hahn, 2002). Following the text of Cathy and Rob’s writings, I write my QSR NVivo analysis of their contextual research experiences on their beliefs and teaching practices, as I look at their first year of teaching.

Chapter 8 and Chapter 9

Chapter 8 and 9 detail observations and interviews of the two participating teachers, Cathy and Rob, during their second year of teaching. These chapters take a critical look at how contextual science research experiences influenced (1) their beliefs about the culture of science versus the culture of science in the classroom, (2) their classroom teaching practices, and (3)
their science content knowledge, and (4) pedagogical content knowledge. These chapters are critical because they reveal what I observed through my lens happening in Cathy and Rob’s classrooms. I discuss how they have put some of their beliefs into practice, as well as those that they have not. I illustrate how the cultural-historical activity theory can help to explain the results by focusing on the coherences and contradictions of the study.

Chapter 10

In Chapter 10, entitled Findings, I focus on Lessons Learned, as there were many over the course of a five-year study. I answer my research questions, which were of personal and professional interest to me. I also discuss the implications and recommendations for the future. In the final sections, I discuss how I learned about myself as a researcher, teacher, a learner, and a participant in life. I divide my Lessons Learned into these five categories: Answers to my Research Questions, Implications and Recommendations for Pre-service Teacher Education in Science and Mathematics, Researcher Bias and This Study, Personal Reflections, and Seeking a PhD: Lessons Learned in Life.
CHAPTER 2: REVIEW OF THE LITERATURE

Introduction

In Chapter 2, I discuss the *apprenticeship model*, as it provides a basis for teacher research experiences. I then proceed to expand upon the different science research programs available for practicing science teachers and those available for pre-service science teachers. I also discuss various studies that support my idea for this doctoral dissertation, which places pre-service science and mathematics teachers in a science research apprenticeship with a research scientist and a practicing science teacher. There is an abundance of literature that supports and outlines the positive influences gained from collaborations among *practicing* science, or mathematics teachers and research scientists. There are relatively few studies involving *pre-service* teachers in collaborations with research scientists, which is why I chose to pursue this endeavor.

Because my study looks critically at teachers’ beliefs, I have included pertinent literature related to teacher beliefs and practices. While my project originally began as a pilot study with pre-service science and mathematics teachers engaged in scientific research, this study now follows these pre-service teachers into the classroom as *novice* science and mathematics teachers. I include discussions, based on the existing literature, on the unique experiences of both pre-service and novice teachers with respect to putting their beliefs into practice. I also discuss the notion of teacher empathy for his/her students in the role of learner as being a catalyst for change in teachers’ beliefs and practices.

The Apprenticeship Model

Rogoff (1990) provides this description of apprenticeship, “Vygotsky’s model for the mechanism through which social interaction facilitates cognitive development resembles apprenticeship, in which a novice works closely with an expert in joint problem solving in the zone of proximal development” (p. 141). Throughout this apprenticeship, the novice builds on existing knowledge via collaborations with experts. Rogoff (1990) views children’s cognitive development as an apprenticeship in that it occurs through guided participation in social activity with those who support and broaden children’s understanding and the use of the tools of *culture*. 
A contextual teacher research experience could be described as an apprenticeship in that the novice (a pre-service or practicing science and/or mathematics) teacher works closely with the experts (research scientists) in the culture of science. The collaboration between the pre-service science and/or mathematics teacher and the practicing science teachers is an apprenticeship in the culture of science in the classroom.

**Learning in Communities**

In her discussion of apprenticeship models for high school students, Richmond (1998) stresses that apprenticeships allow students to become participants in the scientific enterprise. In the process of exercising and negotiating, the students develop understanding and see ideas implemented in communities of professionals. The students can come to appreciate the extent to which science is a human endeavor. Belonging to such a scientific community by learning and participating in its discourse and practices is an opportunity that encourages students to develop a richer understanding and appreciation for the scientific enterprise.

In an article about learning in communities, Abbott (1995) suggests that the core of the apprenticeship system is the active engagement of the apprentice in understanding what the craftspeople are trying to achieve.

Our brains are at their most efficient when all the senses are stimulated and they are absorbing many new ideas. When engaged in challenging activity, the brain tolerates uncertainty and ambiguity, and delights in searching for new and novel solutions. We are, as it seems, biologically designed to deal with complexity. (Abbott, 1995, p. 7)

Abbott also describes learning as an essentially social activity that relies upon knowledge construction rather than knowledge transfer.

Richmond (1998) suggests that teachers need to engage their students in the process of science in order to acquaint them with the personalities, ideas, politics, and other forces that shape the discipline. According to Richmond (1998), this engagement allows students to experience science for themselves and to understand what it would be like to work in within a scientific community. She further explains that in order for teachers to do this, they must incorporate and model, in carefully planned ways, the processes and products of science in the lessons they teach in their own classrooms. She calls for teachers to orchestrate outside experiences for students, incorporating aspects of these experiences into their curriculum and bringing to bear the expertise and services of community-based professionals. Richmond also states that for these types of science experiences to happen it depends, in large part, on two
factors: (1) the teacher’s knowledge of scientific content, and (2) the extent of support, both financial and human, available to the teacher.

Jensen (1998) discusses using more relationship-driven learning by providing apprenticeship collaborations with experts as a strategy to help students develop more deeply felt meaning by engaging productive emotions. Another strategy that he suggests is the use of peer collaboration.

Collaborations

According to Linn and Burbules, (1993) collaborative learning occurs when “two or more students jointly work out a single solution to a problem” (p. 92). I utilize this the definition in this study, as the co-learning team (a pre-service teacher, a practicing teacher, and one or more research scientists) worked together in a collaborative effort.

While cooperative learning might occur during the actual research, the major focus of the collaborations was to help the pre-service teacher bring the culture of science into the culture of the classroom. The specific goal of the collaborative effort was to encourage the pre-service teachers towards such outcomes as: (1) implementing constructivist-based, contextual science research in their own classrooms, (2) forming collaborations with scientists and the science community, (3) integrating science and mathematics in the classroom, (4) implementing inquiry-based, hands-on science activities, and (5) constructing science content knowledge and PCK.

Thus collaborations can be synergistic, with the whole being much more powerful than the individual effort. Bruffee (1993) states:

The teacher’s job is to design tasks that help people discover and take advantage of group heterogeneity and thus, by expanding the group’s collective “zone of proximal development,” to increase the potential learning power of every individual in the group. (p. 40)

The term, “zone of proximal development,” coined by Vygotsky, refers to “understanding that lies just beyond current knowledge and ability: what we cannot learn on our own at the moment, but can learn with a little help from our friends” (Bruffee, 1993, p. 39).

As the teacher of the course highlighted in this study, my purpose for uniting the pre-service science and/or mathematics teacher with the practicing science teacher and science researcher is to expand their collective zone of proximal development, as I believe this synergy can transform the current way that teacher preparation programs educate pre-service teachers. University teacher education professors may offer limited expertise to pre-service teachers
because, often, they have not taught in an elementary or secondary classroom in many years, if ever. In addition, many have never worked in a science research laboratory. Providing opportunities for the pre-service science and/or mathematics teacher to collaborate with practicing teachers and science researchers expands the power of their learning in a myriad of ways.

In the following sections, I discuss the importance of collaborations with practicing science teachers and science researcher in the education of a pre-service science and/or mathematics teacher.

**Collaborations with Practicing Science Teachers**

A group of teachers initiated the Professional Practice Community Project (PPCP) because of their interest in changing their practices. They approached the university for assistance, with particular attention towards science and mathematics learning. The project involved an elementary school, a middle school, a high school, and a state university. These schools worked together in a collaborative effort among pre-service and practicing science and mathematics teachers, university educators, and school administrators. The description of the study mentions that the pre-service and practicing teachers “could join together as co-learners” (Tippins, Nichols, & Tobin, 1993, p. 68) in conversations about science teaching and learning.

Tippins et al. (1993) report that:

Learning alongside practicing teachers who are also interested in learning enables prospective teachers to move beyond a superficial understanding of teaching activities—they develop a better understanding of the role of reflection in teaching and the ways in which socio-cultural aspects of teaching and learning influence the practices of teachers and students. (p. 69)

The article, however, does not discuss the science researchers’ role in the collaboration even though there was at least one researcher involved (Gilmer, personal communication). I believe that science researchers are a key element in bringing science into the classroom.

**Collaborations with Scientists**

Bruffee (1993) asserts that introducing pre-service teacher education students to science as it is actually done should be a priority of college and university educators. I agree with Bruffee, science teachers should be scientists at some point in their training. In my opinion, the earlier, the better. Bruffee (1993) calls for college and university educators “to teach the interpretive, constructive, collaborative process by which scientists build models of the natural
world” (p. 144) and not to “display what scientists believe they know about the natural world” (p. 144).

Falk and Drayton (1997) believe that extended scientist–teacher collaboration can be instrumental in promoting teacher change. The teachers benefit from increased content knowledge and access to a wide range of professional resources. Such a relationship can also be liberating for the teachers, as the scientists may motivate the teachers to seek more content knowledge and to reflect on how to incorporate inquiry into their classrooms.

Their study reveals that the scientists benefit from the collaboration in that the scientists believe they provide the teachers with a renewed enthusiasm for science and an interest in inquiry. The teachers assist the scientists with the collection of research data and form a connection with the school environment. Atkin (1991) points out that partnerships including scientific work experiences for teachers depend on trust between the teacher and the scientist, and are a necessary investment in the future that will make a difference.

Involvement in contextual research experiences in the science community could translate into increased access to scientists and the scientific community for the novice teachers’ classrooms. Subsequently, their own students gain invaluable and otherwise inaccessible resources from businesses, university research laboratories, and governmental agencies. Kochan (1992) calls for a fundamental change in the paradigm of school, or a re-creation of community. This would require the reconnecting of people and resources, involving changing roles, relationships, and responsibilities between and among teachers, students, parents, and community personnel.

The employer of the scientist benefits, as this opportunity can be used to inform teachers as to what the employer seeks in future employees. Many companies complain that too many employees are entering the workforce without the skills to work effectively with their co-workers. According to Senge (1996), many companies cite teamwork as a critical skill lacking among new employees. The collaborative effort and emphasis on learning community offered by this research gives teachers, and ultimately their students, the opportunity to experience this type of teamwork.

The collaborating scientists could benefit by gaining willing and eager helping hands to work on his/her research project. The scientist may become involved with the education of new scientists and/or future employees. The research scientist will have an opportunity to teach
within the context of the middle school classroom, as he/she becomes the Scientist in Residence for a day or more. This experience will allow him/her to better understand the classroom culture of learning science and to see how vastly different it is from the science laboratory setting amidst fellow scientist-learners. Many people, including scientists, do not realize the limitations within the classroom. Non-teachers, too, greatly misunderstand the limitations of classroom management. Immersing the research scientist in the classroom enables the scientist to develop more empathy for the classroom teacher, as they work together to develop effective strategies to implement real science within the context of the often crowded and unruly middle school classroom.

**Teaching for Inquiry**

*Inquiry* is a broadly applied term for teaching strategies in which teachers and students emulate the activity of scientists in order find answers and understand science concepts (Windschitl, 2002). A major focus of the NSES (NRC, 1996) is inquiry. The NSES refer to inquiry, as the abilities students should develop in order to design and carry out scientific investigations. The NSES encourage teachers to engage students in real-world science, inquiry, and experiments. The NSES define scientific inquiry as:

> Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

(NRC, 1996, p. 23)

In their study involving pre-service teachers who apprentice with scientists, Brown et al. (2002) conclude that for pre-service teachers to comply with what state and national standards recommend for inquiry teaching, teacher preparation programs must provide pre-service teachers with the opportunities to perform authentic research experience.

In a case study of 12 pre-service teachers, Windschitl (2002) finds a link between involvements in research experiences with the use of inquiry activities in the classroom. Windschitl reports that while all of the participants in his study are enthusiastic about using inquiry, during the teaching internships, they often do not incorporate inquiry into their classrooms. However, the participants who had more experience with research experiences as undergraduates or as professionals are more likely to use inquiry. This seems to suggest that involvement in research projects may help pre-service teachers re-frame their cultural models of
science from one of information and fact collecting to one that is more dynamic and involves sense-making. Windschitl (2002) concludes:

Knowing, then, how potentially powerful inquiry experiences can be, it suggests that teacher education programs should promote some authentic science research experiences either in conjunction with methods classes or within other areas of the pre-service program. Other studies are necessary to determine whether and how such programmatic efforts will affect teacher practice. (p. 20)

Although Windschitl’s study does not follow the participant into their novice year of teaching, preliminary results demonstrate a connection between science research experiences and the use of inquiry during the internship year of teaching.

Practicing Science Teachers Conducting Science Research

There are various programs across the country that provide contextual science research opportunities for practicing science teachers to gain science experience within the context of a science research facility. Practicing science teachers have worked alongside science researchers during the summer months in a variety of programs across the United States for many years. In fact, one of the early goals of the Marine Biological Laboratory at Woods Hole was to train women to teach science in high schools and colleges and to provide teachers in Massachusetts with hands-on experiences in biology. The Massachusetts’s Women’s Educational Association founded the Marine Biological Laboratory at Woods Hole in 1888 (Silverstein, 1999; Marine Biological Laboratory, 2004).

In many cases, a government funding agency or the participating science facility compensates the practicing teachers for their work in a program called a Scientific Work Experience Programs for Teachers (SWEPT) (Triangle Coalition for Science Technology Education, 1995). I use the term SWEPTs when referring to the plural form of the many programs, while I use SWEPT as an adjective when describing the programs. More recently, the NSF now calls SWEPT programs by the name, Research Experiences for Teachers (RET) (NSF, 2004). Some of the programs I discuss in this literature review are RETs. They are the same type of program, only the terminology is different.

As of 1994 (Triangle Coalition for Science Technology Education, 1995), there were over 91 known SWEPTs operating in the U.S. In fact, SWEPTs served 1,546 math, science, and technology teachers in the summer of 1993. Although the number of internships is higher due to the repeat participation of some participants, SWEPTs have served 5,500 teachers since their
inception. I would predict that this number is much higher since the 1994 report. Approximately 180 universities and colleges participate in SWEPTs by opening up their research facilities and/or by assisting the teachers with classroom applications of their research. I looked for updates to these statistics; however, the Triangle Coalition has no new report or update (Triangle Coalition, 2004).

Other programs offer no monetary compensation for practicing teachers, but they may provide tuition waivers for course credit. Some programs cover the teacher’s travel expenses, room, and board in exchange for his/her participation. Rather than earn a salary, the participating teachers gain research experience, professional enhancement, and science knowledge.

In the following sections, I discuss a few of the SWEPT programs and several of the other teacher research programs that are not part of SWEPT or RET. There are too many programs in existence to describe them all. Some of the programs that I have selected are those with which I have some familiarity, either through participation, or through contacts made at various conferences.

Scientific Work Experience Programs for Teachers

SWEPTs (Triangle Coalition for Science Technology Education, 1995) provide K-12 teachers with paid summer fellowship opportunities in workplaces and research settings. Teachers typically work for 4–8 weeks in industry, university, or government research laboratories. The Triangle Coalition for Science and Technology Education assists individuals and organizations in the establishment of SWEPT programs in their communities. These scientific work experiences have proven extremely worthwhile to the teacher participants and to the researchers (Alters, 1998).

A teacher of physical education is likely to have been involved with sports prior to his/her teaching, an art teacher probably painted or sculpted prior to teaching, and an English teaching probably tried his/her hand at writing a poem, a short story, or perhaps a novel. A football team led by a coach who had never played football might not have much field success. However, most science teachers have never served in the role of a scientist.

For instance, only 63 percent of high school science teachers and 17 percent of middle school science teachers hold degrees in science (National Science Board, 1998). Additionally, holding a degree in science does not guarantee science research experience. This suggests that aside from laboratory classes in college, science teachers, particularly those without a science
degree, have probably had little experience with what a scientist actually does in the context of science. Being involved with an actual scientific investigation, which may or may not yield definitive results, is far different from the scientific method traditionally learned in school. An NSF report (Triangle Coalition, 2004) indicates that many teachers “make textbook learning the center of their lessons, teach laboratories that do not reflect the inquiry process, and rarely discuss nonacademic applications of science and mathematics” (¶3).

I now discuss three of the existing SWEPT programs that form a network of SWEPTs throughout the country as well as abroad.

The STARS Program

The Science Teachers as Research Scientists (STARS) program is a SWEPT at the University of Missouri–St. Louis that provides internships to secondary science teachers with faculty researchers (Gottfried, 1993). An evaluation of the STARS program reveals that participating teachers believe that they have: (1) made substantial gains in terms of science content knowledge, (2) increased the use of research/process methodologies in the classroom, and (3) substantially improved their ability to implement hands-on laboratory activities. Additionally, teachers express an excitement regarding working in the laboratory, including the Columbia University’s Summer Research Program

Dr. Samuel Silverstein initiated the Columbia University Summer Research Program for Secondary Teachers in 1990 (Silverstein, 1999). Silverstein’s rationale for the program is that, “you can’t teach something that you haven’t done” (p. 1). Each year, approximately 50 New York City public, private, and parochial school science educator apply for the program, but the program only selects 10 participants. Teachers in the program conduct full time research in Columbia University laboratories under the mentorship of Columbia faculty for eight weeks during two consecutive summers. It is one of the first programs to require two consecutive summers of commitment. Teachers receive a stipend of $6,000 per summer. Silverstein (1999) explains that the program treats teachers as professionals, challenges them to think, and involves them in investigations of real science problems. He further adds that, the experiences “require them to become students again” (p. 1).

In a recent study of Columbia University’s Summer Research Program for Secondary Teachers, Silverstein (1999) reports an increase in teacher morale and confidence. Silverstein asserts that science work experience gives teachers a feel for science and that the teachers with
science research experience are better equipped to help students than the teachers who do not have science research experiences. Silverstein also asserts that students show more respect for teachers who have these types of experiences in science.

The Columbia program was part of a multi-site study of eight participating SWEPT programs across the country. In 1998, the NSF awarded the consortium of SWEPT programs a $1.6 million grant to conduct a four-year study on the effects of teachers participating in a SWEPT program on student outcomes. Silverstein, who serves as the Principal Investigator of the grant, and the collaborating researchers in this study anticipate that they need two more years of data collection with a sufficient number of teachers and students to yield more statistically significant results (Columbia University’s Summer Research Program, 2002).

**Industry Initiatives for Science and Mathematics Education**

Industry Initiatives for Science and Math Education (IISME) is another one of the many SWEPTs throughout the country. A consortium of San Francisco Bay Area industries founded IISME in 1985 in partnership with the Lawrence Hall of Science at the University of California at Berkeley. IISME is best known for the Summer Fellowship Program (SFP), which provides Bay area science, mathematics, and computer teachers with mentored, paid summer jobs in high technology companies, government agencies, and university laboratories. IISME (2002) offers year-round assistance to teachers as they strive to translate their summer experiences into updated and enriched classroom instruction. Summer meetings, peer coaching, resource brokering, academic year workshops, small grants, and an electronic network are among the services IISME provides to teachers.

Over 90% of teacher participants each year report that the SFP is one of the best professional development experiences available to them. Teachers rank attitudinal gains as the most important outcome of participation, stating that the experience restores their enthusiasm for teaching and boosts their professional self-confidence. The most commonly reported instructional outcomes of the SFP are teacher-initiated changes in the areas of career counseling, student process skills development, science content, and access to industry (IISME, 2002).

IISME reports quantifiable evidence that teachers who participate in the IISME SFP remain in the teaching profession at a higher rate than their non-participating peers across the state and nation (IISME, 2002). I believe that this type of participation has the capacity to
recharge science teachers’ enthusiasm for teaching as indicated by participants in the IISME program who demonstrated a higher retention rate than their non-participating peers.

*Other Research Experiences for Practicing Teachers*

The following are examples of programs offered through universities, governmental agencies, or private companies, but which are not part of SWEPT. The NSF funds some of these programs. Teachers generally do not receive a salary, but they might receive course credit, inservice points for teacher certification renewal, and/or reimbursement for travel expenses. In some cases, teachers participate simply to enhance their teaching and to update their science knowledge.

*Science FEAT at Florida State University*

In a NSF-funded teacher enhancement grant called Science FEAT there were 66 middle level science teachers who participated in summer research experience. The program (Spiegel et al., 1995) spanned three summers. The immersion of practicing elementary and middle level science teachers into a constructivist-based learning environment, which included science, technology and society, the philosophy of science, statistics, educational foundations, and science content, provided teachers with the opportunity to receive a Master’s or Specialist’s degree in Science Education, depending on their level of education.

One aspect of the program that specifically relates to my study involves a summer research experience that engaged the participants in a scientific investigation along with a science researcher during one of the summers. Spiegel et al. (1995) assert that developing an understanding of the nature of science and the nature of scientific knowledge is a critical part of understanding science. Teachers gain this understanding through experiencing science research as active participants and contributors. They also find that the teachers learn to question the scientific method as traditionally presented in the first chapter of every science textbook and that science does not always follow a systematic or step-like procedure.

Results from the Science FEAT (Gilmer, Davis, & Spiegel, 1995) program support the notion that because of experiences in scientific research, the teachers develop a commitment to taking a stand on making changes in their classrooms. As a participant and graduate of this program, I can attest to this feeling of empowerment and commitment to change because of my own scientific work experiences. My beliefs and practices in the classroom have never been the same since my experiences with Science FEAT.
Kielborn and Gilmer (1999) describe practicing teachers’ accounts of the detailed experiences in summer scientific research. The monograph entitled, *Meaningful Science: Teachers Doing Inquiry + Teaching Science*, includes these experiences. I am one of the authors of a chapter in this publication. In my chapter, I detail the biochemical-related research experience in which I participated, and I explain how it greatly impacted my teaching (Hahn, 1999). This experience was also the catalyst for my interest in doing a doctoral research study about science research experiences for pre-service science teachers in teacher preparation programs.

In *Meaningful Science* (Kielborn & Gilmer, 1999), Bosseler (1999), a 28-year teaching veteran, states, “I am a teacher. I was not originally trained as a scientist, but now I am beginning to think like a scientist and feel I am becoming one” (p. 108). Bosseler’s comment reveals that she feels like she is becoming a scientist, and it helps to illustrate the power behind such an experience for science educators.

Greenspan (1999), a 22-year teaching veteran, who studied migrating birds, relays this comment on her experience, “Having first-hand experienced scientific research and the opportunity to interact with scientists in the field further gave me the confidence and the ability to incorporate multiple areas of science content into my teaching” (p. 90). Again, this teacher, who has taught elementary school science, demonstrates a growing confidence with science and science content through her science research experience.

Kielborn (1999) describes her experience studying algae in a NSF-funded program entitled, Teacher Research Update Experience (TRUE) at the University of Florida, as “an infectious prelude for a year of scientific inquiry and discovery for my sixth-grade students” (p. 71). Her experience influenced her so much that for her doctoral study she chose to observe sixth grade students in scientific research and then to study how their experiences affected their perceptions of scientists (Kielborn, 2001).

After completing a scientific work experience at a governmental research laboratory, as a practicing middle school science teacher, I wrote the following:

The simple act of being in a real research laboratory is empowering. As I sat at my desk in the laboratory looking at the equipment, I felt that I was learning through active transport, to borrow a metaphor from chemistry. This feeling of empowerment is one you
do not get by simply reading about the research of others. It has to be experienced! (Hahn, 1999, p. 54)

As a teacher, I stress the importance of the immersion in science. As I stated previously, many science teachers have never actually worked as a scientist. A scientific research work experience gives that boost to one’s confidence with respect to teaching science. It has been my experience that when you really know what you are talking about because you have been there in that context, your students tend to listen more attentively and with more interest.

Reflecting on her experience working with the olfactory systems of crustaceans, Foley (1999), a nine-year veteran of middle level science teaching, describes the impact of experiences on her own teaching. Foley (1999) calls for teacher preparation programs and classrooms to incorporate such opportunities for pre-service and practicing teachers.

*The Science/Math/Technology Institute at Southwest Texas State University*

In this study of 23 secondary school science teachers paired with university research scientists for two months during the summer, Westerlund (2001) reports the following findings:

1. Teachers are satisfied with their relationships with the research scientists;
2. Teachers increase their content knowledge;
3. Teachers increase enthusiasm for science and conducting laboratory experiences with their students; and
4. Teachers have more opportunities for participation in scientific dialogues.

The research from this study implies that summer research experiences encourage teachers to develop more scientific, inquiry-based classrooms. Of her study, Westerlund (2001) asserts:

If teachers achieve active participation in the development of their experiments and are able to collect data based on that design, we would argue that they have had a genuine scientific research experience. On the other hand, if teachers are merely passive observers and “dishwashers” in a research laboratory, their experiences are profoundly different. (p. 9)

This comment is critical, as the research experience must be an authentic research investigation in order for the teacher to receive the full immersion into the culture of science. I agree with Westerlund, as otherwise, the teachers feel like “free labor” (Tarter, 2002, p. 96) and the whole intent of the immersion into science is lost.

*The Research Internship in Science/Mathematics*

New York University (NYU) offers a course entitled, *Research Internship in Science/Mathematics*. The course is available during the summer for practicing teachers enrolled
in the Master’s program. The course involves a six-week internship in a scientific laboratory and provides teachers with a personal experience in scientific enterprise. Each intern works as a research associate with a practicing scientist. Upon completion, the intern prepares a report based on his/her experience (NYU, 2002). The course is collaborative between NYU and the Brookhaven National Laboratory (BNL). According to the program director, staff members at BNL report “the transformation of teachers from anxious participants to confident, self-assured educators, eager to convey the inquiry-based teamwork approach to their students” (Fraser-Abder & Leonhardt, 1996, p. 33).

Fraser-Abder and Leonhardt (1996) assert that the transfer of the total laboratory work experience is often impossible, but that the experience and information gained are invaluable and do emerge in the classroom in the form of teacher enthusiasm, confidence, enhanced leadership skills, and improved pedagogical skills. In other words, “the process of ‘doing science’ is brought to the classroom” (Fraser-Abder & Leonhardt, 1996, p. 33).

University faculty associated with the Research Internship in Science/ Mathematics at NYU note a significant difference in how teachers view science and scientists after their participation in the program. Fraser-Abder and Leonhardt (1996) also find that this course can help foster a change in teaching methods. Evaluators of the program agree that this model helps teachers experience the reality of science, increase their knowledge base, and acquire scientific skills and attitudes.

In addition to helping the teachers gain knowledge and skills, the scientists may form collaborations with other scientists through visits, presentations, and the development of a community of scientists, teachers, and students striving to make science accessible, enjoyable, and relevant. Fraser-Abder and Leonhardt (1996) note that participants from universities, government agencies, and sponsors of the teacher education partnerships agree that this “model improves science, mathematics, and technology teaching and learning and may be the paradigm for systemic change” (p. 33).

“Enhancing Program Quality in Science and Mathematics”

Enhancing Program Quality in Science and Mathematics (Kaser, Bourexis, Loucks-Horsley, & Raizen, 1999) is an extension of the National Center for Improving Science Education’s work with the Office of Science Education Programs of the DOE. The book of the same name focuses on four types of programs that support improvements in science and
mathematics education for all students. These areas are: pre-service teacher development programs, practicing teacher research programs, student enrichment programs, and systemic program.

In this profile, among the recommendations of the *Teacher’s Research Experience* (Kaser et al., 1999), there are several that apply to my study. A program should:

1. have a well-defined research task that is integral to, or a spin off of, the mentor’s ongoing research;
2. include elements of the research process, such as: designing experiments, creating mathematical models, collecting, analyzing, and synthesizing data, keeping a research journal, communicating results;
3. make the teacher part of the research team, modeling the interdependence of team members; and
4. provide opportunities for updating teacher knowledge and skills.

I note that Kaser et al. published these recommendations in 1999, concurrent to when I first started to conduct my pilot study in 1999. During this time, the climate was ripe to support science research for practicing, as well as pre-service science teachers.

*In Summary: Positive Influences of Science Research on Practicing Science Teachers*

This section details how science research experiences affect the practicing teachers. Various studies and research demonstrate positive influences on practicing teachers with respect to the following: collaborations with scientists and the scientific community, transfer of experiences to the classroom, teacher change, teaching for inquiry, science content, and immersion into the culture of science. I now discuss each area of influence.

*Collaborations with the Scientists and the Scientific Community*

In their study of high school science teachers engaged in an eight-week laboratory research program with ecologists, Falk and Drayton (1997) report that the scientists and the science teachers have a complex relationship. Falk and Drayton concur that teachers benefit in four ways. In summary, these are:

1. The teachers acquire equipment and laboratory materials. The affiliating research laboratory donates or loans equipment and materials to the schools.
a. The teachers gain a greater capacity to know how to acquire equipment in the future. The participating scientist shares his/her sources for equipment and contacts.

b. The teachers gain resources that help to simplify and organize the actual doing the research.

c. The teachers experience the culture of the scientific community.

2. The teachers’ experience professional networking among the colleagues of the participating ecologists. They visit laboratories and field sites, use the equipment, and are part of other research in progress during their program.

According to Falk and Drayton (1997), the work with the ecologists stimulates the teachers’ engagement with science content. The following quote sums up how this type of collaboration can help science teachers bring science back to the classroom. “A partnership with a scientist provides important values which enable the teacher to incorporate live science into his or her own work, and make it more available to students” (Falk & Drayton, 1997, p. 20).

Transfer of Experiences to the Classroom

According to the Columbia University’s Summer Research Program (2004), one of the major goals of SWEPT programs is for teachers to translate their experiences into their classrooms, thereby providing a richer learning environment for their students. The goal of any science research experience for teachers is to immerse the teachers into a constructivist-based contextual learning situation, rich in inquiry-based and meaningful learning, ultimately leading to the teachers emulating these types of experiences in their own classroom.

Melear (2000) asserts that as the teachers see their own role changing, they begin to see science teaching less as a matter of knowledge transfer and more as an activity in which students generate knowledge and investigate science content in-depth. Melear’s (2000) study provides a scientific immersion experience as a course for pre-service science teachers. The course, taught by a scientist, uses an inquiry approach in an investigative science class. Findings from the study show that the pre-service teachers “no longer view themselves as a direct conveyor of knowledge” (Melear, 2000, p. 4); instead, they strive to become a guide helping students construct their own meaning from experience. This type of teacher awareness is critical at the secondary school level.
It is my belief that in order for a teacher to change teaching methodology, the teacher must also experience a significant change in beliefs about teaching and learning. However, what type of catalytic experience can influence the transformation of a set of beliefs to the degree that the teachers will transform their teaching? According to Silverstein and Dubner (1999):

There is substantial evidence that teachers value their SWEPT experiences highly, that they gain both knowledge and confidence from them, and that they are encouraged by these experiences to undertake more inquiry-based, constructivist educational practices in their classrooms. Advocates of such constructivist educational methods believe that these methods stimulate students to become active learners and give relevance to schoolwork. (p. 3)

This statement provides some evidence of a shift to more inquiry-based and constructivist-based teaching practices by teachers who participate in contextual science research experiences.

In-service programs, workshops, content courses, and motivational speakers may initiate a spark. However, any of us who have participated in these types of programs know that they generally do not. It is very frustrating to believe one way, but to act another because you just cannot seem to make that change. This happens all too often because most schools still adhere to traditional instructional methods and pedagogy. Teachers are unable to practice their beliefs without fear of reprimand.

However, the more significant the catalytic agent for change, the higher the likelihood that it will trigger a behavioral change, as evident in my own experiences. With a change in more effective practice being the ultimate goal, a contextual learning experience in a science research setting has the potential for being a powerful agent for change for science teachers. This is what Guba and Lincoln (1989) call tactical authenticity. Tactical authenticity can be described as the extent to which the stakeholders and participants are empowered to act (Guba & Lincoln, 1989, p. 250). In my study, I hope to find out if the teachers who state certain beliefs during the pilot study will act on these beliefs by putting them into practice.

Because science teachers form views about science from their college course, the NRC (1996, 2000) recommends that pre-service and practicing teachers take courses in which they learn science through inquiry. This allows teachers to develop a deeper understanding of how their own students develop understanding using inquiry. The NRC (1996) also calls for science classrooms to go beyond the confines of the school facilities and utilize the resources of the community.
In a quantitative study, students of teacher participants in the Summer Research at Columbia University demonstrate a significant increase in several areas. Silverstein (1999) describes the first quantitative evidence that participation in a science work experience program for practicing teachers improves their students with respect to:

1. interest in science, as measured by increased student participation in science fair projects, and student participation in after school science clubs;
2. achievement in science as measured by a 10% increase in the percentage of students who pass a New York State Regents Examination in science; and
3. an increase in the number of students participating in the Intel/Westinghouse Talent Search Program, a competitive science research program for high school students. Prior to teacher’s participation in the program, the percentage of their students participating in the Talent Search was 0.42%. After two years, the percentage increased to 1.80%. The control group (students of non-participating teachers) change was negative, going from 0.74% to 0.42% participation.

This may be evidence of a catalytic effect in which the teacher participants become inspired to translate their own contextual learning experience into opportunities for their students. Thus, the results of the research experience suggest that the teachers experience such an impact that they may become inspired to bring similar experiences to their students.

**Immersion into the Culture of Science**

Participation in research immerses teachers in the culture of science. Sewell (1999) says, “The study of culture…is the study of the activities that take place within these institutionally defined spheres and of the meanings produced in them” (p. 41). The sphere in my study is science; therefore, when I discuss the *culture of science*, I am referring to the activities (such as the planning of research, executing experiments, carrying out procedures, and using the language of science) that scientists use to find answers to problems in science.

Asking questions, writing proposals, using new scientific vocabulary, analyzing data, presenting results, and being with research scientists, graduate students, and technicians on a daily basis are all part of the culture of science. Through immersion in this culture, teachers join a community of scientists and come to understand science, not from an abstract textbook-oriented perspective, but through scientific inquiry in an authentic experience (Westerlund, Garcia, Koke, Taylor, & Mason, 2002). Teachers whose only experiences in science learning
have come from lecture, textbooks, and cookbook laboratory experiences have greater difficulty teaching scientific inquiry. Therefore, if universities want to produce science and/or mathematics teachers who use inquiry methods, it would be logical to place them in situations in which they experience true inquiry.

Conducting contextual research immerses the learner in the culture and language of science (Lemke, 1995), without forcing them to memorize useless information. The teacher as learner could reflect upon his/her experiences, compare them to traditional textbook learning experiences, and understand that this was a far richer step to learning. The teacher can apply this to his/her own classroom, where more contextual learning opportunities may be implemented.

**Gaining Science Content**

Content, too, is vital to future science and/or mathematics teachers. Westerlund et al. (2002) find that the summer research experiences directly affect the practicing teacher participants by increasing their science content knowledge. All of the teacher participants make some progress during the summer in terms of increased scores on the knowledge tests. Overall, this study reports that the major effects of the research experience on the teachers are: (a) increased content knowledge, (b) increased enthusiasm for science, and (c) expanded opportunities for participation in scientific dialogues.

**Teacher Change**

Other teacher comments from the previously mentioned STARS program (Gottfried, 1993) include:

1. The learning cycle strategy reminds me that what kids really master is what is important.
2. The learning cycle strategy gives me more time to help students help themselves.
3. I now let my students do more discovery. I don’t just tell them the answers. I give them the opportunity to find out for themselves. (Gottfried, 1993, p. 12)

These quotes from teachers participating in this program suggest that some type of change in teacher practice occurs. This change appears to be catalyzed by the teachers’ experience with research. It may also involve the actual change in practice, or the teacher may simply be looking through different lenses, which impacts his/her decision-making. This could later emerge as a change in classroom strategies as the teacher participant becomes confident while implementing change.
**My Own Scientific Work Experience**

On a personal note, the most rewarding teaching experiences in my own teaching are those that include immersing students in true scientific research. I utilized funds from grants, which I had written and received for buses, substitute pay, and materials for several different environment projects. I assigned all six of my classes during those years to a specific environmental project in a program that I called, “Earth Reach.” These projects included the planting of sea oats in a sand dune restoration area, the building of snow fencing in a sand dune restoration area, the building and placement of bat houses, designing and constructing a butterfly garden, the building and placement of wood duck houses, habitat restoration, and litter control. Students, who normally showed no interest in class work, became very actively involved in these projects. To this day, when I see former students who participated in these projects, they tell me how much “Earth Reach” projects meant to them. My former students can still recall content, and explain to me what they did. I doubt that they could recall other types of factual information that I introduced in my classroom during that year.

By planning and implementing these research projects for my own students, I applied my own experiences in my classroom. My inspiration to plan the projects, apply for grants, and carry out the project was due to my own experiences in summer research. The extra time and effort I spent were well worth it because I knew that this was the best way for students to learn. To immerse students in contextual learning experiences, to involve them with their community and their environment, and to make the learning more meaningful were critical. I knew this, not because I had done any research on the subject at that point, but because I had experienced it myself. Without my own involvement, I may have never experienced the catalytic reaction that enables me to transfer this type of pedagogy into my own classroom.

**Pre-service Science and Mathematics Teacher Preparation Programs**

If university teacher preparation programs expect their teacher education graduates to go into the schools and teach in the way research suggests, then we must offer this type of learning to the future teachers. Pre-service science and mathematics teachers should be provided an opportunity to “learn by doing” before entering the classroom. Scientific work experiences should not be limited to practicing teachers.

A teacher who better understands science content and process because of his/her experience may be more likely to offer this type of environment in the classroom. Brunkhorst
(1991) reports that if the educational experiences of the pre-service teachers include intimidation, lecture, and memorization without reason, the teachers would behave the same way, believing that their training represents true science. The data seem to be there, so why do so few universities offer contextual science research experiences for future science teachers?

In the following section, I discuss some of the innovative courses offered to pre-service science and mathematics teacher education students. I also highlight a few of the existing, although limited, programs offering SWEPT-like experience for pre-service teachers. Since the experiences for pre-service teachers are generally not salaried work positions as the SWEPTs are, I refer to them as science research experiences or in my specific study, contextual science research experiences.

Innovations in Pre-Service Teacher Education

One problem that I see is with the science and science education professors themselves. Many have not been in a secondary classroom in over 10, sometimes 20, years. Some science professors have never taught science at the secondary level. In addition, many science education professors may have never engaged in scientific inquiry. In many cases, the two cultures have not been brought together in pre-service teacher education. There are certainly exceptions to this, as I outline in the following paragraphs.

Gilmer (1997) incorporates contextual science opportunities in her biochemistry courses, as well as the use of Internet-based instruction. The courses are constructivist-based and provide contextual opportunities for her students.

At Westfield State College, Darling (2001) teaches an inquiry-based animal behavior course that requires students to design their own research projects, write a scientific research proposal, conduct experiments, and present their findings in the form of a scientific paper. Darling (2001) says of her students, “I have found that many students do not have a thorough understanding of how scientists conduct research because they have not experienced the entire scientific process for themselves” (p. 102). While Darling’s course is for biology majors, not for science education majors, she reports that the students lack the confidence and experience necessary for open-ended, inquiry-based investigations. If biology majors lack confidence and experience, then what does that tell us about future science teachers who take considerably less science courses than science majors? I assert that future science teachers must be offered
opportunities to experience science research if they are to feel confident teaching science that is more constructivist and inquiry-based according to the new science standards.

Barnett, Harwood, Keating, and Saam (2002) integrate a Web-supported professional development system in elementary science methods courses at three different universities. This Web-based professional development program appears to be a successful strategy for fostering collaborations between teacher educators, pre-service teachers, and practicing teachers. Fused into the course are inquiry-based teaching methods.

Tobin (2000) describes how he stepped out of the university classroom and into an inner city high school to teach science. Implications of Tobin’s (2000) study relate to “three aspects of urban high schools: teaching science, identifying and enacting appropriate science curricula, and educating prospective science teachers” (p. 89). Tobin writes, “for more than five months almost every effort of mine was unsuccessful in promoting the meaningful learning of science for most of my students” (p. 101). Tobin’s inner city students, in general, pose a challenge for him, as they were not initially interested in learning science. As a university professor, Tobin concludes that it is critical to provide his own pre-service teacher education students with findings from his experiences and to emphasize the significance of social class (especially poverty) and ethnic diversity as factors that guide what to teach, student participation, and the limitations of what teachers can accomplish. Tobin asserts that failure to provide pre-service teachers with such knowledge would be “interpreted as an inability of prospective teachers to teach appropriately” (p. 101).

As editors and contributors, Taylor, Gilmer, and Tobin (2002) highlight innovative teaching practices of several university professors who are transforming their practices in a book entitled, *Transforming Undergraduate Science Teaching: Social Constructivist Perspectives.*

*Science Research Programs*

With the apparent praises and successes of scientific work experiences for practicing science teachers, I believe that providing these experiences via a teacher preparatory program might yield similar results for pre-service science teachers. An early intervention could possibly give the novice teacher a more confident start.
“Experiential Learning for Pre-service Teachers: Applications to Secondary Classrooms”

A recent monograph (Gilmer et al., 2002) entitled, *Experiential Learning for Pre-service Teachers: Applications to Secondary Classrooms*, details the experiences of pre-service science teachers who participated in the pilot study, CO-LEARNERS. Gilmer focuses on the pre-service high school teachers (Gilmer, 2002), while I, as a graduate researcher, focus on the middle school pre-service science and mathematics teachers (Hahn, 2002). The pre-service teacher works alongside a practicing science teacher and a science researcher in Gilmer’s and my study in order to bring together the culture of science and the culture of science in the classroom. In her chapter, Gilmer (2002) reports that the pre-service high school teachers’ immersion in the science research enhances their science content acquisition, opportunities for collaboration, and experiences with technology.

Brockwell (2002), one of the high school pre-service teacher participants, reports that the experience changes her perspective on teaching. She says, “I experienced the life of a research scientist” (p. 46). She believes that her research experiences will help her combine her science knowledge, her knowledge of teaching methodology, and what she gained from her contextual experience from the research in order to “blend the theoretical with the practical” (p. 46). I believe that she is saying that she is familiar with science content and science methods from her pre-service courses (*the theoretical*), but now she is familiar with science as it really is (*the practical*).

My findings (Hahn, 2002) on middle school teachers are similar. Pre-service science and mathematics teachers think that they:

1. gain science content more easily through being involved in the science as opposed to lectures and textbooks;
2. become more comfortable being in a science laboratory and around scientists;
3. gain ideas to develop collaboration with the scientists with whom they are working; and
4. believe that the best way to teach science is through an active, hands-on, minds-on approach.

Based on an analysis of the writings of the pre-service teachers in the pilot study, their overall experiences are positive. This dissertation is a continuation of my findings from the pilot study. I
include two of the participants’ chapters (Chapter 6 and Chapter 7) from my co-edited monograph as samples of qualitative data using the interpretive genre. Because the outcomes of the pilot study are both encouraging and intriguing to me as a science educator, I elected to continue the study for my doctoral dissertation.

**The University of Tennessee**

One researcher, Melear (2000) at the University of Tennessee, developed two courses for pre-service science teachers, *Teaching Science: Just Do It*, a course offering in botany, and *Research Experiences for Pre-service Teachers*. The latter is a recently developed course, which provides an opportunity for pre-service teachers to be part of an independent study in science research. The *Just Do It* course is a collaborative effort between Melear, a science educator, and Hickok, a biologist/geneticist. They design the course to give pre-service teachers an opportunity for intensive research experiences and to explore the use of inquiry in the classroom (Melear, 2000). The results of this study are positive and suggest that at the end of the experience the pre-service teachers are more comfortable with inquiry and are more likely to implement inquiry as a component in their own teaching (Melear, Goodlaxson, Hickok, & Warne, 2000). There are no practicing teachers working with the pre-service teachers in this study.

**The Future Teachers’ Research Program at the University of Arizona**

The Future Teachers’ Research Program at the University of Arizona provides research opportunities for pre-service secondary science and mathematics teachers. University faculty members mentor the pre-service teacher participants. Based on their findings, Raphael et al. (1999) report that the participants are most vocal about their increased understanding of science in action. One of the participants says, “You can read about (research) all day long, but until you do it, you don’t really know anything about it” (p. 152).

Teacher participants have become more closely linked with the scientific research and the teaching community. Thus far, their findings indicate that their program not only benefits the individual participants, but also the science education community. “The experience with this particular innovative program appears to support the hypothesis that first-hand experience will enhance teachers’ abilities to implement the widely accepted objectives of science education” (Raphael et al., 1999, p. 157). This program does not include the practicing science teacher as a mentor along with the science researcher.
**Pre-service Teachers’ Program with the U.S. Department of Energy**

The PST is a program of the Energy Research Undergraduate Laboratory program. The DOE and the NSF co-sponsor the program in which this research takes place at a national laboratory. Here, participants are either undergraduate science majors, mathematics majors, or science and/or mathematics education majors. Upon completion of the research, the pre-service teachers publish an abstract. The PST program invites the teachers to publish a formal scientific paper along with their science research mentor in a publication entitled, *Journal of Undergraduate Research* (DOE, 2001). The PST program also requires pre-service teachers to produce a lesson plan that relates to their research. Such a requirement aligns with national science teaching standards.

Brockwell (2002), a pre-service teacher and CO-LEARNERS participant at the ORNL, writes about her research experience in which she learns about the fuel efficiency of automobiles at the National Transportation Research Center at the ORNL. She states, “I am beginning to see how an effective science lesson or activity can potentially change a student’s thinking. …One of my goals as a classroom teacher is to help my students understand the impact their choices have” (p. 43).

The PST program is a relatively new program; therefore, there has been no formal follow-up evaluation published other than the published papers of the participants’ research. However, Brockwell’s writing demonstrates that her experience was a positive one. While she has just begun teaching in her own classroom, I anticipate that she will bring her experiences with her. Brockwell was not part of my study, but participated in the CO-LEARNERS project as part of the high school study (Gilmer, 2002; Brockwell, 2002).

**Maryland’s Collaborative for Excellence in Teacher Preparation**

The *Maryland Collaborative for Excellence in Teacher Preparation* (Ross & Denniston, 2002) offers a summer program that allows a pre-service science teacher to work alongside a practicing science teacher. During the summer, both teachers team with mentor scientists for a 6–12 week internship to participate in research at government, university, and private laboratories throughout Maryland. Whenever possible, the project coordinators pair a pre-service science teacher with a practicing science teacher. The Maryland program now provides internship opportunities for up to 34 practicing teachers and 25 pre-service teachers. Using ongoing communications and surveys, the program monitors the professional activities of the
interns during and beyond their commitment. Ross and Denniston (2002) report that reflective journals of the pre-service teachers reveal “increased understanding of the process and value of authentic research, renewed enthusiasm for using inquiry-based instructional strategies, and a depth of appreciation for the overall quality of the research experience” (p. 100).

In their study of pre-service teachers from the Maryland program, Langford and Huntley (1999) find that the pre-service teachers report a sense of pride and empowerment as they discover “that not only could they do the work, but they had done it, and they had done it well” (p. 295). They have not followed the graduates of this program into the classroom, but envision that the participants will become teachers who understand the connections between science and mathematics and who create “an exciting and interactive environment for all students” (p. 297). While not originally implemented in all cases due to funding, Langford and Huntley now recommend that the pre-service teachers be paired with a practicing teacher because they believe this will help the pre-service teachers with “translating their research experience into the classroom” (p. 296).

**Novice Teachers**

In this following section, I discuss the relevant characteristics and research on novice teachers. I offer some of the existing research on novice teachers with respect to the first few years of teaching, the mentoring of novice teachers, and the PCK of novice teachers.

**The Induction Years**

Klepper and Barufaldi (1998) define the *induction years* as at least one year and no more than four years of science teaching experience. During the induction years, Klepper and Barufaldi find that novice teachers are under constant evaluation. The authors also cite that science content courses, which the teachers took while undergraduates, at the university level usually consisted of three hours of lecture and a once-a-week laboratory activity, which did not provide an appropriate teaching model for pre-service teachers.

During these induction years, the novice teacher begins to establish behaviors and beliefs about practice and to model his/her teaching practices on these types of experiences. Therefore, pre-service teachers need positive experiences while still in training that will reflect the way that students should be taught according to the NSES (NRC, 1996, 2000).
Mentoring Novice Teachers

In her study of mentoring novice teachers, Dawson (2002) asserts that teachers in science and mathematics have needs that go beyond better classroom management skills, better understanding of the workings of the school, and better communication with parents. Teachers in science and mathematics also need help with understanding science content, obtaining and preparing laboratory materials, and guiding students to understand difficult subject matter. Dawson also discusses the importance of mentors during the first year of teaching. Such collaborations often continue beyond the teacher’s pre-service experiences and extend as the, now, novice teacher enters his/her classroom. These collaborations can occur on a more dynamic level if the teacher maintains contact with the mentor(s), or on a cerebral level as the pre-service teacher retains what was learned during the mentorship.

Dawson (2002) believes that supporting novice teachers in science and mathematics can improve student learning, teacher success, teacher morale, and teacher retention. She cites the current shortage of teachers, particularly in the areas of science and mathematics, because of the failure to support novice science and mathematics teachers.

Pedagogical Content Knowledge and the Novice Teacher

The novice teacher often has difficulty trying to decide just how to teach his/her students. New teachers have major concerns about PCK, and they struggle with how to transform and represent the concepts and ideas in ways that make sense to the specific students they are teaching (Wilson, Shulman, & Richert, 1987). Several studies report that novice teachers have incomplete levels of PCK (Crawford, Bell, Blair, & Lederman, 1999) and find that PCK will not occur in K-12 teachers without contextual learning in the field of study, such as science. Crawford’s study suggests that teacher education programs should require all pre-service teachers to participate in authentic scientific inquiries as well as in courses or experiences that emphasize the nature of science and scientific inquiry.

A novice teacher tends to rely on subject matter knowledge, most of which comes directly from the mandated curriculum. The novice teachers may not have a coherent perspective from which to present the information. The novice teacher also tends to make broad pedagogical decisions without assessing students’ prior knowledge, ability levels, or learning strategies (Carpenter, Fennema, Petersen, & Carey, 1988). Frequent use of factual and simple recall questions relates to low levels of PCK (Carlsen, 1987). Therefore, a course in which pre-service
teachers work with a practicing, experienced science teacher and a science researcher could provide a good learning environment for blending the teaching (pedagogy) perspective with the science research perspective (Gudmundsdottir, 1987a, b)

Beliefs About Science and Science Teaching

The focus of this study is to look at the influence of the contextual science research course on the novice teachers. The areas of influences that I address affect the novice teachers’ beliefs and classroom practices. I also address teacher change, as it emerges in this study.

Teacher Beliefs

Tobin, Kahle, and Fraser (1990) defines a belief as “a proposition, or statement of relation among things, accepted as true…a belief is a way to describe a relationship between a task, an action, an event or another person, and an attitude of a person towards it” (p. 36). In this section, I discuss pre-service teacher beliefs, novice teachers’ beliefs, how beliefs are put into practice, and the reality of the classroom, and how it affects beliefs.

Pre-service Teacher Beliefs

Barnett et al. (2002) profess that pre-service teachers need educational experiences that give them the chance to confront their own beliefs about science teaching, which can lead to a deeper understanding of teaching. They argue that there is more interest in teachers’ beliefs because “teachers’ beliefs color and influence their decisions regarding how content should be taught and how they think students learn” (p. 2).

Barnett et al. (2002) also assert that pre-service teachers’ beliefs develop over the years through their own experiences as students. Their study finds that the prior experiences that have shaped these beliefs make it difficult for pre-service teachers to consider alternative approaches to teaching and learning that are different from the way they were taught. One way to support pre-service teachers in reflecting on their own pedagogical beliefs and practices is through electronic networks that support the sharing of ideas among pre-service teachers, which in turn lead “to the development of a community of discourse about how to improve and reform teaching practice” (Barnett et al., 2002, p. 3).

Novice Teacher Beliefs

Klepper and Barufaldi (1998) report that the first years of teaching include constant evaluation, compromise, and adjustment for the teacher. This time also influences and helps to
establish teaching behaviors and beliefs about practice. Facing evaluation by the school administration, the school district, and to an extent by parents, the novice teachers must compromise and make adjustments on a daily basis in order to accommodate school policies, special events, student disruptions, parental requests, and so on. Influences from all directions, their past experiences, their current situation, and their plans for the future affect the novice teachers’ beliefs and practices.

When the novice teachers discuss their beliefs about teaching science and classroom practices, their beliefs reflect their own experiences from times when they experienced optimal learning. They base their beliefs on some emotions and attitudes, constructed from their own learning and lived experiences. According to Nelson (1999), among the teacher beliefs that evolve are:

1. The belief that students are “empty vessels” waiting to be filled evolves toward the belief that students are intellectually generative, with great capacity to pose their own questions and develop their own solutions to problems.

2. The belief that students learn by being told what to do and how to do it evolves toward confidence that students will learn through their own effort and can take greater responsibility for their own learning.

3. The belief that the subject (for example, mathematics, science, or history) consists of a series of isolated facts and topics that should be taught in certain order, or hierarchy, evolves toward a view of the subject as a flexible network of ideas, with many interconnections, which can be approached in a variety of ways.

4. The belief that instruction should follow the textbook and that the teacher’s responsibility is to cover the material evolves toward the belief that instruction should build on what students know and can do and should focus on important questions and ideas in the field. (Nelson, 1999, p. 5)

Nelson (1999) also asserts that changes in beliefs begin in summer programs or workshops, but that changes in teachers’ beliefs about teaching and learning also take place in the classroom and in interactions with changes in their classroom teaching practices. The question remains as to which comes first, beliefs or practice? Nelson suggests that the relationship between beliefs and practice is dialectic, going back and forth between change in belief and change in practice.

Ramey-Gassert (1997) asserts that state and local education programs encounter classroom-level resistance unless reformers consider teachers’ beliefs and attitudes by involving teachers in the change process, curriculum development, and professional development. Ramey-Gassert (1997) finds that having teachers involved in the reform will increase the use of hands-
on science in the classroom. This involvement starts with the teacher preparation programs of pre-service teachers and extends to the professional development of in-service teachers.

**Putting Beliefs into Practice**

Tobin (1998) discusses a case study of a science teacher who expresses a strong belief in student autonomy, constructivism, and inquiry-oriented approaches to learning. However, the same teacher often exhibits more concern with covering content, maintaining control of his students, and exposing students to a variety of ideas. In other words, the teacher resumed traditional teaching practices, although he strived to use constructivist practices.

Tobin (1998) asserts, “The extent to which a teacher is prepared to teach is a component of the context that must be considered in analyses of teaching and learning” (p. 137). He further adds that effective planning can be lost when teachers are asked to teach out of field, teach too many classes per day, or teach large classes. “In such circumstances, the focus of the teacher can be on survival rather than the learning needs of students” (p. 137). This could explain why many well-intentioned teachers’ beliefs and plans are often not put into action.

While I hate to admit it, there have been times in my early teaching career when I resorted to having students copy words from a list, define the words, and memorize them for a quiz the following day. I may have done this because my students had been unruly the previous day, and I simply did not feel like dealing with the classroom management of a laboratory activity that day. I knew that this was not the most effective teaching strategy, but as Tobin (1998) points out, sometimes my focus was on survival for the day.

In another study, Tobin (2000) reports that his own teaching experience in an inner city high school proved to be challenging because the students he encountered were resistant to learning science, and they became constant discipline problems. Many novice teachers encounter similar experiences during their first years, especially if they teach in a school where discipline problems are rampant. How can a first or second year teacher try to focus on implementing fun, hands-on, and inquiry-based science activities when survival in the classroom becomes the primary concern? A novice teacher may enter the classroom with the best of intentions and strong beliefs about teaching science, but his/her practices might be very different due to the constraints of the classroom in terms of disciplinary problems.

Bell (1998) asserts that teachers’ concerns about doing something new in the classroom include “fear of: losing control in the classroom; the amount of teacher intervention; covering the
curriculum; knowing the subject; meeting assessment requirements; relationships with students; and appraisal” (p. 686). These types of pressure make it difficult for teachers to put their beliefs into practice.

In a study of four elementary education graduates in their first year of teaching Gee and Gabel (1996) find that all of the novice teachers support the notion of inquiry; however, only one of the teachers showed any evidence of putting those beliefs into practice. Again, there are various contradictions or constraints that come into play as novice teachers enter the classroom full of ideals and beliefs based on what they have heard and read throughout years of teacher education courses taught by professors who have not been in a classroom in several years, if ever. The internship experiences of pre-service teachers often reflect the ideal classrooms and students. Their training often does not prepare them for reality.

Praxis: “A Synergistic Change in Both Beliefs and Practices”

Praxis (practical action) is taken from the Greek notion that action should be taken on the basis of a thorough understanding (Grundy, 1987). Grundy offers these assertions; “Praxis takes place in the real, not an imaginary or hypothetical world” (p. 105) and, “[t] his reality in which praxis takes place is the world of interaction: the social or the cultural world” (p. 105). To relate this to teacher practice, the opportunity for a science and/or mathematics teacher to experience praxis would be within the context of real science, as in a science research experience, through collaborations with other teachers and a researcher within the culture of science. A teacher would be less likely to experience a change in beliefs and practices, or praxis, within the limitations of learning from a textbook or lecture.

Peterman (1993) describes a teacher who “seemed to experience praxis—a synergistic change in both beliefs and practice” (p. 241) through an active engagement of reflections, discussions, practices, and ideas. Peterman’s study raises questions about the training of teacher and the need for projects that address the teacher as a learner and that involve the teacher in “praxis—doing, reflecting, learning, changing” (p. 241). This parallels with Gilmer’s (1999) definition of contextual learning in science as “learning in the context of doing, thinking, speaking, and experiencing science” (p. 13). Placing pre-service science and/or mathematics teachers into a contextual science research setting is the heart of this study. My hopes are that experiences with contextual science research will help guide them, as novice teachers, towards
praxis with respect to their pre-conceived beliefs and practices about teaching and learning science.

Lather (1986) states, “For researchers with emancipatory aspirations, doing empirical research offers a powerful opportunity for praxis to the extent that the research process enables people to change by encouraging self reflection and a deeper understanding of their particular situations” (p. 141). I assert that teacher–researchers, immersed in a contextual science research experience, have a similar opportunity for praxis to the extent that the contextual science research assists the teacher to change his/her practices by encouraging self reflection and development of a deeper understanding of the science content and pedagogy used in a contextual situation.

**The Reality of the Classroom and Beliefs**

Toll, Nierstheimer, Lenski, and Kolloff (2004) describe the notion of the desire to “wash the students clean” (p. 164) in describing their urge to cleanse the teacher education students of the beliefs and practices they bring back from their field experiences. They describe their frustrations of having their reading education students leave their university classrooms with one set of ideas, which are constructivist-based, and then return from their K-12 classroom teaching field studies with completely different notions about teaching and learning. Toll et al. (2004) state:

In developing our own sense of the kind of teachers we wish to be—that is, how we want to do it right—we indirectly create a vision of the kind of teachers we wish for our [teacher education] students to be. This vision conflicts with our constructivist notion that our students will develop an emerging sense of themselves as teachers as they construct a meaningful understanding of theory and practice. (p. 171)

Toll et al. (2004) discuss how students come back from their field experiences complaining that their education professors had not prepared them for the reality of the classroom. To remedy their situation, Toll et al. use strategies such as using more discussions on the complexity of teaching and learning, providing different perspectives, story-telling, and brainstorming to avoid the “danger of oversimplifying” (p. 175) the classroom experience.

**Empathy**

In the following section, I offer a definition of empathy and then explain how I believe that this empathy can help catalyze teacher change. I know this happens for practicing teachers, as it did in my own teaching, but will this work for novice teachers?
**What is Empathy?**

How do I define empathy? Abell (1999) describes the notion that some of the trustworthiest knowledge comes from personal experience as opposed to the voices of authorities. Abell (1999) states, “[t]o appreciate difference one uses one’s own experiences and empathy as a bridge” (p. 183).

Empathy equates with compassion. When a teacher develops empathy for his/her students, there is an element of compassion. Banner and Cannon (1997) say that, “[c]ompassion is therefore inherent in teaching because some teachers share with their students a sense of frustration, regret, and pain at the difficulties and struggles that they must undergo to learn” (p. 82). Banner and Cannon also have sharp criticism for teachers who lack compassion, as they assert that teachers who cannot accept compassion in the classroom, who resist sympathy, or who prefer to teach from a exclusively intellectual perspective, should not teach. I tend to agree, although I am sure there are excellent instructors who do not necessarily have compassion, or show empathy for their students. However, my focus is on the teachers of middle level students and such students have unique needs (Irvin, 1992).

To further reflect upon my own personal experience, which catalyzed teacher change in my own classroom practices, I include existing research on how participating in science research can directly influence the classroom by providing the teachers with the opportunity to experience learning science in a laboratory setting where there are no pre-conceived answers and where they must experience failures, as well as successes. Ideally, participation in contextual science research places the teacher in the role of learner, experiencing both the frustrations and successes of learning. Experiencing the type of authentic learning that occurs in a contextual situation might initiate the evolution of teachers’ beliefs towards a more constructivist-based epistemology. It is my belief, based upon personal experiences and the research of others (Tobin & Tippins, 1993; Roth, 1994; Gilmer, 1997), that constructivist teachers view the development of their own knowledge at the individual and social interactive level and see the learning of science as a process of change. Therefore, we become more sensitized to students’ alternative constructions. This relates to a type of empathy as a learner.

I believe that empathy compels science teachers to provide more opportunities for students to learn in a contextual environment, rich in constructivist-based pedagogy, and inquiry-based hands-on experiences. According to the NSES (NRC, 1996, 2000), these are the very types
of activities that students need to excel in science. I (Hahn, 2002) discuss empathy in my chapter from the SERC@SERVE monograph, when I assert, “teachers can develop empathy from being a learner through their science research experience” (p. 77).

In discussing adolescent mood swings, Mendes (2003) says, “When I remember these mitigating factors, I feel more empathy” (p. 58). I believe that he is saying that he remembers what it is like to be an adolescent; and therefore, he can feel empathy for his students. Because of adolescents’ propensity towards mood changes and hormonal imbalances, any experience that can instill empathy in the prospective middle school science teacher should prove to be of value.

Educators who try to understand schooling through students’ eyes are the ones who are more responsive to the needs of their students. Listening to students and gaining empathy promotes teachers’ growth as educators and learners. From my own experiences, I find that the teachers who participate in scientific work experiences develop a type of empathy for their students because they must assume the role of learner in a new situation, just like their students. By empathy, I mean that these teachers experience many of the same frustrations that students experience when confronted with a new learning situation. Mendes (2003) says that empathy can serve many purposes for the teacher. He believes that viewing a situation empathetically can lead to a calmer internal state.

In his study of teaching in an urban school, Tobin (2000) gains empathy for his science education college students by immersing himself in a teaching situation in an urban high school. He says of his experience, “Now, I cannot imagine teaching a science methods course without having an active classroom in which to show what can and cannot be accomplished…” (p. 104). Therefore, I ask this question, “How can science teachers teach science to students without ever having done science?” While this is a rhetorical question, it does give us pause.

Empathy as a Catalyst for Teacher Change

Teachers can read, again and again, about the positive experiences others have gained from science research experiences, but what will make them put beliefs into practice? In my opinion, based on my own experience, it takes some intrinsic motivation and a desire to make the extra effort. However, what will catalyze that motivation and transformation?

The significance of scientific research experiences for pre-service or in-service teachers, and ultimately their students, is that such an experience could provide the teacher with the opportunity to become a learner once again and to experience both the frustrations and
excitement of learning. This results in the formation of empathy as a learner and can aid in the transformation of the teacher changing towards a more student-centered classroom. It is my strong personal belief that teachers will “teach the way that they were taught” (Macala, 2003, p. 1) and that they might develop some empathy for their own students when faced with similar emotions. In addition to working with a scientist, the students of participating pre-service teachers have the advantage of having a science teacher who has worked in a science setting. Gilmer (1999) describes this as the process of *doing* science. The frustrations, questions, and often-intimidating experiences further enable the teacher to share empathy with his/her students.

**In Summary: “Practice What You Teach”**

An early immersion into science research could provide the novice teacher with more confidence as he/she enters the classroom full of new ideas and awareness about the culture of science, constructivism, contextual learning in science, inquiry-based hands-on science, community resources for the classroom, science and mathematics connections in the classroom, science content knowledge, and PCK in science teaching. The intent of this dissertation is to follow two teacher participants, who, as pre-service teachers, experienced scientific research as part of their teacher preparation programs. As they begin their teaching careers, this follow-up involves studying what influences, if any, these experiences have on the beliefs and teaching practices of the novice teachers. As Silverstein (1999) states, “Perhaps someday our program’s slogan, ‘practice what you teach,’ will have meaning for all teachers” (p. 9). I interpret this to mean that if you *teach science*, then you should at some time, *practice science*.

So why not begin this *practice* of science in teacher preparation programs?
CHAPTER 3: THEORETICAL FRAMEWORK, METHODOLOGY, AND EVALUATION

Restatement of Research Questions

In this study, each participant experiences the role of teacher, learner, and science researcher within the contextual learning environment of an experiential science research course. Within the context of science, the teacher participants immerse themselves in the culture of science through their interactions with scientists. The context involves using the equipment of science to carry out procedures, using the language of science to converse with others to conduct the research, and using analytical thinking skills to make sense of the research. Within the context of the science classroom, the novice teacher participants immerse themselves in the culture of the classroom science, as it currently exists. As a doctoral student, I carry out observations, interviews, and E-mail discussions to observe any significant changes that emerge through the hermeneutic dialectic discourse within this group of co-learners in order to address the following research questions:

1. What are the beliefs towards the culture of science and the culture of science in the classroom of a novice science and a novice mathematics teacher after completing a constructivist-based, contextual science research course?

2. What are the classroom practices of these novice teachers after completing a constructivist-based, contextual science research course with respect to:
   a. implementing constructivist-based, contextual science methodology in their own classrooms?
   b. forming collaborations with scientists and the science community?
   c. integrating science and mathematics in the classroom?
   d. implementing inquiry-based, hands-on science activities?

3. After completing a constructivist-based, contextual science research course, what are the influences on the novice teachers’ constructions of (a) science content knowledge and/or (b) pedagogical content knowledge?
The intent of this research is to examine how two novice teachers who have experienced scientific research as pre-service teachers are bringing critical pieces of their experiences into the classroom. According to Hines and Mussington (1996), when pre-service science teachers have an opportunity to contextualize their learning and apply their knowledge prior to student teaching, they become more reflective teachers who are more comfortable with critical examination of educational issues.

Theoretical Framework

In this section I discuss my theoretical framework for teaching and learning, which is that of constructivism, more specifically, social constructivism. I view constructivism as a way of thinking about teaching and learning, a theory of knowledge or epistemology. Learning, according to the constructivist epistemology, is the acquisition of knowledge by an individual as he/she constructs and interprets his/her prior experiences, blended with new experiences he/she encounters.

Tobin et al. (1990) assert, “To learn science from a constructivist philosophy implies direct experience with science as a process of knowledge generation in which prior knowledge is elaborated and changed on the basis of fresh meanings negotiated with peers and the teacher” (p. 7). This implies that through social interactions there are new, or “fresh,” ideas to be encountered by individuals. Linn and Burbules (1993) find that collaborative groups are successful in brainstorming activities for problem solving, building on the ideas suggested by others, and engaging in co-construction of knowledge.

Dana and Davis (1993) state, “As one considers the pedagogical implications of constructivism, the focus of teaching moves from proficiency at content delivery to assisting individuals in their interpretations of concepts” (p. 328). In other words, teachers whose teaching styles reflect the constructivist epistemology provide their students more collaborative learning, more student-centered instruction, less teacher-centered instruction, and more student involvement in the activity of learning.

Based on data that supports the notion of collaborations, such as those that highlight my study, I choose social constructivism as the theoretical framework for my study. Cultural-historical activity theory allows me to take constructivism one step further because it provides an organized way to more critically examine the pieces of my study and the way they interact. Through cultural-historical activity theory, I am able to view constructivism as it occurs in my
study in a more organized and multi-layered construct. This view helps me to see the contradictions and coherences in my study, as well as the other critical pieces.

**Constructivist Epistemology**

The theoretical framework of this study is that of a constructivist epistemology. Constructivism emphasizes that knowledge cannot be separated from knowing (Glasersfeld, 1989). In constructivism, science knowledge is not something that teachers possess and transfer to children through lecture, the reading of textbooks, and paper and pencil activities. Instead, students construct science knowledge to make sense of their world. Students construct their own meaning based on their past experiences, and words or visual images they hear or see.

My rationale for placing pre-service science and mathematics teachers into a contextual research experience is that I believe that an immersion into the culture of science will allow them to experience first-hand the learning of science in a constructivist-based setting. The goal is to place them in the role of learner as though they were students experiencing a new learning situation.

My belief is that this is a positive learning experience that promotes the development of empathy as a learner. This may catalyze the novice teachers to engage in a transfer of experiences in their classrooms, thereby including more constructivist-based pedagogy, as well as contextual learning experiences for their own students. Providing the teachers the opportunity to construct their own learning in a constructivist-based, contextual learning environment allows them to not only learn science content, but to experience PCK in science. Prior to their participation in the contextual science research course, their exposure to constructivism and contextual learning were most likely in the form of terminology discussed in their pre-service teacher program.

**Cultural-Historical Activity Theory**

According to Engeström and Miettinen (1999), *cultural-historical activity theory* recognizes two basic processes operating continuously at every level of human activities: internalization and externalization. *Internalization* relates to reproduction of *culture*, and *externalization* refers to creation of new artifacts that makes this reproduction or transformation of culture possible. Since the reproduction of the *culture of science* into the *culture of the classroom* is a critical component of my study, I felt that the cultural-historical activity theory was an appropriate model to help me critically look at the many components involved my study.
Figure 3-1 illustrates the cultural-historical activity theory model. The objective is for the subjects to go to their objects and then to their outcomes. The other four components: tools, rules or schemas, communities, and division of labor, may provide coherences or contradictions for the subjects to reach their outcomes. All points of the triangle interact and influence each other. I apply the cultural-historical activity theory model to my research to see if it is a useful model for analyzing my outcomes. Figure 3-1 makes for an easier understanding of the flow within the cultural-historical activity theory model and of how each critical component of the study interacts with the others. The constructions are not simply one-dimensional. There are multiple layers interacting; some contribute to success, while others hinder the progress towards the outcomes. In Chapter 10, I discuss more on cultural-historical activity theory and how I used it specifically for my study.

Figure 3-1. Cultural-historical activity theory model diagram.

The outcome of my study was to see how placing a pre-service mathematics and/or science teacher within a contextual research experience provides an opportunity for teachers to engage in science research and to see how it positively influences their teaching practices, to allow for the participants to gain:

1. a better understanding of how innovative teaching practices can help bring the culture of science into the classroom;
2. experience with constructivist-based and contextual learning, and incorporate the appropriate teaching styles into his/her own classroom;
3. access to scientists and the science community to form collaborations in the classroom;
4. experience with integrating science and mathematics and implement these in the classroom;
5. experience with inquiry-based, hands-on activities, and implement these in the classroom; and
6. science content and pedagogical content knowledge with respect to teaching science and/or mathematics.

Engeström (1999) states, “an activity system is by definition a multivoiced formation” (p. 35). Because I involve the voices of many participants, I find using cultural-historical activity theory helpful in my study. Additionally, I give much attention to these voices, as they are relevant and critical in the qualitative analysis of the interpretive case studies highlighted in my dissertation.

Methodology: Conducting a Qualitative Study

In this section, I explain why I elect to conduct a qualitative study for my doctoral research on the influences of contextual science research on the beliefs and practices of novice science and mathematics teachers. I also describe the critical pieces involved in conducting a qualitative study and how they pertain to my own study. The evaluation methods of fourth generation evaluation (Guba & Lincoln, 1989; Schaller & Tobin, 1998; Lincoln & Guba, 2000) align with the ideals of a qualitative study (Erickson, 1998; Denzin & Lincoln, 2000); therefore, I chose these methods for my study.

Qualitative Methodology

I prefer a qualitative methodology for my study, in contrast to the more positivist quantitative methodology, because it adheres more to the tenets of the constructivist theoretical framework. According to Tobin and Tippins (1993), from a constructivist perspective, scientists do not collect data; but rather, they construct by using personal theoretical frameworks, gained through experience, that have the greatest salience to their goals. Because of my personal experiences and my preference for the constructivist epistemology, I believe that using a
qualitative study is more consistent with my beliefs about teaching and learning. In support of qualitative studies, Lincoln and Guba (2000) assert:

Human phenomena are themselves the subject of controversy. Classical social scientists would like to see “human phenomena” limited to those social experiences from which (scientific) generalizations may be drawn. New-paradigm inquirers, however, are increasingly concerned with the single experience, the individual crisis, the epiphany or moment of discovery, with that most powerful of all threats to conventional objectivity, feeling and emotion. (p. 179)

This quote evokes very strong emotions, as my own immersion into science research, which I describe as an “epiphany” in Chapter 1, was a very critical “moment of discovery” as I realized I was doing science for the first time in my life as a science teacher. I believe that the only times I had done science was as a child observing nature and experiencing the wonder of science. It was also at that moment that I realized that this could be a wonderful experience for pre-service teachers, as well.

Guba and Lincoln (1989) refer to three different approaches to considering the quality of a fourth generation, or any constructivist inquiry. These three approaches include: (1) Parallel Criteria, or the Trustworthiness Criteria, (2) The Hermeneutic Process for Quality Control, and (3) The Authenticity Criteria.

*The Parallel Criteria (Trustworthiness)*

To refer to the overall quality of a piece of research Guba and Lincoln (1989) use the term *trustworthiness* of research. Guba and Lincoln (1989) argue that all inquirers show concern about these general standards of trustworthiness, but the meaning of each standard, the nature of threats, and the means of minimizing them will be distinctly different within the positivist versus the naturalistic paradigm. Trustworthiness includes four criteria, called the parallel, or foundational, criteria because they are parallel to the positivist reliability criteria. These are: *credibility* (which has six subcategories), *transferability*, *dependability*, and *confirmability*.

*Credibility.* Credibility parallels the internal validity of a conventional positivist study. Guba and Lincoln (1989) recommend the following six methodological procedures to ensure credibility: prolonged engagement, persistent observations, peer debriefing, negative case analysis, progressive subjectivity, and member checks.

This dissertation study emerged from my involvement, from conception to fruition, in a pilot study. In this study, I followed two of the pilot study participants through their first and second year of teaching. For prolonged engagement, I maintained continuous contact with the
participants through E-mails; I observed the participants in their research laboratories and field studies; I assisted the participants on preparing a chapter published for a monograph; I observed their classrooms periodically for their first year of teaching; I observed their classrooms for regular intervals during their second year of teaching; and I conducted personal interviews throughout that same year. In other words, I believe my immersion into the culture of science and the culture of the classroom is a sufficient amount of time for me to interpret what was happening with respect to my research questions.

As issues emerged, persistent observation became increasingly important as I sought to identify those issues that had the most relevance to my study. Peer debriefing was also very important in my study, as I was in frequent communication with my major professor and, to a lesser extent, with other peers who were involved with their own doctoral studies, for advice and suggestions on questions that began to emerge with respect to the study. I used negative case analysis when events occurred that were not anticipated, or did not fit. This occurred when some of the participants’ beliefs did not match their actions. For example, Cathy continues to discuss how she plans to bring scientists into her classroom for various collaborations, however, she failed to demonstrate such collaborations throughout the duration of my study. I will discuss more on this in Chapter 10.

Because I had completed the pilot study with some encouraging results, there were some questions from my doctoral committee that I might “see what I wanted to see” in this follow-up study. Therefore, progressive subjectivity became critically important. As the study progressed, the participants began to discuss what was happening in their classrooms, and I became increasingly aware that I was not seeing exactly what I wanted to see. I was hearing that the participants were going to use more inquiry-based hands-on science lessons, but what I was seeing was mostly traditional textbook-based lessons involving little hands-on science.

Member checks with the participants were vital to the study as the voices of my participants were of critical importance in this interpretive study. I came to greatly appreciate their willingness to participate in this continued study without any compensation. Their time and efforts were of great value to my study; therefore, ensuring that their voices be heard was of critical importance. At times, there were interruptions in the flow of communication due to the busy lives of the participants. Through the convenience and ease of electronic mail, I sent texts of observations and interviews to the participants to provide them with the opportunity to reflect
on their comments and correct any misunderstanding or misinterpretations on my part as the researcher. One problem was participant involvement. There were many occasions in which I was unable to get responses from my participants. My major professor was able to offer suggestions to remedy the situation.

Transferability. Guba and Lincoln (1989) substitute the positivist idea of generalizability with transferability. In other words, can findings from this study transfer to the readers’ research or work? In qualitative case studies, the researcher can also generalize, but it is more likely that the reader will be the one to determine whether the research findings fit the situation. Akin to a good storyteller, the researcher might say something like, “This is what I did and this is what I think it means, does it apply to your situation?” I think of the classic fairy tales and stories of virtue that I read to my son. We talk about how it may relate to our own lives, and what we can do differently to change our behavior.

A university professor and/or researcher who considers offering experiential science courses for pre-service science teachers might find the results of this study valuable in his/her own planning. His/her interpretation of the findings might determine how that information could be useful in the design and evaluation of a teacher preparation course. That is part of the beauty of an interpretive study.

Dependability. “Dependability is parallel to the conventional criterion of reliability, in that it is concerned with the stability of the data over time” (Guba & Lincoln, 1989, p. 242). Due to the maturing and changing constructions of the participants, changes that occur due to the emergent nature of this type of methodological study are acceptable. In fact, “far from being threats to dependability, such changes and shifts are hallmarks of a maturing—and successful—inquiry” (p. 242). In a quantitative or conventional study, statistical changes might be considered unreliable. However a qualitative study, such as my study, allows, and in fact hopes for, participants to transform their beliefs and practices, and therefore the data may change over time.

Confirmability. “Confirmability may be thought of as parallel to the conventional criterion of objectivity” (Guba & Lincoln, 1989, p. 242). Use of the hermeneutic dialectic circle helps to ensure confirmability, as well. As I interviewed and observed the participants, I used electronic mail or further interviews to confirm my interpretations of their responses. I did this when analyzing their writings, as well. Confirmability assures that the data, interpretations, and
outcomes derive from the stakeholders and are “not simply figments of the evaluator’s imagination” (p. 243). This is the criterion that has to do with researcher bias, which I address later in this chapter.

To minimize researcher bias in my interpretations, I took my major professor and committee’s advice to try to remain objective even though I have strong opinions about this study due to my own experiences. However, I am human, and my study involves understanding human emotions, so I felt comfortable in retaining my bias for contextual science research and its benefits for science and mathematics teachers. In spite of this, to keep my focus on the novice teachers, I constantly reminded myself that as a practicing teacher my prior knowledge and experiences were far different from my participants. I also employed the use of a journal, not only to write down what the participants were doing, but also to help me organize my own thoughts about what was happening. This helped to maintain my focus on the novice teachers.

**Hermeneutic Process of Quality Control**

Guba and Lincoln (1989) recommend using a hermeneutic process to insure quality control of a qualitative study. Hermeneutic refers to the process of being dialectic and interpretive in character because it involves comparing and contrasting the divergent views of the stakeholders in an effort to reach a consensus, or, at least, to achieve a higher level of understanding for all stakeholders. I discuss the specific criteria and methods of carrying out a hermeneutic process in this section.

**Quality control criteria: the hermeneutic process.** Using the following quote as a reference point, I adopted the hermeneutic methodology for my study:

> The methodological question is answered by adherents of the constructivist paradigm by asserting that the inquiry must be carried out in a way that will expose the constructions of the variety of concerned parties, open each to critique in the terms of other constructions, and provide the opportunity for revised or entirely new constructions to emerge—a hermeneutic methodology. (Guba & Lincoln, 1989, p. 89)

In other words, all stakeholders’ constructions “are laid on the table” (p. 244). The constructions confront challenges, criticisms, and feedback from other participants, including myself. I did this through electronic mail and interview sessions. I encouraged the participants to clarify any misinterpretations of their words and/or actions in the classrooms that are reflected in their writings, observations, and/or interviews.
Occasionally, there were some gaps in communication as participants, including myself, became busy with other parts of their daily lives. This created some frustrations, but through perseverance, I brought these gaps eventually back to full circle, as I was determined to complete my study.

The hermeneutic/dialectic circle. The hermeneutic dialectic circle, which is the heart of the constructivist-based methodology, can be empowering for stakeholders. In the hermeneutic dialectic circle, an open process of communication occurs among the stakeholders who each hold certain constructions of knowledge. Are stakeholders willing to share, discuss, compromise and negotiate towards a consensual agreement? As previously mentioned, this poses a problem at times with some of the participants’ lack of accessibility due to busy schedules. Guba and Lincoln (1989) state the goals of the hermeneutic dialectic process, which accurately describe my experience:

Nevertheless, the major purpose of this process is not to justify one’s own construction or to attack the weaknesses of the constructions offered by others, but to form a connection between them that allows their mutual exploration by all parties. The aim of this process is to reach a consensus when that is possible; when it is not possible, the process at the very least exposes and clarifies the several different views and allows the building of an agenda for negotiation… All parties are thus simultaneously educated (because they achieve new levels of information and sophistication) and empowered (because their initial constructions are given full consideration and because each individual has an opportunity to provide a critique, to correct, to amend, or to extend all the other parties’ constructions). (p. 149)

In other words, an absolute answer may never be found, but the goal is to continue to improve the construction, and allow all stakeholders to participate in this on-going study, regardless of minor difficulties with accessibility of some participants. Thus, the term interpretive research is a very appropriate one, as I, along with the stakeholder participants, continue to interpret and make sense of what is happening because of the participants’ immersion into contextual science research. Applicability to the study at hand emerges, as each participant shares his/her constructions. With a quantitative study, sometimes the numerical results may make little sense in terms of what happens in the minds of the participants. A qualitative, interpretive study allows us to look into the thoughts of the participants, and it gives each stakeholder a voice.
Authenticity Criteria

I find fairness and the four types of authenticity criteria to be critical to my study, as these criteria are very applicable to my research questions. The authenticity criteria include ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity.

Fairness

According to Lincoln and Guba (2000), fairness is a quality of balance; that is, all stakeholder views, perspectives, claims, concerns, and voices should be apparent in the text. Omission of stakeholders or participants’ voices is a form of bias. In Guba and Lincoln (1989), “fairness refers to the extent to which different constructions and their underlying value structures are solicited and honored within the evaluation process” (pp. 245–246).

Throughout this study, I focused on two participants, my stakeholders, who are now novice teachers. I included as many reflections, constructions, concerns, and beliefs from my stakeholders, including myself, as I believe they are important. I stressed fairness during every communication, as I encouraged all stakeholders to share their opinions, offered suggestions, and sought affirmation of their ideas. For the pilot study, I conducted this through open discussions and we shared ideas among the different teams. Generally, one person from each team of participants served as the liaison between the teams and me. I was careful to stick to the topic at hand and not make personal comments concerning individual participants. For the follow-up study, I communicated with each of the two novice teachers on a one on one basis.

Ontological Authenticity

Ontological authenticity refers to the extent to which we improve the individual, or group’s constructions. The use of reflective writings, journal entries, and individual responses during interviews helped me to determine this type of authenticity. These tools were a critical part of this study as they helped me to interpret what influences that involvement with contextual science research experience had on the participants with respect to his/her beliefs about the culture of science, the culture of classroom science, and science teaching practices. Additionally, I encouraged the participants in my study to transform their required writings for the course into chapters for an educational monograph for the SERC@SERVE. These chapters were a collaborative effort on the part of the pre-service teachers who became novice teachers, my major professor, Penny J. Gilmer, and me. Throughout a shared editing process, the CO-
LEARNERS continuously improved the chapters for publication. My two teacher participants’ chapters are found in Chapters 6 and 7 of this dissertation.

**Educative Authenticity**

“Educative authenticity represents the extent to which individual respondents’ understanding of and appreciation for the constructions of others outside their stakeholding group are enhanced” (Guba & Lincoln, 1989, p. 248). To help establish educative authenticity, SERC@SERVE published the monograph, *Experiential Learning for Pre-Service Teachers: Applications to Secondary Classrooms* (Gilmer et al., 2002) in May of 2002. This monograph includes chapters, written by the pre-service teachers participating in this study, on the influence of their research experiences on their own learning. SERC@SERVE disseminated the monograph to university faculty who teach pre-service teachers in their methods courses.

**Catalytic Authenticity**

*Catalytic authenticity* refers to the extent to which actions become catalysts for change for the stakeholders. As I looked for changes in the participants’ beliefs and teaching practices, I hoped to find evidence of a catalytic change due to the participants’ involvement with the contextual science research course. In other words, did their immersion into the contextual science experience serve as a catalyst for teacher change?

**Tactical Authenticity**

*Tactical authenticity* refers to the empowerment of participants to act upon that what they want and/or need to act. Guba and Lincoln (1989) say, “It is not enough to be stimulated to action. It is quite possible to want, and even to need, to act, but to lack the power to do so in any meaningful way” (p. 250). In this dissertation, I focused on tactical authenticity as the now novice teachers began to teach in their own classrooms. The questions that arose: Will they act upon their beliefs? Will they “teach the way that they were taught” (Macala, 2003, p. 1)? Will they teach the way that they have to come to believe is a good way to teach? Did their immersion into a contextual science research experience influence these beliefs and ability to put their beliefs into action through their classroom practices?

Another determining factor in tactical authenticity is the degree of empowerment that participants expressed during the evaluation process. I determined this through their writings, classroom observations, and interviews. I looked for evidence of *praxis*, as previously discussed in Chapter 2. To further encourage their empowerment, all participants understood that they were
a critical part of the team. I gave no part of the team a larger role than the others, as we were all equal learners in the process. Each contributed to the study in his/her own capacity.

Using Qualitative Case Study

As two of the pre-service teachers who participated in the pilot study began teaching in their own classrooms, I focused on the influences that their contextual science research experiences may have had upon their beliefs about science and/or mathematics teaching and their teaching practices. Using the previously stated research questions, I narrowed my focus to the two participants from the pilot study, based on their geographic location, as well as their current teaching placements. Cathy and Rob were willing participants and were teaching science and/or mathematics at the middle school level during the time of my study.

Denzin and Lincoln (2000) define a qualitative case study as being “characterized by researchers spending extended time, on site, personally in contact with activities and operations of the case, reflecting, revising meanings of what is going on” (p. 445). I spent as much time in the classrooms as I felt was necessary without infringing upon the teachers’ responsibilities as a classroom teacher. Their job as a teacher remains a priority over their role as a research subject. I am very respectful and conscientious of this at all times. As a classroom teacher myself, I understand how valuable planning time, as well as down time are to a teacher.

I kept a reflective journal of all communications, including E-mails to my teacher participants and my professor, related to this study. On keeping a journal, Meloy (1994) writes:

A journal provides a solid link to the many simultaneous levels of experience that are involved in the process of qualitative research. It can provide a place where the research focus and the role of the researcher meet methodological and analytical concerns. It can be a place to make explicit questions and concerns for later answering and organizing; a journal can hold your heart. (p. 60)

As previously mentioned, I include the summer research experiences of the two teacher participants as chapters in my dissertation. Their experiences represent the two case studies that I have chosen to focus on in my research.

I understand that the experiences of these two teachers may differ greatly from many others novice teachers; however, they do represent excellent examples of a typical transformation from pre-service to novice teacher. I feel that there is much to learn from these two individuals, with respect to my study. These two individual teachers have very different
backgrounds and prior experiences, and I anticipate that the influence of the contextual science research may reflect these differences.

In describing case studies, Kvale (1996) states:

The case study is an exemplar. In the present understanding, the use of exemplars is not a mere popularization of theoretical points or putting some “flesh on the statistical bones” of a study. Rather, the case has its own value as an exemplar: It can serve as a vehicle for learning…. (p. 273)

I believe that the voices of the two participants in my study can help others who are responsible for teacher education and in-service. All teacher participants will help others to learn as they speak with conviction about their experiences, both negative and positive.

Conducting a Qualitative, Interpretive Case Study

Stake (2000) describes a qualitative, case study as being “characterized by researchers spending extended time, on site, personally in contact with activities and operations on the case, reflecting, revising meanings of what is going on” (p. 445). This is the type of study that I conducted. I initially began working with the two novice teachers in this study, along with others, as part of the pilot study. In total, I worked with Cathy and Rob for five years.

My initial contact with the participants began when I met with a group of students interested in the contextual science research course. Following the initial meeting, I helped the pre-service teachers who opted to enroll in the course with registration for the contextual science research course as part of the FCETP study. After registration, I met with the pre-service teachers, the practicing teachers, and some of the science researchers, as a collaborative group, to discuss what direction the CO-LEARNERS study would take. We met two more times before the contextual research began.

During the summer(s), I observed their research in the laboratories and in the field. After the completion of their science research course, I observed them once in each of their practicum experiences and maintained contact with them through the completion of their teacher preparation program and internships. Once they began to teach in their own classrooms, I worked with each of them during their first year of teaching, as I assisted them with writing their chapters in the SERC@SERVE monograph. I then followed each of them into his/her second year of teaching, conducting observations and interviews. Working with Rob and Cathy for five years, I fulfilled one of the requirements of conducting qualitative case studies.
Stake (2000) says, “The purpose of a case report is not to represent the world, but to represent the case” (p. 448), and in this study, two cases. The two teachers were very different from one another, and yet there were similarities in the findings. Each case represented itself for the sake of the uniqueness of each of the participants. Rob, after serving in the military, began his second career by entering the teaching profession in his fifties. Cathy, on the other hand, represented a typical early twenties college graduate entering the teaching profession.

While each case study reflects the individual’s experience involved, the implications for other novice teachers are there. The stories of these two teachers might prove beneficial for future novice teachers who may wish to enroll in a contextual science research course. A professor who is interested in developing such a course might find these case studies of value as they can read what worked and what did not work.

**Qualitative Analysis of the Participants’ Voices**

While I use quotes and writings from other participants in the pilot study, I only analyzed the writings and interviews of the two participants using the QSR (Qualitative Software Research) NVivo software to look for emerging patterns on the issues related to my research questions. Using all of the qualitative data (e.g., journal writings, E-mails, classroom observations, published writings, and transcribed interviews), I critically look for patterns, as well as the quality of the events as they relate to my research questions. The QSR NVivo software program makes the collection and analysis much more accessible, as I organize the data into data trees with branches and sub-branches (See Table 3-1).

Much like the way a graphic organizer helps to organize branches, this software design helps me organize this qualitative data into an interpretive writing and allows for feedback from my participants for member checks. The software design also helps to facilitate my interpretive analysis by providing me with coherences, as well as contradictions.

**Qualitative Analysis Using QSR NVivo Software**

I use the QSR NVivo software to categorize issues the participants discussed in their papers, interviews, my observations of the teachers in the classrooms, and electronic correspondence. I sort the data based upon my research questions. I look for patterns in what the participants did in their classrooms, what they have said in interviews and E-mails, and what they have communicated in their writings. I sort the data into data trees using the QSR NVivo software to help me to organize the participants’ thoughts and actions. This organization allowed
me to look for patterns in the data and determine the quality of the evidence of “influence” that the scientific research experience may have had on the participants.

Data Collection

To assist me with organizing the language from the text that I transcribed from the observations, interviews, and writings of the participants, I use the following categories, which derive from pertinent language in my research questions. In Table 3-1, I list the “trees” or nodes, as the QSR language refers to them.

Table 3-1

QSR Node Listing

<table>
<thead>
<tr>
<th></th>
<th>Beliefs About Science Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning science is boring</td>
</tr>
<tr>
<td></td>
<td>Learning science is fun</td>
</tr>
<tr>
<td>2</td>
<td>Collaborations</td>
</tr>
<tr>
<td>3</td>
<td>Collaborations</td>
</tr>
<tr>
<td>4</td>
<td>Science Research</td>
</tr>
<tr>
<td></td>
<td>Contextual learning</td>
</tr>
<tr>
<td></td>
<td>Culture</td>
</tr>
<tr>
<td></td>
<td>Mathematics and Science Connections</td>
</tr>
<tr>
<td></td>
<td>Perception of the scientist</td>
</tr>
<tr>
<td>6</td>
<td>Perceptions of Science</td>
</tr>
<tr>
<td></td>
<td>Science content knowledge</td>
</tr>
<tr>
<td>7</td>
<td>Teaching Practices</td>
</tr>
<tr>
<td>8</td>
<td>Contextual learning</td>
</tr>
<tr>
<td>9</td>
<td>Experiential learning</td>
</tr>
<tr>
<td>10</td>
<td>Hands-on science</td>
</tr>
</tbody>
</table>

In Table 3-1, I list the “trees” or nodes, as the QSR language refers to them.
Table 3-1—Continued.

| 4.3.1 | Engaging students |
| 4.3.2 | Laboratory skills |
| 4.3.3 | Observation skills and visual learning |
| 4.3.4 | Questioning in science |
| 4.3.5 | Scientific method |
| 4.4 | Learning science is hard |
| 4.5 | Making science fun and interesting |
| 4.6 | Meaningful science |
| 4.7 | Pedagogical content knowledge |
| 4.7.1 | Lecture-driven |
| 4.7.2 | Textbook-driven methods |
| 4.8 | Real-life science |
| 4.8.1 | Students’ stories |
| 4.8.2 | Voice |
| 4.9 | Service learning |
| 5.0 | Teaching inquiry in science |

Evaluation

*Using Fourth Generation Evaluation*

To better organize the evaluation of my study to consider the quality of *goodness* of a fourth generation evaluation, in Table 3-2, I adopted the twelve steps based on the fourth generation methods described by Guba and Lincoln (1989). I utilized these steps to ensure the parallel criteria (trustworthiness), and the quality control of a hermeneutic dialectic circle, and to address results related to the fairness and authenticity criteria. I used these twelve steps to evaluate the pilot study and the doctoral research. For the doctoral study, I also employed the use of the QSR NVivo software for data analysis in Chapters 6, 7, 8, and 9.

Table 3-2

Fourth Generation Evaluation Summary

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Step One: Contract with stakeholders</td>
<td>I initiated a contract with sponsor(s):</td>
</tr>
<tr>
<td></td>
<td>I presented and discussed my prospectus with my major professor and members of my doctoral committee</td>
</tr>
<tr>
<td></td>
<td>After committee approval, I discussed the study with the pre-service teachers (now novice teachers to make sure that they agreed to participate in the follow-up study).</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td><strong>Step Two: Organize</strong></td>
<td>I made arrangements to begin the study:</td>
</tr>
<tr>
<td></td>
<td>I applied for Human Subjects approval renewal, which was approved.</td>
</tr>
<tr>
<td><strong>Step Three: Identify stakeholders</strong></td>
<td>Stakeholders included those who were at risk in the project. I formed an evaluation team:</td>
</tr>
<tr>
<td></td>
<td>The stakeholders in this study included the pre-service (now novice teachers), the teacher mentors, the research scientists and his/her organization or agency, FCETP (the granting agency for the pilot study), my major professor, my doctoral committee, and me as the doctoral student conducting the research. All of these stakeholders were a part of the pilot study, however; only two of the now novice teachers participated in the dissertation research.</td>
</tr>
<tr>
<td><strong>Step Four: Determine a method of evaluation and data collection</strong></td>
<td>The evaluation method is that of a hermeneutic dialectic process in which stakeholders were active in the evaluation. I only collected qualitative data in this interpretive study. I also use data from the Pilot Study. These data included:</td>
</tr>
<tr>
<td></td>
<td>Transcribed interviews in which I looked for emerging patterns related to the research questions within the text.</td>
</tr>
<tr>
<td></td>
<td>Qualitative analysis of participants’ reflective journals, E-mails, lesson plans and lessons taught, other writings, and other forms of communications.</td>
</tr>
<tr>
<td></td>
<td>A personal reflective journal, which included analytical memos that I wrote during the study.</td>
</tr>
<tr>
<td></td>
<td>Published writings of the two now novice teachers based upon their experiences.</td>
</tr>
<tr>
<td><strong>Step Five: Encourage participation among stakeholders</strong></td>
<td>I strongly encouraged constructions from each stakeholder. We then discussed claims, concerns, and issues that stakeholders deemed important. In order to maximize the authenticity of the study and to ensure fairness among stakeholders, I encouraged all stakeholders to participate without the fear of becoming disenfranchised. I thoughtfully considered all ideas and suggestions for the betterment of future collaborations. In terms of social constructivism, this learning community enabled each participant to teach one another. This included feedback and suggestions from my committee during my prospectus defense.</td>
</tr>
<tr>
<td><strong>Step Six: Provide Circles for Discussion</strong></td>
<td>I conducted observations and interviews with teachers throughout the two years of the study.</td>
</tr>
<tr>
<td></td>
<td>During the first year of the study, I communicated regularly with each participant through E-mails and classroom visitations, and I assisted them in the writing of a chapter based on his/her summer research experiences.</td>
</tr>
<tr>
<td></td>
<td>SERC@SERVE published these chapters in a monograph. We discussed the first year of teaching in the chapters and in interviews.</td>
</tr>
</tbody>
</table>
During the second year of study, I visited the participating teachers’ classrooms once each week over a nine-week grading period and additional times throughout the year. I also continued to communicate with the teachers via E-mail and telephone.

Due to the busy lives and schedules of all participants, we used electronic mail to limit the amount of meeting times. E-mail, which all participants/stakeholders could easily accessed, was a critical part of the hermeneutic dialectic circle because it allowed the group to disseminate information on a regular basis, to express their opinions more openly, and to have easy communication.

I transcribed these observations and interviews and analyzed the text using the QSR NVivo software for ease with interpreting the “voices” of the participants.

Step Seven: Time for reflection
After I completed the classroom observations and collected all data, I allowed time for the novice teachers to reflect on their experiences and his/her role in the study. They provided feedback to me through E-mails and discussions.

Step Eight: Collecting information/adding sophistication
Stakeholders provided feedback in the form of what obstacles they faced, limitations that existed, suggestions for improvement, as well as what was effective.

I continued to look for current literature related to the study.

Step Nine: Prepare agenda for negotiation
To the novice teachers, I distributed my interpretations of their writings and asked them to provide me with feedback. Were my interpretations of what they are saying correct? Was I biased on my part as a researcher?

Step Ten: Negotiation
During set negotiation times, I met with my participants to discuss my interpretations of their writings, my observations, interviews, and other dialog.

Step Eleven: Reporting the results
We discussed the results of these meetings through personal E-mails. I shared a draft of the study findings and asked for feedback.

Step Twelve: Recycling
Due to the nature of fourth generation evaluation, new information and constructs continued to emerge as one of the teachers entered his third year of teaching. The other is on maternity leave.

**Ethical Issues**

**The Stakeholders**

Because this project involves the ideals of Guba and Lincoln (1989), this study takes place in a natural setting, i.e., the novice teachers’ own middle school classrooms. Stakeholders
actively participate in the learning process. The initial part of the study took place during the Pilot Study throughout the novice teachers’ pre-service science research experience in the science laboratory and field sites. Each participant signed an Informed Consent Form in which each agreed that his/her names would not be used in the study.

Using some of the guidelines from the Science FEAT Program (Spiegel, 1997), I adhered to the following ethical guidelines:

1. *Observe protocol*—Make sure that I informed all relevant persons and obtained all necessary permissions and authorizations. In the school district where much of the study took place, I required all parents to sign a permission slip at the start of the school year that allowed their child to be photographed or videotaped, if necessary, for the study. In addition, I followed the Human Subjects committee protocol and submitted an approval request (Appendix A). I received approval from Human Subjects on April 29, 1999 (Appendix B) and renewed my Humans Subjects Approval each year.

2. *Maintain confidentiality*—I assigned all teachers and science researchers pseudonyms in the research in the writing of the dissertation.

3. *Negotiate*—With the establishment of a learning discourse community, the project allowed for ample negotiations among the stakeholders, the CO-LEARNERS, in this study.

**Researcher as Participant**

As a graduate research assistant on the pilot study, which was a grant funded project, I also served in the capacity of the Principal Evaluator of the Middle School Pilot Study, as well as for this follow-up study. Because the project was my own conception, I used what I studied and learned for the basis of my doctoral dissertation. I became not only a “co-learner,” but also a doctoral student.

During the course of my doctoral program, I presented several papers dealing with contextual learning at science teaching conferences (Hahn, 1999; Hahn, 2000; Gilmer & Hahn, 2000; Gilmer, Hahn, Herr, Lederman, Schwartz, & Westerlund, 2001). I also wrote a chapter (Hahn, 1999), published in the SERVE monograph: *Meaningful Science: Teachers Doing Inquiry+ Teaching Science*. My chapter dealt with my own contextual learning experience in 1996 and how it inspired my own teaching, and beliefs about teaching and learning. I also served
as co-editor and author in the SERVE monograph (Hahn, 2002), *Experiential Learning for Pre-Service Teachers: Applications to Secondary Classrooms*, which was an evaluative project that focuses on several participants of the CO-LEARNERS project (Gilmer et al., 2002).

Based on my own constructions of a fourth generation evaluation, this study is still ongoing, continually seeking improvement, and welcoming all ideas, suggestions, and comments. This is, after all, an attempt to improve the teaching and learning of science in the classroom by “making connections” to those who are directly responsible for the delivery of science. This is of critical importance to me, not only as a new researcher, but also as a teacher of science.

**Researcher Bias**

Because my own experience with contextual science research was so powerful, I hold a strong bias that this would be the case for my two teachers. My bias is in the form of my passion for contextual research and how it can positively influence science teachers in their classroom practices. I equate this type of bias with a teacher showing enthusiasm for learning science in the classroom. I initially believed my bias would be a limiting factor, but due to the nature of a qualitative study and to a paper by Heshusius, I now believe that it is a strength.

Heshusius (1992) describes the notion of *participatory knowing* as an ethical act that helps to eliminate any power struggles between the researcher and the participants. “When one becomes embedded in what one want[s] to understand, to the point of forgetting oneself, there is a sense of equality that no longer allows for privileged status of any kind” (p. 21). In other words, study participants are no longer “someone you can bombard with questions” (p. 22). Heshusius (1992) states:

> But more than anything I tell them, [students enrolled in a qualitative research methodology course] they need to attend fully, not forcing a separation between their cognitive, affective, and somatic knowing, to see with empathy, to ask with true concern and care, in other words to merge more and identify more. (Heshusius, 1992, p. 25)

My relationship with my participants is strengthened by my realization that as a practicing teacher, with 13 years of classroom teaching finally experiencing real-world science during my own contextual research experiences, my pre-conceived notions about science and science teaching are at a far different level than those of a novice teacher. Therefore, I understand that they possess their own set of pre-conceived notions about science and science teaching. Past experiences do influence the way we construct meaning from our newly acquired
learning and experiences. I understand that the revelations of the novice teachers might not be as powerful as my own, as the teachers are not as “jaded” as I had been. I was at a comfortable stage in my career with respect to tenure, confidence with my subject matter, and classroom management, but was looking for something that I felt was missing in my teaching. I recall my own experiences as a novice teacher, and the struggles associated with all of the demands and learning. This helps me to see “with empathy” (Heshusius, 1992, p. 25), retain the participatory element of my bias, and yet focus on my participants’ experiences to answer my research questions.

I do strongly adhere to the hermeneutic dialectic process allowing for member checks to ensure that I interpret the novice teachers’ voices correctly without my own personal bias influencing my interpretations of their experiences. Progressive subjectivity, as previously discussed, is of critical importance, as well. My journal helped me to record my thoughts and ensure that mine were separate from my participants’ thoughts.

As a human being, however, I will not deny my personal bias on this subject because of the impact contextual science research has had on my own teaching. The member checks with the hermeneutic dialectic circles, the progressive subjectivity and recording my thoughts in my journal help to prevent my voice from overshadowing those of my participants’ voices in my interpretive study. Their voices can be heard.

In Chapter 4, I describe the details and findings of the pilot study entitled, CO-LEARNERS. In Chapter 5, I discuss in more detail the Research Activities and how the Theoretical Framework and Methodology described in Chapter 3 support both the pilot study and this doctoral study.
CHAPTER 4: THE PILOT STUDY

“CO-LEARNERS”

The Concept

It was my strong belief that a team of “CO-LEARNERS” from education and science would be an ideal learning community for future science teachers. With this in mind, I conceptualized a project, which would become part of a NSF initiative to improve teacher education programs. CO-LEARNERS (Collaborative Opportunities: Learning Environments and Research uNiting Educators and Researchers of Science) was a pilot project of the Florida Collaborative for Excellence in Teacher Preparation (FCETP, 2002). FCETP was a statewide initiative funded by the NSF. FCETP sought to improve science and mathematics teacher preparation programs across the state of Florida through collaborations with community colleges, universities, secondary schools, and other agencies.

The recruitment, retention, and professional development of practicing science and mathematics teachers were goals of the FCETP, as well. Through CO-LEARNERS, Dr. Penny J. Gilmer and I offered an experiential contextual science course to undergraduate teacher education students at two participating state universities. Practicing teachers and research scientists served as mentors for the pre-service teachers. We selected three teams of CO-LEARNERS at each site. At the university where I conducted my research, all practicing teacher participants were middle school science teachers. Practicing teacher participants at the other university were high school educators, with the exception of one middle level educator. The pre-service teacher participants were either prospective middle or high school science teachers, with the exception of one prospective mathematics teacher. All researchers of science worked either in a university research setting or at a state governmental agency. The science researchers voluntarily agreed to mentor the educator participants without pay. The practicing science teachers received a small salary, equivalent to the current in-service rate, at both sites. The pre-service teachers at one site received full tuition waivers and course credit for a science or mathematics elective for their participation. This was made possible by matching grant funds. At
the other site, there were no matching funds for tuition waivers, but students had the option of taking the course for credit at the regular tuition rate.

For their participation and completion of their research, the pre-service teachers received undergraduate course credit, which could be applied to their program of study requirements for an elective science and/or mathematics course. These aspects of the program made it unique compared with the others that are currently in existence.

The science researcher’s role was to mentor the practicing and prospective science teachers with respect to science content acquisition, expose them to the nature of science through the research, and provide them with an opportunity to become immersed in the culture of science. The practicing science teachers provided the prospective science teachers with pedagogical assistance in translating their summer research experience into classroom lesson plans. The prospective science teachers also helped practicing teachers with technology and other areas of strength. I coined the acronym, CO-LEARNERS, as each participant was to serve in the capacity of “learner” in this collaborative effort to assist pre-service teachers with gaining science content, experiencing science thus gaining insight into effective science pedagogy, and gaining access to the science community.

Significance of the Pilot Study

I designed the pilot study to provide pre-service teachers with an opportunity to experience actual, real-world scientific research. Bringing the practicing science teacher and science researcher into the learning community brought the cultures together for the pre-service teacher to understand the nature of science, experience the culture of science, and how to bring “science” into the classroom. The model for the CO-LEARNERS program placed each participant in the role of teacher, learner, and researcher in a “contextual learning” environment. My question for the Pilot Study was: What is the influence of science research experiences on pre-service science teachers’ (1) science content acquisition; (2) ability to compare the culture of science with the culture of classroom science; (3) access to scientists and the science community; and (4) experience with a type of constructivist-based teaching, through his or her own contextual learning experiences?

I evaluated the pilot study using a matrix (Appendix C) that I developed to assist me with the evaluation requirements of the NSF, because the pilot study was part of the FCETP grant funded by the NSF. It has been my experience that many science teachers have experienced
science only through textbooks and laboratories in “sterile” laboratory settings; they have never experienced true scientific research. I found this generally to be the case with the practicing teachers in the CO-LEARNERS program, as well.

While there have been other studies placing pre-service science teachers into science research, such as those discussed in Chapter 2 (Raphael et al., 1999; Melear, 2000; NHMFL, 2004), only the MCETP (Langford & Huntley, 1999; Ross & Denniston, 2002) program includes, and only when possible, a practicing science teacher in the collaboration with the pre-service teacher and the science researcher. Melear (2000) offers the research experience for course credit, but does not include a practicing science teacher in the collaboration.

My pilot study combined collaboration among the pre-service science and mathematics teachers, the practicing science teachers, and the science researchers in a contextual science research experience in which the pre-service teacher received course credit. After the summer research experience, the pre-service teacher then joined the practicing science teacher in a practicum experience in his/her respective classroom. This part of the collaboration brought the culture of science into the culture of the science classroom.

The Summer Research

I conducted my Pilot Study during the summers of 1999 and 2000 as part of the FCETP and the NSF Collaboratives for Excellence in Teacher Preparation (2002). Each summer, the CO-LEARNERS teams consisted of a pre-service science teacher, a practicing science teacher, and a science researcher (Table 4-1). The CO-LEARNERS teams collaborated on the research as assigned by the science researcher, for six to eight weeks with a time commitment of 20 hours per week. The schedules were flexible in consideration of the other commitments of all of the participants.

The Participants

The participants in the pilot study included pre-service middle school teachers, practicing, middle school science teachers, and science researchers. Pre-service teachers were undergraduate teacher education students who were studying to become middle level or high school science teachers.
Table 4-1

The CO-LEARNERS Teams

<table>
<thead>
<tr>
<th>Summer One</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Service Teachers</td>
<td>Practicing Teachers</td>
<td>Science Researchers</td>
</tr>
<tr>
<td>Cathy*</td>
<td>Pam</td>
<td>Charles (Evan, assistant)</td>
</tr>
<tr>
<td>Mark</td>
<td>Tom</td>
<td>Rick</td>
</tr>
<tr>
<td>Rob*</td>
<td>Martha</td>
<td>Joe (Jane, assistant)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summer Two</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Service Teachers</td>
<td>Practicing Teachers</td>
<td>Science Researchers</td>
</tr>
<tr>
<td>Cathy*</td>
<td>Sandy</td>
<td>Joe (Jenny, assistant)</td>
</tr>
<tr>
<td>Mark</td>
<td>Pam</td>
<td>Evan</td>
</tr>
</tbody>
</table>

*Denotes participant in doctoral study, as well.

The pre-service science teachers. The pre-service teacher participants with whom I worked closely were Cathy, Rob, and Mark. Cathy and Mark participated in the summer research both summers. Cathy and Rob are currently teaching in their own classrooms, and they became the focus of the longitudinal study for my dissertation. There were several other participants, but I will only mention those who worked closely with the participants who are part of my doctoral study.

Mark was eager to participate in the following summer study, as he felt that the experience would help him in the classroom. (Note: Unfortunately, Mark withdrew from the teacher preparation program, due to personal and family problems completely unrelated to his experiences. I note this because if not for his personal conflicts, Mark would have been an excellent subject to follow in this study.)

The practicing science teachers. The middle school practicing science teachers, who served as mentors, included Martha, Tom, Pam, and Sandy. Martha worked with Rob during the first summer of the contextual science research course. Pam worked with Cathy during the first summer, while Sandy worked with Cathy during the second summer. Tom worked with Mark the first summer; while Pam mentored Mark the second summer.

The science researchers. The science researchers involved with the middle school participants include Evan, Rick, and Jenny. Jenny is the laboratory manager, as well as a biologist, for a university based research facility. Jenny is a white female in her mid-thirties. Because of her experience with the CO-LEARNERS pilot study, Jenny considered becoming a secondary science teacher at some point in her career. She is also considering teaching at the university level (Macauley, 2002). While there were other science researchers, the above
mentioned were closely involved with the research carried out by the teacher participants. In addition to these participants, I include some quotations and comments from additional participants, as they were part of the pilot study.

The Research

During the first summer of CO-LEARNERS, there were three teams of CO-LEARNERS involved in the contextual science research. Cathy and Pam collaborated with the Department of Environmental Protection (DEP) in a sea grass study. Cathy and Pam learned to propagate (grow) sea grasses in the laboratory, and then they planted the grasses in a mitigation area along the coastline. Rob and Martha collected water samples in various areas of a boat marina and tested them for various pollutants as part of a contract agreement with the marina and the collaborating laboratory. Mark and Tom studied indicator species to test for pollutants in various areas, including a boat marina.

During the second summer, there was only enough funding for two teams of CO-LEARNERS. To assist the local utilities authority and the collaborating university laboratory, Cathy and Sandy conducted various types of research to help the officials obtain the information needed to determine whether or not the area water supply should be fluoridated. Under the guidance of a laboratory assistant, Cathy and Sandy tested area water samples for the presence of fluoride to determine if additional fluoride in the drinking water supply could contribute to higher than normal levels of fluoride in the area waters. Cathy and Sandy also helped to write reports on fluoride by researching the topic in various journals and Internet data. Mark and Pam continued the sea grass study with the DEP under the guidance of Evan. During this summer, there was more emphasis on the planting of the sea grasses.

Outcomes of the Pilot Study

Science Content Acquisition

Each participant became immersed into the culture of science through his/her interactions with the scientists within the context of science. This context involved using the equipment of science to carry out procedures, conversing in the language of science to communicate with others to conduct the research, and generating analytical thinking skills to make sense of the research. Science content acquisition was a goal of CO-LEARNERS and the Experiential Science/Mathematics in Middle School course that I offered. I designed this course to help teachers develop discussions, ideas, and lesson plans using content as a target area. In the course
syllabus (Appendix D), the objectives for the *Experiential Science/Mathematics in Middle School* course include:

1. helping the pre-service teacher better use the language of science,
2. immersing the pre-service teacher into the culture of science,
3. immersing the pre-service teacher into a contextual learning environment,
4. helping the pre-service teacher develop new contacts in the science community,
   and
5. helping the pre-service bring science into the classroom.

The objectives for this course adhered to the following suggestions for the professional development for teachers of science taken from the NRC (1996): “The challenge of professional development…is to create optimal collaborative learning situations in which the best sources of expertise are linked with the experiences and current needs of the teachers” (p. 58).

This closely describes the basic structure of the CO-LEARNERS model, which unites researchers of science, practicing science teachers, and pre-service teachers in a collaborative situation. The science researchers bring a wealth of content-rich science into the learning community.

When asked, on a post participation survey, if he believed that pre-service teachers gained as much content on a certain topic by doing research, as they would have in a lecture-driven course, Evan, a collaborating scientist, explained his perspective:

I believe they [pre-service teachers] gain much more understanding of the details related to the research, but may not be able to cover nearly as many different scientific concepts as they would in a lecture-driven course. But, most importantly, I think they gain a better appreciation of the practicality of science and its real-life implications by participating in hands-on research.

Consistent with what Evan describes, one of the criticisms of science education in the United States cited in the Third International Mathematics and Science Study (TIMMS, 1997) was that U.S. teachers try to cover *too much information*. Teachers teach *too much content*, because standards and standardized testing say that they must, or at least the teachers interpret them this way. Therefore, teachers have to decide which is more important for students, to cover *more information* or to gain *more understanding*. I believe the latter is more important.
**Contextual learning**

Gilmer (1999) defines *contextual learning* as “learning in the context of doing, thinking, speaking, and experiencing science” (p. 13). In contextual learning, one learns within the culture of science with other practitioners, using the equipment, logic, creativity, analytical reasoning, and communication skills needed to conduct scientific research. Science research experiences for pre-service teachers fulfill the tenets of this definition quite amply. Contextual learning is a step beyond hands-on and “minds-on” science. It is an immersion into the culture of science. Ideally, pre-service and in-service teacher participants in this type of study are those individuals who have not previously worked in a scientific research setting. This was true with the participants in my pilot study, and subsequently my doctoral study.

Participants in the pilot study experienced contextual science research and thus learned the science content within the context of “doing science” (Gilmer, 1997). Because I immersed the participants into the culture of science, they were “learning in the context of doing, thinking, speaking, and experiencing science” (p. 13). This type of learning is much more meaningful than learning from mostly lecture and textbooks.

Another good example of the meaningful learning within in a contextual environment involves Mark, one of the pre-service science teachers involved in the pilot study. During the fall semester following the summer research experience, while speaking to students in a teacher education course, I called upon Mark to tell some other students about the CO-LEARNERS project. In an impromptu response, Mark, very eloquently and accurately described the mollusks that were used in the study, citing the scientific names and descriptions of each species. He discussed the meaning of indicator species and why their study was significant. I told Mark that I was very impressed with the way he remembered everything in such detail. Mark, too, seemed surprised at his amazing ability of recall. He said, “You know, I learned it because I did it.” “Exactly!” I said. This is the power of contextual learning in science.

**The Culture of Science Vs. the Culture of Classroom Science**

Madsen and Gallagher (1992) discuss the culture of classroom science in their study on teacher change and beliefs. The culture of science is different from that of the culture of classroom science. Madsen and Gallagher see culture of science as constructivist in nature because scientists must experience their research to discover answers and obtain knowledge. By contrast, they see traditional culture of classroom science as positivist in nature, in which the
teacher gives the students factual information. Textbook and lecture-driven, the current culture of science in the classroom does not allow students to experience authentic science.

Cathy, a pre-service teacher who worked with plant propagation and environmental restoration, described the culture of science and how this differs from the culture of the science classroom in an interview:

The culture of science is very interesting. Working with people who love what they are doing made me want to bring that feeling back into the classroom. Research, discovery, focus, and love of science make the culture of science exciting. Again, the culture of science in the classroom lacks excitement and interest. Students are not motivated to seek answers to questions and research interesting topics. I want to make science fun and interesting. I do not want my students to just read chapter after chapter and answer questions at the end. I want students to develop their own questions and then research to find answers. I want students to share with their classmates what they discovered and why it was important to them. I hope to make students aware of how much fun science is and that everyone can be a scientist.

Cathy, too, began to make the connections between science and the way she should teach science as opposed to the way teachers actually teach. Cathy further described being immersed in an authentic research experience:

My experience working in the laboratory and on the field with the Department of Environmental Protection was wonderful. I learned how much work and detail goes into restoring the environment. I worked in a sterile environment making sure to follow steps correctly. Much emphasis was placed on detail and procedure. It was a little tedious sometimes, but fun.

Although she experienced some of the tedium involved with scientific investigation, Cathy emerged from her research with a deep appreciation of science, and a desire to share her experiences with her students. She went on to participate in the CO-LEARNERS project for the second summer.

**Pedagogical Content Knowledge (PCK)**

In the Columbia University study (Silverstein, 1999) previously mentioned in Chapter 2, the students of participating teachers are more active in Westinghouse projects, science clubs, and extra-curricular activities in science at a higher rate than students whose teachers had not participated in summer research experiences. This suggests that teachers are able to relay their experiences into their own classrooms for their students. In other words, the teacher participants are able to effectively translate their experiences with constructivism and contextual learning into similar types of learning opportunities for their students in their respective classrooms.
This ability to gain knowledge on how to teach the content ties in with notion of PCK, as discussed in Chapter 1. The pre-service teacher could reflect upon their experiences, understand how they learned the content, and formulate how they could emulate this in his/her own classroom. They are learning to teach science while gaining the science content knowledge. In an E-mail interview, Rob, a prospective teacher working at a wetlands research facility in the CO-LEARNERS project described this feeling:

Hands-on experience makes you realize that you, the teacher, had fun learning. Whoa, if I had fun, then do my students have fun in class just learning from books? Every once in a while teachers need to be a student to bring them back to the reality that learning needs to be fun. Learning also needs to be hands-on and pertinent to their everyday life. (Excerpt from an E-mail during the summer of the 1999 research).

In my own experience, as well as the research of others (Gallagher, 1991), teacher change comes about slowly. In Rob’s situation, this intervention early in his teaching career has generated three major goals for his teaching: (1) Learning should be fun, (2) Teachers need to return to learning at some points in their career to keep them in touch with reality, and (3) Learning needs to be hands-on and pertinent to their everyday lives.

Based upon my personal observation of participants in this pilot study, the earlier a pre-service teacher becomes immersed in an authentic science investigation, the more likely a change in teaching philosophy would occur. A goal of the pilot study was to help shift teachers away from the classroom that is traditional positivist, lecture-based, and objectivist (Davis, 1993) towards a more constructivist-based classroom (Tobin & Tippins, 1993). Gallagher (1991) reports that the majority of science teachers hold traditional positivist views of science. This goes back to the “teaching the way we are taught” (Macala, 2003, p. 1) concept.

Cathy expressed her thoughts in an E-mail interview:

Teachers should leave textbooks alone as much as possible. It is too easy to just tell students to open up their book and start answering questions. Student involvement in planning activities could make students more involved in what they are learning. Allowing students to work in groups for research and laboratory activities is a good idea to improve student interest. Also, if we want students to have positive attitudes about science education, then we must make what they are learning useful and applicable in the real world. How we can do that is plan more laboratory exercises, bring community scientists into the classroom to answer questions and promote interest, and take the time to develop more powerful lessons. (Excerpt from an E-mail following the summer of the 1999 research).

Cathy understood the need for real-world science. She also mentioned another important facet of teaching middle school students: positive attitudes about science education. To do this, she
stressed three key points: more laboratory exercises, bringing in community scientists, and planning better lessons. Her teaching goals were almost in parallel construction to the goals of this pilot study.

The National Science Education Standards (NRC, 1996) would further support a program such as CO-LEARNERS based on this statement, “Prospective and practicing teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop understanding” (p. 60). By experiencing inquiry-based learning, pre-service teachers can apply their own experiences in lesson plan development and teaching strategies. I believe that students learn more when they are physically and mentally involved in a productive effort that has some meaning and purpose. The learner, in this case, the pre-service teacher, who is involved with the contextual experience, may construct his/her own meaning from the experience. The research process immerses the learner in the culture and language of science without forcing the memorization of useless facts. The pre-service teacher as learner can see this, reflect upon these experiences, compare these experiences to traditional textbook learning experiences, and understand that this is a far richer step to learning. It is hoped that this will then be an impetus, as in my own personal transformation, to transfer this experience into his/her own classroom. Thus contextual learning, rich in constructivist pedagogy, may become a part of the pre-service teacher participants’ PCK.

**Access to the Science Community and Collaborations with Scientists**

The collaboration between a pre-service teacher, a practicing science teacher, and a research scientist blends contextual learning opportunities with a unique collaboration in which each participant played an integral part in the learning community. Each participant brought his/her expertise, reflections, and constructions. The goals of this collaboration are to create classroom environment rich in constructivist thought and to develop effective strategies to promote the teaching and learning of science for the middle school learner.

Using suggestions from Jensen (1998), the CO-LEARNERS collaboration included dialogue time, choice, reflection, teaming, journaling, peer coaching, more feedback, and experimentation. This model paralleled the fourth generation evaluation described by Guba and Lincoln (1989), which Schaller and Tobin (1998) also discuss. The results created learning communities that have the capacity to make an impact on the way science teachers teach science
in middle school classrooms. In a concluding interview response from the first summer, Cathy stated:

I plan on using less lecture, more hands-on activities, research, and student participation. I want my students to want to learn more and apply themselves in science education. I want to invite scientists from the community into my classroom so students can learn what their options are in the future. I also want to communicate with scientists also to create new science plans to implement in my classroom. Having contacts in the community is beneficial for practicing and prospective teachers. During this summer program, I gained several contacts and teaching materials from the people I worked with at the DEP. One person, I forgot his name, gave me bookmarks, magnets, lesson plans, case studies, and fun activities that I can give to and implement with my middle school students no matter what level they are on. Knowing that people in the community are willing to contribute to science education makes my job easier. (Interview, August 11, 1999)

I assert that Cathy has established enough community contacts and has developed a comfort level in making continued contacts so that in her own future classroom, she will be able to develop many partnerships within her community. I also include a chapter (Chapter 6) on Cathy’s research experience and how her experience influenced her beliefs about the culture of science and the culture of science in the classroom. In my follow-up study, I look more closely at how Cathy is bringing her experiences and collaborations with scientists into her own classroom.

The insight that research scientists can share with educators is extremely valuable. I asked scientists such questions as, “What inspired you to be a scientist?” “Did a certain science teacher inspire you to pursue science as a career?” and others. Their answers can shed great insight as to what teachers can be doing in their classrooms to capture their students’ interest in science.

Evan, the DEP biologist who worked with Cathy in the first summer of CO-LEARNERS, described in an interview how a teacher ignited his interest in science:

My first grade teacher brought in a cow’s heart that he got at the butcher shop and we tried to get it to start beating by hooking it up to a 6-volt battery. Also, I was inspired by my 7th grade science teacher’s enthusiasm and his support of me during the science fair. (Interview, August 11, 1999)

When asked, in an interview, what types of things he believes science teachers should be doing in the classroom to promote the learning of science, as well as positive attitudes towards science and scientists, Evan said:

Teach by using more demonstrations instead of relying on explanations from a book. I think students will remember the concept being taught better and show more interest in the lesson—most students will actually have more fun doing instead of just reading. By
showing them that science is often fun, they may accept that many scientific jobs would be cool to have. Teachers should do more experiments/demonstrations. (Interview, August 11, 1999).

While demonstrations, alone, are not ideal, I believe what Evan is saying is that teachers should not rely heavily on information from a textbook. He does, in fact, mention experiments in addition to demonstrations. His words, “more fun doing,” are important.

This aspect of the pilot study demonstrates that pre-service science teachers realize that they can benefit greatly from the interactions with science researchers. The exposure can yield not only insight into what to do in the classroom to ignite student interest and excitement in science, but what NOT to do in the classroom. Community collaborations are invaluable, as the school’s resources no longer limit the classroom, but expand the classroom through access to a science research facility, and the experiences of the researcher.

The Learning Pyramid

According to Williams (2000), the National Training Laboratories of Bethel, Maine created a learning pyramid that verifies that the rate of retention over a 24-hour period relates directly to types of teaching methods. In the Learning Pyramid, the average retention rates for learning activities are as follows:

- 5% from lecture
- 10% from reading
- 20% from audio-visual
- 30% from demonstration
- 50% from discussion group
- 75% from practice by doing
- 90% from teaching others and immediate use of learning

Looking at the Learning Pyramid (Williams, 2000), the activities from a contextual science research experience provide more opportunities for higher retention rates. The contextual research experience described in this study involves the pre-service teacher experiencing the following learning activities:

1. *Immediate use of learning* occurs as the pre-service teachers learn new information, they in turn *teach* the other participants as they conduct the research;
2. *Practice by doing* occurs throughout the research as the pre-service teachers implement techniques and laboratory activities;
3. *Discussion group* involvement occurs as the pre-service teachers collaborate with the practicing science teachers and the science researchers;

4. *Demonstration* occurs as the pre-service teachers are learning various laboratory techniques from the science researchers; and

5. *The use of lecture, reading, and audio-visual materials* occurs as needed to supplement the contextual science research.

Often it takes first-hand experience for teachers to *see* and *feel* how this learning occurs. My hope is that they will come to realize that their pedagogical teaching style must provide these types of opportunities for their students for optimal learning and retention to occur.

**Lessons Learned from the CO-LEARNERS Pilot Study**

**Limitations of the Pilot Study**

Despite some limitations to the pilot study, there is a rich base of information from the voices of each participant that reveal the answers to the original questions of the pilot study. However, I note the following limitations. Because the pilot study was only partially funded through a NSF grant, the number of practicing teacher participants was low due to the cost of teacher salaries. Another constraint was the limited availability of the participants. Therefore, the pilot study was somewhat limited in terms of numbers of participants and prolonged engagement. Despite these limitations, I still believe there are significant questions to answer. Because of the extensive practice and study on the impact of research experiences on practicing science teachers with respect to their own classroom applications, a look at this same phenomenon and its influence on pre-service teachers warrants careful consideration.

**Participant Feedback**

Based upon the interviews of the participants in the pilot study, scientific work experiences for pre-service teachers were as valuable as those designed for practicing teachers. Due to the nature of the study, discussions among the participants yielded several ideas and suggestions for improvement. These suggestions involved: keeping a journal, course requirements, scheduling difficulties, accessibility of the researchers, assuring real research, and limited funding.
Keeping a Journal

To better improve the learning, in a concluding interview after the first summer, Cathy suggested that:

During the program, university students should be required to keep a daily log, be evaluated weekly on progress and what is being learned, and should be guided by the university coordinator and lead teacher on completing lesson plans and research paper. University students need to know beforehand what is expected of them with a concrete syllabus and whom they can contact if problems arise. (Interview, August 11, 1999)

Initially, I did not require the pre-service teachers to keep a journal; however, many did keep one. Cathy’s suggestion played an important part in the planning for the second summer of the study. During the second summer of the pilot study, I required a journal as part of the course requirement. This helped the pre-service teacher to better assess and monitor their learning, as well as inform me as the researcher.

Course Requirements

While I distributed a general syllabus the requirements were not specific, due to the constructivist nature of the course, I did this so the pre-service teachers could construct their own meaning of the experience and their learning. They could demonstrate their learning in any way they wished. Explanations at the start of the course should be done to eliminate any undue stress over the course requirements. Taking recommendations from the participants into consideration, I prepared a syllabus during the second summer (Appendix D).

Scheduling Difficulties

There were some scheduling difficulties early in the summer, as all of the teacher participants taught summer school, which overlapped with the summer research. This created a delay in uniting the pre-service and practicing teachers, in some cases. By the middle of the summer, the teachers could work together. We decided that in the following summer I would only allow teachers who were not teaching summer school to participate in the research experiences.

Maintaining Scientist Accessibility

During the first summer of the pilot study, one of the groups had difficulties maintaining a professional relationship with the lead researcher. After discussions with the researcher, I remedied this situation with the addition of another researcher, who worked with the participants to design their research study. This researcher turned out to be an excellent addition to the co-
learning team. This predicament occurred with one of the teams during the second summer, as well. This collaboration, too, included an extra laboratory assistant to work with the pre-service and practicing teachers.

**Conducting Real Research**

During the first summer, coinciding with the lack of accessibility of the lead researcher, one of the teams expressed disappointment with their research. They believed that their work was free labor and not research. One of the teams expressed an early concern that the research was “not research,” but rather various laboratory maintenance duties. For the following summer, I brought this concern to the participating scientists’ attention in advance of the start of the project so that it would not occur again. This researcher allowed the teachers to conduct groundbreaking research in sea grass propagation and planting. This work has evolved and is currently a major environmental project in the Pensacola area.

**Limited Funding**

The teams also expressed concern that there was not enough funding available to have more teams, in terms of paying the practicing teachers. They felt that with more teams, there would be more learning. Funding is simply an issue that cannot be easily remedied. We discussed writing grants and asking for more support from the business community.

**Evaluation of the Pilot Study**

Like a good fourth generation evaluation (Chapter 3), this study left all participant stakeholders in the Pilot Study more informed than beforehand. Fourth generation evaluation studies, because of the stakeholder participation, can be empowering. Because of this evaluation, the participants’ experiences may be catalytic in producing action. All of the pre-service teachers expressed that they had gained confidence due to the content that they had learned, they all expressed that they planned to include more contextual learning experiences in their classrooms, and they all planned to access community resources for their classrooms.

The benefits of a contextual science research courses for pre-service teachers were evident in the pilot study. Course requirements, scheduling difficulties, availability of the researcher, questions about specific research duties and “what constitutes research,” and the lack of funding for additional teams, need to be addressed. The information learned from this pilot study will be valuable towards improving future contextual science research courses, as well as
assist other community colleges and universities that wish to implement experiential programs for pre-service science teachers.

Problems Areas

Using lessons learned from the pilot study, based upon dialog and feedback from the participants, the following problematic areas uncovered in the pilot study should be considered in future courses of this nature:

1. Keeping a journal—Participants should be encouraged to keep a journal of their experiences, as part of their course requirement.

2. Course requirements—Participants should receive a syllabus detailing exactly what is expected of them with respect to the course requirements. The actual research should remain constructivist-based and inquiry-based in keeping with the suggestions of the NRC (1996, 2000) for classroom science.

3. Scheduling difficulties—Many students must work during the summer and cannot participate in such a program. Additionally, many teachers teach summer school during the summer. However, there are still plenty of practicing teachers willing to participate, who are not teaching summer school.

4. Maintaining scientist accessibility—Often the researchers who express an interest in working with such a project are very busy and are involved with other research. This problem can be remedied with the addition of another researcher who could serve as a liaison between the pre-service and practicing teachers, and the lead researcher.

5. Conducting real research—Ensuring that the science research assignment is an actual research investigation conducted by the science facility is a critical component. If participants feel they are menial labor, this could completely ruin the experience for the teacher participants. They need to feel like scientists, immersed in science and doing science.

6. Limited Funding—Paying for the teacher’s salaries can be difficult, particularly if there are no laboratories with budget to provide such jobs. Creative ways to pay for the teachers’ salaries can be utilized by the university representative involved with the project. There are grants available to provide such salaries that unite researchers with the education community.
Encouraging Outcomes from the Pilot Study

Based on the initial responses from the pre-service teachers interviewed as part of my pilot study, as well as practicing teachers and researchers, the contextual learning experience for pre-service teachers was beneficial in a variety of ways:

1. The pre-service teachers acquired science content and pedagogical content knowledge. This science content learning is evident in the participants’ writing completed the year following the research experience, as well interviews during their research and shortly afterwards. While more studies need to be done on content acquisition, preliminary findings suggest that the pre-service teachers, as well as practicing teachers, did acquire content through the contextual experience. Due to the constructivist nature in which the teacher learned, the content appears to be more ingrained. This could have implications on the teacher participants own classroom pedagogy in science.

2. The pre-service teachers experienced the culture of science first-hand. The difference between the culture of science and the culture of the science classroom became more evident to the teacher. I inferred that a merging of the two cultures is a necessary step towards making science seem more real to the students.

3. The pre-service teachers gained empathy for their students. As they became learners, the pre-service teachers experienced the frustration of having to encounter sometimes previously unknown subject matter. This happened by allowing the pre-service teacher to experience the nature of science first-hand.

4. The pre-service teachers experienced somewhat of a catalytic effect. The pre-service teachers expressed that after their own experience they wished to create similar types of opportunities for their own students. The pre-service teachers were better able to see a constructivist-based pedagogy and contextual learning as important parts of the classroom. Pre-service teachers might be more compelled from their own experiential learning than they would be if they had only read about experiential learning prior to coming novice teachers. I anticipated the “transfer of experience” to the participants’ own classroom, and chose to study this for my dissertation.
5. The pre-service teachers learned about their community science resources and contacts. These contacts were accessible to pre-service teacher participants should they desire to utilize them. They became aware of how to make appropriate contacts for when they would begin teaching within their own classroom. Science researchers, too, can contribute to improving the classroom by sharing their own experiences with the teachers with whom they are collaborating as to why they enjoy science and what teachers can do to make it more interesting to students.

In a survey response, Cathy expressed her thoughts on the value of an experiential course for pre-service teachers:

The program is worthwhile. I learned valuable information this summer that will make me a better teacher. The scientists were very helpful and excited about helping me learn about their field. The lead teacher was excited as well and helpful in suggesting ways to implement various ideas into the classroom. This program should be a part of teacher preparation programs so future and current teachers can realize the importance of meaningful science education. University students need more field experience in their content areas if they are to make learning meaningful and exciting. (Interview, August 11, 1999)

Based on Cathy’s, as well as the responses of other participants, I believe that experiential and contextual-based science courses for pre-service teachers can be beneficial and warrant future consideration.

**Implications and Recommendations for Future Studies**

Many years of SWEPTS have demonstrated that such experiential science has a positive effect on practicing science teachers and their classrooms (Silverstein & Dubner, 1999; Gottfried, 1993). Programs or alternative courses, such as those utilized in CO-LEARNERS, could prove beneficial to pre-service science teachers in a myriad of ways. It is my opinion, as a researcher and as a practicing middle school science teacher, that the re-designing of teacher preparation programs should include experiential courses for pre-service science teachers.

Pre-service and practicing teachers should be required to enroll in science courses in which they learn science through inquiry, so they can provide similar opportunities for their students. Dana, Campbell, and Lunetta (1997) believe that professional development for most pre-service and practicing teachers is a hodgepodge of unconnected courses, workshops, and classroom-based experiences that seldom require teachers to deepen and enrich understanding of teaching and learning. They suggest extended connections between science content, science
pedagogy, and opportunities for meaningful “sense making.” The CO-LEARNERS model, through the collaborations between classroom teachers, pre-service teachers, and science researchers, satisfies this suggestion.

In terms of economic feasibility, experiential course offerings for pre-service science teachers require minimal costs to the university. The researchers are not paid, but rather offer their assistance on a voluntary basis. Therefore, the laboratory space and facilities, most of which are stocked with state of art equipment, become accessible to the pre-service science teachers. The researchers at one site were all volunteers from a state laboratory, so the cost sharing was extensive. I found that many scientists are willing to help, due to fact that they are parents of school age children and they wish to do their part to improve science education in their community. However, there is still the cost of the faculty member or a Teaching Assistant who supervises the students and organizes the program.

While an experiential course could involve just the pre-service teacher and science researcher, I highly recommend the extended collaboration with the practicing science teacher. The practicing science teachers can serve as the bridge between science and the classroom science to help make the connections to science. This mentorship is valuable in terms of acquainting the pre-service teachers with science teaching and the culture of classroom.

The school district sets the in-service rates for summer pay for teachers. Collaboration with the school districts could yield the summer salary through in-service or other grant funding. Other options include asking a research facility to pay the teachers (Maryland CETP, 2002). The state EPA laboratory paid the practicing teachers at one site on an experimental basis, with the thought that this could be expanded with teachers throughout the state, provided we could get the additional funding. Practicing teachers are more than willing to participate as most need the extra income and are eager to mentor a pre-service teacher. Most science teachers desire to update their own science content and understanding of science. For those who are pursuing advanced degrees, course credit could be offered in lieu of, or in addition to, a salary. At one site, one of the three practicing teachers registered for college credit so that she could renew her teacher certification in chemistry. There are many creative alternatives to establishing such a program.

*From the Pilot Study to the Dissertation*

My pilot study focused mainly on the actual science research experience, how the participants perceived the experience, and how it may have affected their beliefs about science
teaching. In Chapter 5, I discuss the continuation of the pilot study and why it was necessary to follow these former pre-service teachers as they entered their own classroom as novice teachers. Will their contextual science research experience continue to influence their beliefs, as well as their teaching practices?
CHAPTER 5: RESEARCH ACTIVITIES

The Beginning

Based on the blending of my own insights and experiences with what I heard from the participants during the pilot study and with what the existing literature says on scientific work experiences for teachers, I chose to focus my study on the influences of contextual science research on teacher beliefs and practices in the following areas:

1. culture of science versus the culture of the science in the classroom;
2. access to the scientific community and collaborations with scientists;
3. immersion into constructivist-based pedagogy, through contextual learning;
4. inquiry-based, hands-on activities;
5. science and mathematics connections in the classroom; and
6. science content and pedagogical content knowledge.

The pilot study participants addressed and discussed these areas with greatest frequency. Teachers also find these areas critically necessary for creating classrooms rich in hands-on, inquiry-based science, which is the kind of classroom envisioned by the National Science Education Standards (NRC, 1996).

Why These Questions?

With the lessons learned from my pilot study greatly influencing the direction of this dissertation, I refined the areas of focus into the following research questions:

1. What are the beliefs towards the culture of science and the culture of science in the classroom of a novice science and a novice mathematics teacher after completing a constructivist-based, contextual science research course?
2. What are the classroom practices of these novice teachers after completing a constructivist-based, contextual science research course with respect to:
   a. implementing constructivist-based, contextual science methodology in their own classrooms?
   b. forming collaborations with scientists and the science community?
   c. integrating science and mathematics in the classroom?
d. implementing inquiry-based, hands-on science activities?

3. After completing a constructivist-based, contextual science research course, what are the influences on the novice teachers’ constructions of (a) science content knowledge and/or (b) pedagogical content knowledge?

I believe it is necessary to pursue these questions as the pre-service teachers advance into their novice years of teaching to determine if their experiences continue to influence their beliefs and begin to influence their teaching practices. I address each area of focus in the next section and explain why I believe they are pertinent to study.

**The Culture of Science versus the Culture of the Science in the Classroom**

The culture of science is much different than the culture of classroom science. In science, the emphasis is more on finding out something previously unknown to the researcher. There is more *inquiry* involved in the culture of science; while in many classrooms today, science teachers continue to teach science mostly by the dispensing of known facts and information. Often the laboratory experiences and activities are mostly cookbook-type, with specific directions and established answers. According to the NRC (2000), “Learning environments that concentrate on conveying to students what scientists already know do not promote inquiry. Rather an emphasis on inquiry asks that we think about what we know, why we know, and how we have come to know” (pp. 5–6). In other words, students should be allowed to *construct* meaning through more open-ended investigations in science.

While many educators are aware of the differences between *real* science and classroom science, they have difficulty bringing more open-ended types of science activities into the classroom. This is evident in every school in which I have ever taught or visited over the years. The difficulty is partly due to the fact that these teachers have not experienced an immersion into contextual science research environment where they can see “science” happen. Their own early education experiences in science were most likely from traditional schooling, with just facts and information and a few hands-on pre-ordained activities.

**Access to the Scientific Community and Collaborations with Scientists**

Novice teachers are commonly limited with respect to contacts and resources in their community. Often they are simply restricted by time, as teachers have very limited time to make telephone calls. I expect this experience should provide pre-service teachers with the initial resources and confidence necessary to access useful contacts within the scientific community.
These resources could include guest speakers, science fair assistance, equipment and financial donations, and mentoring. Falk and Drayton (1997) find supporting evidence for many of these ideas among practicing teachers who participated in science research. Atkin (1991) also asserts that partnerships between science teachers and scientists are of great importance for the future betterment of science in the classroom.

Because of the working relationship, I anticipate that the novice teacher may feel less intimidated because s/he worked with scientists. Knowing the scientists as colleagues may help them to develop the confidence to initiate these partnerships and collaborations with the scientific community. This may benefit the students in the classroom, as well as the image of the scientist and science, as the partnerships develop.

Constructivist-Based Pedagogy, Contextual Learning the “Transfer of Experience”

For my study, I immersed pre-service teachers in a contextual learning environment in science guided by a constructivist epistemology. Within this environment, they had the opportunity to explore new pedagogical methods for their future students. I based my concept behind this study of pre-service teachers on findings from studies on practicing teachers who participate in science research (Gottfried, 1993; Silverstein, 1999; Silverstein & Dubner, 1999; Westerlund et al., 2002). In these studies, practicing teachers included more hands-on, inquiry-based activities, gained science content, and felt more confident with science. In some cases, their students became more involved in science research and clubs. Studies with pre-service teachers conducting science research (Langford & Huntley, 1999; Melear, 2000; Ross & Denniston, 2002) show promise, as well. To my knowledge, these studies do not follow the pre-service teachers as novice teachers into the classroom as my study does.

Making Science and Mathematics Connections in the Classroom

In science research, mathematical applications are commonplace. However, in the classroom, the schools usually treat mathematics and science as completely separate subject matter. Lessons that integrate science and mathematics can help students to see real-life applications of both, to better understand the importance of each to the other, and to make the connections between science and mathematics. One of my goals for this study is for the novice teachers to use mathematical applications in their own science research. Then the teachers might be able to transfer this connection to their students, who can then see how useful mathematics is
in science and how useful science is for learning mathematical concepts. This study includes a science teacher and a mathematics teacher. I hope that both will bring pieces of each subject into his/her own classroom to help students make these connections.

**Science Content and Pedagogical Content Knowledge**

In his study of the STARS program, Gottfried (1993) finds that teachers demonstrate incorporation of research/process methodologies into their curricula and that their research experience impacts their ability to implement hands-on, laboratory-oriented curricula. Additionally, Gottfried (1993) finds that teachers from the STARS program attribute their acquisition of science content knowledge to their participation in science research.

Westerlund et al. (2002) also finds that summer research experiences directly affect the practicing teacher participants by enhancing their science content knowledge. I anticipate that pre-service teachers will benefit in much the same way. Similar studies by Silverstein (1999) report increased science content and confidence among practicing teachers participating in the Columbia research program.

I assert that by gaining content and PCK, science teachers also gain confidence with their subject matter and how they will teach it. Novice science teachers, especially, could benefit from this added boost of confidence. Based upon the theoretical frameworks of constructivism and cultural-historical activity theory, it is my belief that the individual person constructs learning by using previous experiences coupled with newly acquired experiences and knowledge. Therefore, the novice teachers acquire content knowledge from their immersions into the contextual learning experience. This type of content knowledge is longer lasting and more richly ingrained than the type of content acquired through memorization such as for a test. I expect the novice to make that connection in their own classrooms, and to adapt their own science pedagogy to include more contextual experiences for their own students.

**A Data Collection Matrix**

Table 5-1 is a matrix of my Data Collection includes data collected from the pilot study as I look at the beliefs of the novice teachers before, during, and after their involvement with the pre-service science research course. These beliefs continued to emerge throughout my doctoral study phase of my research. The other two questions focused on the practices of the novice teachers. I wanted to find out if the constructivist-based, contextual science research course had
any degree of influence, as to whether or not the novice teachers were able to put their beliefs into practice.

Table 5-1

A Matrix for My Data Collection for the Pilot Study and Follow-Up Study

<table>
<thead>
<tr>
<th>Data collected</th>
<th>Time line</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Observations</td>
<td>Pilot Study 1999–2000</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Teacher Interviews</td>
<td>Pilot Study 1999–2000</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Teachers’ discussions via E-mail: (Hermeneutic Dialectic)</td>
<td>Pilot Study 1999–2000</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Lesson plans</td>
<td>Pilot Study 1999–2000</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Teachers’ reflective journals</td>
<td>Pilot Study 1999–2000</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Researcher’s reflective journal and E-mails from major professor</td>
<td>Doctoral Study, Fall semester 2002</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Novice teacher participants’ chapters included in a SERVE monograph detailing</td>
<td>Doctoral Study, Spring semester 2002</td>
<td>Qualitative and Interpretive using QSR software</td>
</tr>
<tr>
<td>his/her experience</td>
<td></td>
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</tr>
<tr>
<td>Classroom observations and interviews with novice teachers</td>
<td>Doctoral Study, Fall semester 2002–Spring semester 2003</td>
<td>Qualitative and Interpretive using interviews and QSR software</td>
</tr>
<tr>
<td>Transcribed data from classroom observations and interviews with novice</td>
<td>Doctoral Study, Spring semester 2003–Spring semester 2004</td>
<td>Qualitative and Interpretive using QSR software</td>
</tr>
<tr>
<td>teachers</td>
<td></td>
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<tr>
<td>Teacher observations</td>
<td>Doctoral Study, Fall semester 2002–spring 2003</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Teacher interviews</td>
<td>Doctoral Study, Fall semester 2002–spring 2003</td>
<td>Qualitative and Interpretive using QSR software</td>
</tr>
<tr>
<td>Teacher E-mail discussions</td>
<td>Doctoral Study, Fall semester 2002–spring 2003</td>
<td>Qualitative and Interpretive</td>
</tr>
<tr>
<td>Final Exit Interviews</td>
<td>Doctoral Study, Spring and Summer 2004</td>
<td>Qualitative and Interpretive to help me clarify my interpretations of the participants’ writings and interviews used in my dissertation</td>
</tr>
</tbody>
</table>
Creating Communities of Learning

Learning Communities

*The Fifth Discipline* author, Peter Senge, describes systems thinking as *collective learning* (Senge, 1996). Senge asserts that organizations that excel will be the ones to discover how to tap people’s commitment and capacity to learn at all levels of organization (Senge, 1996). By creating a learning community comprised of a practicing science teacher, a pre-service teacher, and a researcher of science in this research, I purport that productive discussions, educational partnerships, ideas, and applications in the science classroom should naturally emerge from the collaboration.

Melear (2000) asserts that pre-service science teachers should be placed in situations that mimic the learning communities of scientists. In order for pre-service science teachers to be properly enculturated into the science they will be expected to teach, they need to be surrounded by persons who “speak the language” (p. 10) with scientists who have varying degrees of expertise.

Peck (1993) defines a community to be a way of being together with both individual authenticity and interpersonal harmony so that people function with a collective energy even greater than the sum of their individual energies. The science researcher brings with him/her science knowledge, expertise, and ideas concerning what kind of science should be included in the classroom. The practicing science teacher brings with him/her teaching and classroom expertise and realistic expectations of how the teacher can bring science to the classroom. The pre-service teacher brings enthusiasm, new ideas, current educational research, and a willingness to learn. All individuals are critical to the learning community. This synergy provides a dynamic new situation for enhancing the way teachers can bring science to the classroom.

*Collaborations Between Pre-service and Practicing Teachers*

Brown et al. (2002) report that pre-service teachers, who participate in an apprenticeship with scientists, learn science techniques and content. However, the pre-service teachers possess limited capabilities in replicating the science research methods in their secondary classrooms. I assert that a third critical component of the collaboration is missing—the practicing teacher. The practicing secondary science teacher could be the key element in assisting the pre-service teacher with the implementation and pedagogy for the classroom.
Unlike many existing programs for practicing science teachers, I base my research upon unique collaborations among pre-service science teachers, practicing science teachers, and researchers of science. The collaboration revolves around an actual or real-world science research investigation. This means that the research relates to the researcher’s current area of study, a study that is relevant in the science community, or real world. This is research that s/he has offered to share with the participants, as opposed to trivial laboratory work, or a cookbook laboratory similar to those found in traditional science courses.

Fosnot (1993) asserts that teacher education programs should provide opportunities for teachers’ beliefs to be “illuminated, discussed, and challenged” (p. 77). Fosnot’s program for pre-service teachers involves engaging the pre-service teachers in experiences that confront traditional beliefs about teaching and learning, in experiences in which they can study meaning making in children, and in experiences in the field where they can experiment collaboratively with practicing teachers. Because teachers still hold such inherent beliefs like “teaching is telling” (p. 70) and “covering the curriculum is more important than conceptual understanding” (p. 70), Fosnot calls for teacher education programs to systemically challenge these beliefs “through activity, reflection, and discourse in both course work and field work throughout the teacher preparation program” (p.70).

Fosnot’s (1993) approach to teacher education stresses the involvement of both pre-service and practicing teachers in cooperative and reflective fieldwork. She uses a multi-tiered approach to teacher education consisting of four levels or tiers that involve both a pre-service teacher and a practicing teacher. I elaborate on Fosnot’s approach and add an additional tier as my study follows the pre-service teacher into the first year of teaching as a novice teacher. My five tiers are summarized as follows:

1. Practicing and pre-service teachers participate in a “community of discourse” (p. 72) to reflect upon their own learning and challenge beliefs about teaching as “most educators still tend to teach as they were taught rather than as they were taught to teach” (p. 70).

2. Practicing and pre-service teachers construct pedagogy from analyses of children’s thinking, with the practicing teacher providing the pre-service teacher with this insight.
3. Practicing and pre-service teachers undertake cooperative fieldwork in contextual science research collaborating with the science researcher who provides them with insight into the culture of science.

4. Practicing and pre-service teachers engage in reflective fieldwork in science, and collaborate on pedagogical issues associated with science (lesson plans on how to bring the culture of science into the culture of the classroom), and engage in an integrative field experience (a classroom practicum).

5. Novice teachers transfer experiences from the contextual science research experience into their own classrooms, merging the culture of science through the collaboration with the research scientist, and the culture of the classroom through the collaboration with the practicing teacher.

My study takes Fosnot’s (1993) approach into consideration along with science research as an additional component of the collaborations between practicing and pre-service teachers. Fosnot’s study deals primarily with classroom pedagogical issues. By blending the research of Fosnot and the results of SWEPT programs across the country, my study could serve as a model vehicle for meaningful change in pre-service science and/or mathematics teachers’ training, if successful. I now discuss the role of each participant in the CO-LEARNER pilot study, as well as the subsequent follow-up study for this dissertation research.

*The Science Researcher’s Role in the Study*

The role of the science researcher is to mentor the team of science educators throughout the research. The science researcher also brings the culture of science into the collaboration. In my study, we achieved this through dialogue that helped familiarize both the practicing and pre-service teacher with the language of science, science content, the culture of science, and the potential role of the science community in education.

In their study of four practicing teachers who participated in scientific research, James and Wilson (2002) find that it is not sufficient to just immerse the teacher (in this case, the pre-service teacher) in a research experience. Instead, they should collaborate with the scientist to produce a curriculum product to ensure the transfer of science knowledge and process to their students. This is a requirement in the contextual science research course in my study. The addition of the practicing teacher to assist with PCK in the course in my study further supports this suggestion.
The Practicing Science Teacher’s Role in the Study

The practicing science teacher’s role is to serve as the bridge between research science and classroom science. He/she assists with the research and facilitates the pre-service teacher as to how science can be brought into the classroom through laboratory experiments, contextual learning in the classroom, field studies, guest speakers, and other connections to the science community. Because the practicing science teacher is familiar with the limitations of the classroom, the nature and needs of the students, the politics of the school, and other constraints, s/he will be essential in assisting the pre-service teacher with how to use their experiences in the best interest of his/her future students.

Following the summer research experience, the pre-service teacher conducted a university-required practicum with the same teacher with whom s/he worked during the CO-LEARNERS project. This allowed a better opportunity for the pre-service teacher to see what happens in an authentic science laboratory, and how to bring or transfer what was learned from the contextual science research experience to the classroom.

The Pre-service Teacher’s Role in the Study

The pre-service teacher’s role is to share his/her perspective as a learner and future science and/or mathematics teacher with the others. This might simply be to share current educational reform, educational standards, and other relevant information acquired from his/her teacher preparation program. I gave the syllabus of the course to the pre-service teachers during their participation in the contextual research (Appendix D). I designed this course to assist the pre-service teacher, who was the primary focus of this collaboration, with:

1. learning science content while gaining “scientist” status;
2. experiencing science in a contextual learning environment, rich in science inquiry, in hopes of setting the stage for future implementation of these sorts of experiences in his/her future classroom;
3. experiencing the nature of science;
4. becoming immersed into the culture of science; and
5. acquiring the necessary skills for gaining access to the science community and forming collaborations with scientists.

The pre-service science teacher received course credit, upon completion of the course requirements for his/her participation in the research. To satisfy these course requirements, I
required the pre-service teacher to keep a reflective journal, to complete a report on the research in a scholarly paper assigned by the researcher, and to complete a lesson plan with the pedagogical guidance of the practicing science teacher.

The pre-service teacher’s role, now as novice teacher, is to blend the culture of science with the culture of science in the classroom, bringing together his/her collaborations with the scientist and the practicing teacher. The idea is to transform the current notion of the *culture of science in the classroom* into a more effective teaching model in which the science more closely reflects the true culture of science. This model includes more hands-on science, contextual science investigations, collaborations with scientists and the science community, real-life science, meaningful science, inquiry, and less textbook-driven lessons and lectures. While all participants should benefit from this collaboration, the focus of my research is on the pre-service science teacher and what influences, if any, result after his/her immersion into the contextual science research experience as they enter the next phase of the study as *novice teachers*.

**My study**

*The Participants*

In table 5-2, I outline each of the participants’ roles during the course of the five-year study.

**Table 5-2**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cathy</th>
<th>Rob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer 1999</td>
<td>Science research course (Contextual science research experience with sea grasses)</td>
<td>Science Research Course (Contextual science research experience with water quality)</td>
</tr>
<tr>
<td>Summer 2000</td>
<td>Science research course (Contextual science research experience with water fluoridation)</td>
<td>Finishing teacher education courses (Working full time to support family, unable to participate in second summer)</td>
</tr>
<tr>
<td>Fall 2000–Spring 2001</td>
<td>Finishing teacher education course and semester-long teaching internship</td>
<td>Finishing teacher education courses and semester-long teaching internship</td>
</tr>
<tr>
<td>Fall 2001–Spring 2002</td>
<td>1* year of teaching (SERVE monograph work and some observations and interviews)</td>
<td>1* year of teaching (First school) (SERVE monograph work and some observations and interviews)</td>
</tr>
<tr>
<td>Fall 2002–Spring 2003</td>
<td>2* year of teaching (Observations and interviews)</td>
<td>2* year of teaching (Second school) (Observations and interviews)</td>
</tr>
<tr>
<td>Fall 2003–Spring 2004</td>
<td>Maternity/family leave (final member checks done this year)</td>
<td>3* year of teaching (Final member checks done this year.)</td>
</tr>
</tbody>
</table>
“Rob”

One of the two novice teachers in this study is an older, retired military man with grown children. After serving in the military in an enlisted capacity, he worked nightly at a local paper plant while attending college.

Initially, he was not comfortable doing science research. He told me in an interview that he avoided taking science courses during his schooling because he really did not like science. As a pre-service teacher, he said that he felt that he would prefer teaching mathematics. However, Rob was an enthusiastic participant in the pilot study. During this study, Rob wrote a paper (Wark, 2002) on his experiences, published in the monograph, *Experiential Learning for Pre-service Science and Mathematics Teachers: Applications to Secondary Classrooms*. I included his paper, with my own comments, in Chapter 7 of this dissertation.

As the follow-up study progresses, Rob grows increasingly tired of my many classroom observations, interviews, and member checks. I believe this is due to his demanding schedule of teaching, working part-time elsewhere, and maintaining his family life. In consideration of Rob’s schedule, I try to keep my observations to a minimal while maintaining the integrity of the study.

“Cathy”

The other novice teacher, Cathy, participated in the pre-service science research for two consecutive summers. During the course of the study, Cathy presented at two conferences on the CO-LEARNERS project and wrote a chapter for the SERC@SERVE monograph (Tarter, 2002). I include her paper, with my own comments, in Chapter 6 of this dissertation. She was an enthusiastic participant, and hopes to pursue her own graduate degree(s) in the near future. She was eager to observe the graduate student role to better prepare herself for her future studies. Cathy, too, has some time management issues as she was teaching full-time, was a newlywed, and then an expectant mother during the final phase of the study. She is now a new mother, and will return to teaching in the fall of 2004.

Unlike Rob, Cathy has always enjoyed science. She remembers that a certain teacher sparked her interest. She hopes to emulate that teacher when she begins teaching again in her own classroom.

*Description of My Study*

Based on the data collected from the CO-LEARNERS’ Pilot Study, my study focused on the novice teachers previously mentioned. I followed these novice teachers into their respective
classrooms to look for evidence that their participation in contextual scientific research may have on their actual classroom practices. While my pilot study looked mostly at the beliefs of these teachers while engaged in the contextual research, my dissertation study focused on what influences the contextual research experiences may have on their actual teaching practices, as well as their beliefs.

The Follow-Up

After the first summer of the pilot study and contextual science research course, I arranged for Rob and Cathy to work with their practicing teachers in a teaching practicum in the fall semester to further the collaboration and transfer their experiences into the classroom. I maintained contact through E-mails and infrequent observations during the practicum experiences. Following the second year of the pilot study, both teachers were still enrolled in their respective teachers education programs for an additional year. After the second summer of the contextual science research course, Cathy was unable to work with Sandy as she had already completed a science practicum, and needed to complete a mathematics practicum.

Following the completion of their coursework, they participated in teaching internships. Christy and Rob completed semester long teaching internships. I did not observe the participants because university faculty observed them and there were other pressure involved. I did maintain contact through E-mails. While Rob and Cathy were completing their studies, I completed the summative and formative analysis requested by the NSF of the pilot study, and presented papers on the pilot study at various teaching conferences.

The First Year of Teaching

During the first year of teaching during the follow-up study, the primary data source was a piece of reflective writing by the novice teachers. This writing was originally an assignment completed as part of the summer research course. During the first year of the follow-up, SERC@SERVE gave the participants an opportunity to submit a chapter for their monograph. This monograph entitled, *Experiential Learning for Pre-service Science and Mathematics Teachers* (Gilmer et al., 2002) includes chapters from participants from the CO-LEARNERS’ pilot study, my major professor, and me. I, along with my major professor and a fellow graduate student, also served as co-editor of the monograph, as well as a contributor.

Due to the time and effort required in taking the assignment from a simple report to a piece of reflective writing suitable for publication, I negotiated with the participants to postpone
the observations and interviews until the second year of teaching. For their first year, we elected
to use the writing as a piece of data which would reflect their research experiences and how that
experience had begun to influence their first year of teaching. Rob and Cathy were delighted
with the opportunity to publish a scholarly piece of work.

I felt that this was an excellent option, since the first year of teaching is a very trying time
for a novice teacher. I made several classroom visits to assist them with their writing, take
photographs of their classrooms for inclusion in the monograph, and provide feedback on their
chapters. I needed this prolonged engagement in order to follow the teachers into their second
year of teaching and to observe any influences their participation in a constructivist-based,
contextual science research experience may have had on their teaching beliefs and practices. In
support of the need for prolonged engagement, Hickok, Melear, and Suters (2002) assert that the
impact of pre-service education programs may not be evident until the teachers have been
teaching two or three years, or more.

The Second Year of Teaching

Beginning in the summer of 2002, I contacted the teachers to arrange for the best time to
begin classroom observations and personal interviews during the fall of 2002. Once we arranged
classroom observations, I conducted one-to-two classroom visits per week for each teacher over
two nine-week grading periods in the same class period for consistency. I observed and
interviewed the teachers one-to-two times in each of the nine-week grading periods, one in the
first semester and one in the second semester of the school year. In some instances, more
interviews were necessary to clarify information. It was my assumption that two nine-week
grading periods in each semester were sufficient amount of time for a variety of teaching
practices to occur. By variety, I mean lecture, inquiry lessons, laboratory experiments, field trips,
guest speakers, and other types of classroom practices. This was also a sufficient amount of time
for the teachers to cover a range of different content areas in science or mathematics.

I allowed the novice teacher to choose the class period for observations. This class time
was generally prior to a teacher planning time or break so that we could conduct a short
interview afterwards. Each classroom visit included:

1. Classroom observation: During each classroom observation, I took field notes. I
also utilized audiotapes during these classroom visits in order to help me
transcribe dialog and check my field notes.
2. An interview with the teacher using questions such as those listed in Appendix A: Due to nature of the emergent design of this study, these questions deviate slightly. I designed the questions to look for evidence related to my research questions that involved the influence of the contextual science research on the beliefs and practices of the teachers with respect to:
   a. the culture of science versus the culture of classroom science;
   b. access to the science researchers and the science community;
   c. implementation of constructivist-based, contextual science experiences;
   d. integrating science and mathematics in the classroom; and
   e. construction of science content knowledge and pedagogical content knowledge.

3. Follow-up electronic sessions designed to encourage participation and discussion from both teachers: After each classroom visit, I E-mailed the teachers to generate reflections on that week’s observation. E-mails occurred as needed for maximum output of reflections, ideas, feedback, concerns, and other comments. Further questions and findings continued to emerge, as this is the nature of this type of interpretive study.

   Along with field notes, I also transcribed the dialog between the novice teachers and their students; between the novice teachers and myself; and any dialog between my doctoral committee and myself. This dialog resulted from observations, interviews, E-mails, or telephone conversations. After each visit to the teachers’ classrooms, I transcribed the field notes and the interviews, and then sorted the qualitative data using the QSR software to look for emerging patterns related to my research questions. I refined my interpretations and attempted to answer my research questions in a reflective and interpretive manner based upon the qualitative data collected from the study. These observations and interviews continued through the end of the spring 2003. I completed the final analysis of the data and writing of the dissertation throughout the spring of 2004. I completed my final submission of the dissertation during the summer of 2004.

   **Voice**

   Another feature that endears me to fourth generation evaluation, as well as the qualitative methodology is the use of voice. I believe that qualitative studies effectively display the use of
expressive language and the presence of voice in text. I enjoy writing as though I am telling my story of what I have learned throughout this journey, or research. The detachment of voice, as in quantitative studies, gives an air of distrust in my opinion. Researchers are human beings. One’s voice makes it clear that a caring person, who is interested in learning something important that will ultimately help others, is behind the voice. I find it ironic when people use rhetorical devices in some social science journals, it masks the fact that a person did the work. When I read the research of others, I trust the researcher with whom I can identify more than the one who writes “the researcher did this or that.”

The presence of voice and the use of expressive language are powerful tools, which can imply empathy. I define my interpretation of empathy (as previously discussed in Chapter 2) as the feeling that the teacher develops through experience that will enable him/her to know what it is like to be a student, a learner, and, therefore, will be able to teach with those feelings in mind. With empathy, we gain feeling and emotion. When studying the importance of improving teacher training and education in the lives of our children, there is emotion. Reading about any type of research that can impact the lives of children can be emotionally powerful. To disguise the emotion of the researcher makes it less powerful, in my opinion. Analogous to reading a great novel, the first person always draws you in.

Kvale (1996) asserts that both quantitative and qualitative methods are useful tools, but their usefulness depends on their power to answer the research questions asked. As tools, she explains, they require different competencies from the researcher with respect to ability and interest. To carry out qualitative research requires linguistic or empathic analysis of the qualitative data. I think that I am well suited as a qualitative researcher, as I feel great empathy for teachers as learners, based on my own experiences as a teacher/learner.

My Voice

Lincoln and Guba (2000) offer the “notion of a ‘passionate participant’ as facilitator of multi-voice reconstruction” (p. 171), when discussing voice, which they call “inquirer posture” (p. 171). I cannot deny that my voice is passionate in this paper, as I base this study on strong personal beliefs, as well as passion. However, as Lincoln and Guba (2000) would agree, this is one of the unique qualities that separate a constructivist-based study from a study done by a positivist, “disinterested scientist” who serves only as an informer.
To limit bias on my part as a passionate participant, my major professor and committee members serve as “devil’s advocate” of my research. They effectively call for me to continue to question and limit my own personal biases. For this I am grateful, as it is difficult to separate my own experiences from those of my novice teachers.

**Voices of the Participants**

The participants’ voices will be heard in this dissertation. I strive for this by using the qualitative, interpretive analysis of *their* reflective writings, observations and interviews, which take place in *their* classrooms. To insure that their voices are heard, I utilize a modified triangulation (Lather, 1986; Guba & Lincoln, 1989; Stake, 2000) to provide a variety of participants’ reflections, actions, and discussions. Lather (1986) calls for the use of “a triangulation expanded beyond the psychometric definition of multiple measures to include multiple data sources, methods, and theoretical schemes” (p. 146).

To respond to Lather (1986), I prefer the crystallization approach described by Richardson (2000). To avoid the positivist implication of triangulation, the crystallization approach recognizes that “there are far more than ‘three sides’ from which to approach the world” (Richardson, 2000, p. 934). Richardson describes crystallization:

> Crystallization, without losing structure, deconstructs the traditional idea of ‘validity’ (we feel how there is no single truth, we see how texts validate themselves), and crystallization provides us with a deepened, complex, thoroughly partial, understanding of the topic. Paradoxically, we know more and doubt what we know. Ingeniously, we know there is always more to know. (p. 943)

This beautifully sums up how the qualitative nature of this study emerged and how I chose to analyze the data. However, closer to the definition of triangulation, I use three types of qualitative data.

First, I included two chapters written by the novice teachers (Tarter, 2002; Wark, 2002). I encouraged the two teachers to submit these chapters for an educational monograph. I assisted in the editing of their chapters, as they were initially reports submitted to me as part of their requirements for the contextual science research course. Through negotiations, feedback, and the hermeneutic dialectic circle, these reports evolved into quality pieces of reflective writings.

Second, I observed their classrooms to reflect their practices in terms of any influences from the contextual science research. I note what takes place in the classrooms and how it may or may not reflect the beliefs that they discuss in their writings, E-mails, or interviews. Third, I include
analysis of interviews with each teacher. These interviews include discussions extending back to their prior experiences, their contextual science research experience, their pre-service experiences, their first year of teaching, and their second year of teaching. Their voices are critical in this qualitative study to help determine what influence their scientific experiences has on them as novice teachers, thus giving insight into considering science research for pre-service science teachers.
Chapter 6 begins with a chapter (Tarter, 2002) written by Cathy, taken from the SERC@SERVE monograph entitled, *Experiential Learning for Pre-Service Science and Mathematics Teachers*. Her chapter details how the research experience influenced her beliefs about science and science teaching. She also discusses the benefits of the experiential, contextual research course, offers recommendations for improvement of the course, and stresses the importance of utilizing teaching practices that make science fun and meaningful for students. Cathy does not include much discussion on the classroom activities or practices that she utilized during her first year of teaching. Her chapter mostly focuses on her summer research experiences and on her thoughts on how these experiences might influence her teaching in the future.

Cathy had much to say in her chapter, as she had been a participant in the CO-LEARNERS study for two summers completing two distinct research projects. I chose not to edit the length of Cathy’s chapter for this dissertation, in order to retain its integrity because it provides evidence of her gains in science content and professional confidence. I made some formatting changes for electronic dissertation submission purposes. I also changed the names of the practicing science teachers and science researchers involved with Cathy’s study in order to maintain their anonymity. A more formal, interpretive analysis using the QSR software program follows Cathy’s writing.

**Cathy’s Reflections Through Her Writing on Her Contextual Science Research Experiences**

I elected to include Cathy’s excerpt in my dissertation because it was part of the course requirement for the *Experiential Science and Mathematics in Middle School* course highlighted in this study. She originally submitted this paper to me, the instructor of record. The original paper later became the foundation for the SERC@SERVE chapter in which Cathy described her contextual science research experiences. Cathy’s voice is important to hear in this dissertation. I include copyright waivers from Cathy, Rob, and SERC@SERVE in which they grant me
permission to use these chapters. These can be found in Appendices E, F, and G. Cathy’s text is all in italics.

Science: Not Your Typical Textbook and Lecture-Based Class Anymore introduction
A CO-LEARNERS Participant Over Two Summers

As a participant in CO-LEARNERS Program for two summers, I would like to address each summer as a distinct research project. While both experiences were educational and valuable during my teaching education, each was unique and presented various challenges. In this chapter, I will discuss each research experience, then compare the two by discussing the benefits, and finally make recommendations for improvement.

Prior to my first summer with the CO-LEARNERS Program, the only research experiences I had were in college laboratory classes. So, when the opportunity arose to work with real-life scientists, I jumped at the opportunity. In the first summer, I worked at the State of Florida Department of Environmental Protection (DEP) laboratory on the cloning of various sea grasses. My experience working in the laboratory and in the field with the DEP was wonderful. I learned quickly how much work and detail goes into restoring the environment. In the laboratory, I worked in a sterile environment making sure to follow procedures correctly. In the field, I participated in rebuilding areas with sea grasses grown in the laboratory. Much emphasis was placed on detail and procedure. It was a little tedious sometimes, but fun.

During the second summer of research, I worked at the Wetlands Research Laboratory located at the University of West Florida. The project involved researching the benefits and concerns of the use of fluoride in local drinking water. My practicing teacher/partner was Sandy Porter. She and I conducted several water collections at various sites, performed several laboratory tests, and contributed to a report on the safety of adding fluoride to the county drinking supply. The Wetlands Research Laboratory prepared the report for the Escambia County Utilities Authority (ECUA). The report targeted the community’s concerns relative to the addition of fluoride to the county’s water supply.

Summer One—Cloning Sea Grass

Perceptions of the Scientist

When students picture what a scientist looks like, they usually envision a man with black-rimmed glasses, lab coat, pocket protector, and crazy white hair. I, too, imagined the same type
of individual before working on the summer research projects. I expected the people at the DEP to be boring and nerdy. However, this was not the case. Both Charles Kirsch and Rich Hart were far from that image. In fact, everyone that I met from DEP was excited about their work and explained their research enthusiastically. In turn, I became excited about the work I was doing. I had expected the work to be boring, but I changed my mind quickly.

“Cloning” Around

During my summer with the DEP, I learned how to clone sea grasses that would one day be planted in the local environment. Sea grasses are flowering plants that live underwater. Like land plants, sea grasses produce oxygen. The depths at which sea grasses are found are limited by water clarity, which determines the amount of light reaching the plant. Although sea grasses naturally occur throughout the coastal waters of Florida, they are most abundant from Tarpon Springs northward to Apalachee Bay. Sea grasses also grow in protected bays and lagoons, as well as along the continental shelf in the Gulf of Mexico. Florida’s estimated 502,000 acres of sea grass meadows are important natural resources that perform many significant functions including:

1. Maintaining water clarity by trapping fine sediments and other particles in their leaves
2. Stabilizing the bottom with their roots and rhizomes in much the same way as land grasses retard soil erosion
3. Providing habitat for many fish, crustaceans, and shellfish
4. Providing food for many marine mammals as well as the smaller organisms that live on their leaves, and
5. Providing a nursery area for much of Florida's recreationally and commercially important marine life

Sea grass leaves provide excellent protection for young marine animals from larger open water predators. Some animals, including manatees, eat the sea grass blades. Still others derive nutrition from eating algae and small animals that colonize the sea grass leaves. The colonizing organisms provide an additional link in the marine food chain (Florida Keys National Marine Sanctuary, 2002).

My lead teacher and partner was Pam Brown. She and I gathered various sea grasses in the area from local state parks and bayous and brought them back to the laboratory to begin the
cloning process. Gloved, Pam and I worked under a sterile hood to separate the sea grasses into many smaller parts that were then placed in test tubes containing a saltwater solution. The test tubes were dated, labeled, and placed under artificial light for about six weeks. Once the sea grasses matured, they were split again and placed in test tubes again. When enough sea grasses were cloned, they were transported to a tank containing a mesh-like material where they would continue growing. Once the sea grasses were large enough, they were taken to the greenhouse.

At the greenhouse, Pam and I continued our work of separating the sea grasses into smaller plants for continuous growth and reproduction. The process of cloning and growing sea grasses is long and takes a lot of work. However, when I was able to take the sea grasses I had worked with and plant them back into the environment where they were needed, I felt a great sense of accomplishment and pride. Today, two years after planting the sea grasses, the impact from my efforts to help the environment is still seen. In fact, the DEP has begun a huge sea grass restoration project based on our initial research.

Textbooks Have Their Place, But...

The culture of science in the classroom differs from my experiences because most teachers rely on textbooks to teach students what is science. Students have little opportunity to work in laboratory settings where they can apply what they learn in the classroom to real-life experiments. Many teachers lack laboratory skills, do not have or do not know how to obtain resources, or do not think their students are capable of performing in a laboratory setting. There are many reasons why it is convenient to use a textbook. One reason is that it takes time to develop and implement hands-on projects and laboratories. What incentive is there for teachers to spend a lot of time developing curriculum? Well, most of what a student reads or tries to read in a science textbook is incomprehensible because of students’ reading level and interest in reading. Someone who has ever tried to put something together, like a child’s bicycle, by relying on an instruction manual, understands the difficulty of reading unfamiliar information. Students who lack prior knowledge face such difficulties with textbooks.

Teachers should use textbooks as only one of many resources. Student involvement in planning activities could make students feel more ownership of their learning. Allowing students to work in groups for research and laboratory activities enables students to change previously held science misconceptions and discover that science exists in the real world outside of a textbook.
If the goal of science education is to promote the learning and interest in science, then we must make what students are learning useful and applicable in their world. Science teachers can do that by planning more laboratory exercises and bringing community scientists into the classroom to answer questions and promote interest.

Out of the Lecture Hall and into the Laboratory

In a lecture-only science course, topics are condensed in order to cram in as much information as possible, and by the end of the course, most of the information is forgotten. However, by reducing the amount of material covered and focusing on learning for understanding and application of what students are learning, students and teachers benefit.

My interest in science began in middle school in the sixth grade. We dissected frogs and worms. I loved it! My science education in middle school was mostly hands-on. This ignited my desire to solve problems and study weird and exciting topics.

As a teacher, I want to make science fun and interesting. I will not have my students read one chapter after another and answer questions at the end of the chapter. I do not learn that way. I encourage students to develop their own questions from science laboratories and activities and discover how things work and grow. Using discovery-based lessons and asking open-ended questions make students think about what they are learning and gives them the opportunity to develop communication, research, and technical skills. I also want students to share with their classmates what they discover and help each other understand and explain various concepts. I hope to make students aware of how much fun science is and that everyone can be a scientist.

Recommendations from Summer One


One thing that we concluded from the first summer was that university students should be required to keep a daily log, be evaluated weekly on progress on what is being learned, and have continual contact with the university instructor and research coordinator. This helps when an individual has a question. It is my opinion, too, that when people write something down, they are more likely to remember it.¹

¹ Cathy offers excellent recommendations for the project, which I noted and implemented the following summer. Her insight into the notion that “when people write something down, they are more likely to remember it,” is very critical in this type of study. I required participants to keep a journal for the following summer.
2. Offer Limited Guidance.

The university coordinator and lead teacher should guide the pre-service teacher to create lesson plans and a research paper. University students need to know beforehand what is expected of them with a syllabus. They should contact the teacher if a problem should arise. This recommendation, too, was met somewhat. It was explained to us later that because the project is constructivist-based, we were not told exactly what to do because we were to “construct” our own learning and develop evidence of this learning.

3. Have a Back-up Researcher.

Because our lead researcher was extremely busy, he did have the foresight to have Rich Hart work with us directly along with an intern. This was a problem in the second summer, as I will address later. This point is extremely important because a science researcher is an integral part of the learning process; therefore, one should be accessible at all times. This was not a problem in the first summer with the DEP, as Rich Hart worked very closely with Pam and me. He answered our questions, helped guide us through our investigations, and gave us necessary feedback. He was also very open to suggestions made by me and Lori Hahn, the graduate researcher and instructor of the course.


Initially, Pam and I felt as though we were doing “free labor” for the DEP. Since this was the first year with such a project, it was difficult for Rich to know exactly what we were supposed to be doing. He was very agreeable that this project needed to be more research-based. The following summer, while I did not work with the DEP, the group that did was immersed in an actual research investigation from the beginning.

Benefits from Summer One

1. Learning [Science] Content

All in all, the first summer was very worthwhile. I learned valuable information that will help me be a better science teacher. The scientists were helpful and excited about helping me learn about their fields of science. Pam, as the experienced teacher on my team, was excited and helpful in suggesting ways to implement various ideas into the classroom. This type of program should be a part of teacher preparation programs for all levels of education so future and current teachers can realize the importance of meaningful science education. Teacher education students need more field and laboratory experiences.
2. Making Contacts in the Science Community

Having contacts in the science community is beneficial for practicing and prospective teachers. During this summer program, I gained several contacts and obtained teaching materials from the people I worked with at the DEP. One gentleman gave me bookmarks, magnets, lesson plans, case studies, and fun activities that I can use with my middle school students no matter what their level. Knowing that people in the community are willing to contribute to science education makes my job easier.

3. Ideas and Encouragement to Provide More Student Involvement

I now know how much fun science education can be for students. During my research experience, I enjoyed learning how to solve problems, how to help the environment, and how interesting environmental science is today. As a teacher, I will be able to explore with my students all areas of science and find ways to promote student involvement. I realize that students and I need to get as much as possible out of what is being learned and taught. Science education needs to be applicable, interesting, and hands-on if teachers and students are to maintain interest and develop a love of learning science.

4. Classroom Applications

What I learned from participating in my first summer research project can easily be implemented in my classroom. The scientists and staff at the DEP were very supportive. I received many lesson plans and materials from the DEP that can be used with all grade levels. Many of the lessons are activity-based where materials are cost-friendly or can be obtained from the DEP. One idea I found is to present groups of students with an environmental problem to solve, while taking into consideration the cost, protection of plants and animals, resources, and time. Many resources and lesson ideas can be found on the Internet. The DEP (2000) and EPA (2000) Web sites provide lessons, information, and materials to use in the classroom.

DEP scientists were willing to visit my classroom to discuss what they do and to show students how the environment can be improved. I also can take students on a field trip to the DEP laboratories and greenhouse where they could plant their own sea grasses. Students could return months or years later to see their work making a difference in the environment.

Summer Two—To Add or Not to Add Fluoride?

My Initial Research—Learning What Was Known
During the summer of 2000, I worked with Dr. Jim Little, Dr. Randy Smith, student Amy Hamilton, and practicing teacher Sandy Porter researching the impact of fluoridation of the municipal drinking water for Escambia County at the Wetlands Research Laboratory at the University of West Florida. The Escambia County Utilities Authority (ECUA) contracted the Wetlands Research Laboratory to conduct research, which would enable them to answer questions from concerned citizens about the ECUA’s decision to add fluoride to the county municipal drinking water at 0.8 mg/L. Several tasks were developed for this project, including assessing the concentration of fluoride and the pH of area waters and ground water wells, analysis of hydrofluosilicic acid to be added for metals contamination, and analysis of the environmental fate of the fluoride ion by laboratory simulations. Though all tasks were not completed during my allotted time on the project, I have learned what water fluoridation means, the pros and cons of water fluoridation, the research findings during that summer, and the importance of applying hands-on science learning in the classroom.

Fluorine is a halogen. The word halogen comes from a Greek word meaning, “salt former.” Halogens are nonmetals that combine with metals to form salts. Halogens, such as fluorine, can accept one electron and form an ion with a single negative charge, such as \( F^- \), which is called fluoride. None of the elemental halogens are found as single uncharged atoms but as diatomic molecules, like with fluorine as \( F_2 \).

Fluoride helps prevent tooth decay by making teeth resistant to the acids that cause tooth decay. Fluoride “is an essential element for mammals” and “it is toxic to both animals and plants at high concentrations” (Lepo & Snyder, 2000, p. 1). However, the amount of hydrofluosilicic acid that the ECUA is adding to the municipal drinking water is only 0.8 mg/L, which is between the recommended concentration level of 0.7 to 1.2 mg/L. Water fluoridation “is the process of adjusting the natural level of fluoride to a concentration sufficient to protect against tooth decay” (ADA, 1999). Water fluoridation began in January 1945 in Grand Rapids, Michigan (Doyle, 1996). Since then, water fluoridation has spread across the United States as a way to reduce dental caries and dental costs.

Fluoride is everywhere. It “flows from the continental drainages to the ocean at an estimated rate of 3.7 million metric tons a year” (Lepo & Snyder, 2000, p. 1). It is in all soils and waters in various amounts. Many water systems in the United States are naturally fluoridated at levels higher than what is recommended. Those cities or communities who have
added fluoride to the drinking water systems do so to provide everyone, both rich and poor, a nutrient needed by the body to increase the stability of teeth and bones. The cost to those cities is related to the size of the community, number of wells and treatment plants, amount and type of equipment, amount and type of fluoride chemical, and personnel costs (CDC, 1992).

In saltwater, “fluoride is naturally present at a concentration around 1.32 parts per million (ppm), [so] anyone who spends a significant amount of time in the Gulf/Ocean, consumes seafood, or uses sea salt for food preparation/consumption… already experiences levels of fluoride near that which will be added to the municipal drinking water supply” (Lepo & Snyder, 2000, p. 3). Fluoride is a nutrient used by the body. What the human body does not need is excreted in urine. However, like other nutrients, there is a toxic level. A human must consume 2.5 g to 5 g at one time, which has not occurred from naturally fluoridated water systems or those where fluoride has been added (Richmond, 1985).

Even though water fluoridation has been around since 1945 and over 35,000 papers have been written reporting its safety, debates still exist over the issue. However, with this issue, and countless others, people are influenced by what they learn from the media, so-called experts, the Internet, and rumors. It is difficult for most people to read scientific journal articles to understand what water fluoridation is and its impact over the past 57 years.

Water fluoridation has been provided for over 50 years because it prevents and/or reduces dental caries. Dental caries are formed when “oral bacteria in plaque ferment sugars to produce a range of organic acids that promote dissolution of tooth enamel” (Lepo & Snyder, 2000, p. 9). When water fluoridation began, people were not taking fluoride supplements or using fluoride toothpastes and gels because they were not available. If people could not afford to go to the dentist regularly, they most likely developed dental caries. Water fluoridation became a solution because it is the “most equitable and cost-effective method of delivering fluoride to all members of most communities, regardless of age, educational attainment, or income level” (CDC, 1995).

With regard to all of the research that has been done on water fluoridation, fluoride added to water would not be here today if it were life threatening. Lepo and Snyder (2000) report that the National Cancer Institute:

  evaluated the relationship between fluoridation and cancer mortality in the U.S. during a 36-year period and a 15-year period. There were 2.2 million cancer death records and
125,000 cancer case records in counties using fluoridated water, but there was no correlation between cancer cases and fluoridated drinking water. (p. 15)

Other studies have also proven that water fluoridation does not cause cancer, kidney disease, or heart disease. The American Dental Association has endorsed fluoridation for more than 40 years.

Many communities all over the United States already provide fluoridated water. As of February 1996, the following percentage of communities in states had fluoridated water: North Dakota, 96%; South Dakota, 100%; Iowa, 91%; Minnesota, 93%; Georgia, 92%; Alabama, 83%; South Carolina, 90%; and Kentucky, 100% (Doyle, 1996, p. 20). More than “half the children in the country now live in fluoridated water districts, and most dental health officials say this is why U.S. tooth decay rates have plummeted 50% in the last 20 years” (Marshall, 1990, p. 276). Opponents of water fluoridation argue that adding fluoride is a violation of civil rights. If it works and has worked for so long and no one has been harmed by it, why fight so much?

What I Learned from the Experience

1. Working as a Team

During my research, I wrote this in my journal:

I met Sandy Porter today, and she is really nice. Angela showed us how to clean the sample jars with HCl and DI [deionized] water. Everything we do in the lab is very detailed. We learned how to test the jars for pH level after cleaning them and the need to return our wastewater to neutral before discarding it. We also calibrated our stock solutions. Angela has done this before, but she told us that calibrating the stock solution again lets us know if it is still good to use. This process took awhile to complete. Angela explained all the steps clearly, which made it easy. Angela also showed Sandy and me what we would be taking out to the field to collect samples, in case she couldn’t come with us. After completing the lab activities, all three of us discussed different school issues, such as discipline, lesson plans, state testing, etc. Sandy informed me of many useful points and ideas. I feel comfortable asking her questions. I also spent two hours looking up fluoridation/fluoride articles to begin my paper.

This passage illustrates the value of teamwork and collaboration in science. Pre-service science teachers, practicing science teachers, and science researchers truly learn from one another. This will ultimately benefit the students in the science classes.

2. Getting Dirty

One of our first tasks was to collect water samples to test for the presence of fluoride as it occurs naturally. From my journal:
Angela, Sandy, and I went to the Bayou Marcus Water Reclamation Facility to collect water samples. We collected three jars each of raw sewage, sludge, clarified, and final effluent. The ECUA men at the facility explained the treatment process and walked us through the facility. They also gave us a pamphlet. The information and treatment process were very interesting. We put the jars on ice and carried them back to the lab where they will refrigerate until we begin fluoride testing.

Teachers need to get their students out of the classroom and get “dirty” sometimes. Students are pretty resilient. There is a lot to be learned from expanding the classroom from the traditional four walls.

3. Gathering our Scientific Findings

Experiments and tests still needed to be conducted so conclusions could be drawn for this project. Because fluoride is a nonmetal, it naturally bonds to metals to form salts. So, reactions with copper and solder piping and the hydrofluosilicic acid will occur, but the amount of change and how quickly were to be determined. We were not able to perform tests with the hydrofluosilicic acid because it was on back order.

The Bayou Marcus Water Reclamation Facility in Pensacola, Florida, uses a state-of-the-art water treatment process to purify wastewater before it is released into surrounding wetlands. Fluoride will remain in the soil. How much is dependent on the type of soil, pH conditions, amount of calcium in the soil, precipitation, and water flow. “Clay soils retain fluoride better than sandy soils” (Lepo & Snyder, 2000, p. 2). Escambia County has both types of soil, so the amount of fluoride retention will be determined. With the research conducted for the ECUA by Angela, Sandy, and me, we made the following conclusions:

1. There is natural fluoride in our area waters and municipal water wells (see Table 6-1).
2. Fluoride does not disappear or go away. It gets recycled and filtered through wastewater treatment processes, soil, precipitation, and water flow.
3. Fluoride eventually is released into the environment and back into area waters and the ocean.
4. Fluoride will most likely react with copper and solder piping, but the effects will take years to determine.
5. The effects of fluoride, when released into our local environment and area waters, will take years to determine.
Table 6-1
Fluoride Concentrations of Water Treatment Facilities (mg/L)

<table>
<thead>
<tr>
<th>Treatment Site</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Street (Final Effluent)</td>
<td>1.63</td>
<td>1.55</td>
<td>1.60</td>
</tr>
<tr>
<td>Main Street (Clarified)</td>
<td>1.20</td>
<td>1.17</td>
<td>1.18</td>
</tr>
<tr>
<td>Bayou Marcus (Final Effluent)</td>
<td>0.0838</td>
<td>0.0365</td>
<td>0.0362</td>
</tr>
</tbody>
</table>

Recommendations from Summer Two

1. Making Researchers and Materials More Accessible

Sandy and I conducted as many experiments as possible during this summer project. One inhibiting factor was the inaccessibility of the researchers. While these researchers were willing to work with us, volunteered their time, and were committed to helping teachers with bringing science into their classrooms, they were very busy researchers. I see this as a possible weakness in this type of program. While another student did work with us, teachers need someone with knowledge of the project with whom to be in direct contact, if the researcher is unavailable at any time.

During my first summer, this was remedied by having Rich Hart work directly with us. Mr. Kirsch knew that he would be busy with many projects and designated Rich to work closely with Pam and me. I see this as an answer to such problems. We also had a few other minor problems such as waiting for materials on order. I suppose this is part of the culture of science, however.

2. Scheduling to Avoid Conflicts

However, sometimes there are scheduling conflicts. It is very important that the pre-service science teacher, the practicing science teacher, and the science researcher work together as much as possible. This can be easily remedied with good planning. This should not be considered as a barrier to establishing such programs to allow pre-service teachers the opportunity to experience science research prior to their classroom teaching assignment.

Benefits from Summer Two

1. Learning Science Content

This project was a good experience because I learned what water fluoridation is and factors for its safety and benefits for communities. I knew very little about fluoride prior to this research. I feel like I learned the content better than if I had read it and then was tested on it in a
traditional learning situation, because I actually needed to know the background information before we began running the tests and assisting with the report.

2. Seeing Relevance

My research has helped me realize that I need to keep informed about what is going on in the world and what new things are being done to help our society. I didn’t even know that our water would be fluoridated until I started the project. I believe that keeping my students informed about what’s going on in the science world and performing relevant experiments will boost their interest in what really goes on around them.

3. Experiencing the Culture of Science

I enjoyed working in the laboratory and in the field. Laboratory work is tedious and time consuming but beneficial because the hands-on experiments and tests, along with my research on the topic, made everything applicable and interesting. From this experience, I was able to better understand what is meant by the “culture of science.” The culture of science is very interesting. In contrast, the culture of science in the classroom, as I have experienced, is mostly textbook-oriented and not really hands-on. I think the lack of ideas, time, equipment, and desire to make learning science fun and useful inhibit teachers.

Again, in my experience, the traditional culture of science in the classroom lacks excitement and interest. As a student, I was not motivated to seek answers to questions and research interesting topics. However, working with people who love what they are doing made me want to bring that feeling back into the classroom. Research, discovery, focus, and love of science make the culture of science exciting.

4. Motivating Students to Make Science Fun

I want to make science fun and interesting. I do not want my students to just read chapter after chapter and answer questions. I want them to develop their own questions and then research the answers. I want them to share with their classmates what they discovered and why that information is important to them. I hope to make students aware of how much fun science can be and that everyone can be a scientist.

5. Developing Classroom Applications

A prospective science teacher should be required to perform research and tests in a laboratory setting before graduating. The information and experiences gained can easily be brought into the classroom to make learning rewarding and interesting. Why major in science
education and go into the classroom just to teach out of a textbook that most students have trouble comprehending? A science teacher can give all types of learners a chance to understand and appreciate science because the possibilities are endless in a science classroom.

My research experience will be beneficial to my students. Lesson plans can be developed to help students understand pH, the scientific method, strengths of different solutions, and what the terminology “parts per million” means. Students can bring in water samples from their homes to test the pH, color, smell, and taste. Science and mathematics are better understood through hands-on activities, inquiries, experiments, problem solving, scientific method, and trial and error. I will implement as many hands-on science learning activities as possible to help my students better understand what they are learning and how it applies to their world and surroundings.

QSR Analysis of Cathy’s Reflections on Her Contextual Research Experiences

I divided each section to analyze according to my research questions, which I also used to generate the QSR coding nodes (Table 3-1). I looked for patterns in Cathy’s writing that would reflect any influence that her contextual research experience might have on certain aspects of her beliefs and classroom practices. I found the following four main categories: Beliefs About the Culture of Science and the Culture of Science in the Classroom; Collaborations; The Science Research; and Teaching Practices. I further divided each category into subcategories, as they emerged from the analysis of the writings. There are 316 total sorted passages from the SERC@SERVE chapter and 523 from the interviews with Cathy. When I quote from her chapter, I indicate so by saying she “writes” or “in her writing.”

Beliefs About the Culture of Science and the Culture of Science in the Classroom

Based on her writing, Cathy clearly sees the differences between the culture of science and the culture of classroom science. While she may have mentioned these differences because they were included on the objectives in the syllabus of the science research course, she demonstrates an increased understanding, regardless of what influences she may have had prior to her summer research experience.

The Culture of Science

Cathy divides her beliefs about the culture of science into the comments that she used to describe science before and after her contextual science research experiences. Her beliefs
changed during the course of her involvement over the two summers. Although Cathy came into the contextual science research course with certain pre-conceived notions about science and scientists being boring, as she became involved with the CO-LEARNERS program and began to work alongside scientists and practicing science teachers, Cathy realized that she was having fun. She writes, “I now know how much fun science education can be for students.”

For Cathy, the question remains on how to bring this fun from the science laboratory to the science classroom. The key could lie within the collaboration with the practicing teacher or simply within herself as she begins to feel more comfortable with her role as teacher. I believe that Cathy is determined to make sure her classroom is one that is fun and exciting. She writes, “I hope to make students aware of how much fun science is and that everyone can be a scientist.” While she has the desire to make this a reality for her students, she is already aware of the constraints of the classroom, as evidenced when she writes, “I think the lack of ideas, time, equipment, and desire to make learning science fun and useful inhibit teachers.” Cathy’s thoughts reflected in this statement may play a pivotal role in her inability to do many of the things that she expressed a desire to do during her first year of teaching.

Gaining Laboratory Skills

There are 10 passages from her chapter specifically about learning laboratory procedures. While Cathy expressed that the laboratory work was tedious and detailed, I think that this helps her to better appreciate the learning experience because it provides her with better insight into the differences between classroom science and authentic science. She writes, “Laboratory work is tedious and time consuming but beneficial because the hands-on experiments and tests, along with my research on the topic, made everything applicable and interesting.” Cathy, deeply committed to helping her students gain and experience laboratory skills, writes, “I encourage students to develop their own questions from science laboratories and activities and discover how things work and grow.” This is one of few passages that imply that Cathy has begun to put some of her beliefs into practice during her first year.

Perceptions of Scientists

In one of my first interviews with Cathy, I asked her to describe how she felt students’ perceived scientists and the study of science. She responded, “When students picture in their minds what a scientist looks like, they see a man with black-rimmed glasses, lab coat, pocket protector, and crazy white hair. I, too, have pictured the same thing” (Interview, May 12, 1999).
However, after her contextual experience working with the scientists, Cathy realized that her perceptions had changed as she became immersed into the culture of science. Additionally, I believe that she feels that she became a scientist herself. She made this statement following her first summer of research, “[After working side by side with scientists], I perceive scientists and the study of science to be very interesting and fun!” (Interview, August 11, 1999).

This is an important revelation for Cathy. Our popular culture has a great deal to do with the way our students perceive scientists. In results from a “Draw A Scientist” study, Chambers (1983) finds that students draw images of scientists that portray scientists, in general, as the bald, middle-aged white man with a white laboratory coat. He works in a laboratory, has crazy hair, and has no social life. I find similar results in my own classroom, and these results can be echoed in many classrooms across the country. Pop culture plays a significant role in the perceptions that students have of scientists. Movies, such as “The Nutty Professor,” “Frankenstein,” and “Jurassic Park,” often portray the scientist as “mad,” crazy, nerdy, and, often, evil. Such scientists often use science for destructive and diabolical purposes that violate the ethics of science. These images also portray scientists as smarter than the average person, making science seem unapproachable to the average person. Another reason that students’ perceptions of scientists and science are so distorted could be that they, themselves, have so few opportunities to be scientists. Teachers may also feel that they have few opportunities to be scientists.

Kielborn (2001) finds that 6th grade students’ perceptions of scientists change after they themselves have become immersed in science field-based investigations. Post-DAST (Draw a Scientist Test) (Chambers, 1983) yields drawings of scientists with more laboratory tools and equipment, scientists working outdoors as opposed to in laboratories, and younger scientists than those drawings on the pre-DAST. This provides evidence that when students become scientists, they begin to look at scientists in a more realistic way, and they see themselves as scientists.

I think that one of Cathy’s goals in teaching is to make sure that her students see scientists without the stereotype because she had these negative perceptions, as well, prior to her summer research experience. When I asked Cathy, “Did working in a science research facility meet your expectations?” She responded in an interview following her first summer research experience:

I expected the people I worked with to be boring and “nerdy.” However, everyone was excited about their work and explained everything with enthusiasm. I, too, became excited about what I was doing. I also expected the work to be boring, but it wasn’t. I
learned how to clone sea grasses to one day be planted in the environment. (Interview, August 11, 1999)

By the teacher inviting a practicing research scientist into the classroom, the students have the opportunity to glimpse into the real world of science and of the scientist. Through negotiations, discussions, and critical discourse among the stakeholder participants in this study, this collaboration helps the novice teacher participants establish a classroom environment that embraces a more realistic image of the scientist. A program that brings scientists and teachers together would greatly help to demystify science by bringing the real world of the scientist to the classroom. Massell and Searles (1995) assert the following:

Typically, elementary students think of scientists as white males wearing laboratory coats. When children meet and work with scientists who do not fit these stereotypes, they often are as curious about the scientist as they are about the science that he or she practices. (p. 23)

One caveat of the CO-LEARNERS pilot study was to recruit a science researcher who was willing to work with the teacher in the classroom. The most important factor was the scientist’s desire to become involved with the project, and his/her interest in improving science teaching and learning in the middle and/or high schools. He/she should have been able to establish a good relationship with middle school students and been one who refrained from talking “over their heads.” An ideal participant would be a female, ethnic minority, or younger individual in order to ensure a move away from the stereotypical older white, male scientist. To recruit someone who fits the stereotype and had difficulty relating to the students would negate the attempts to demystify science and could make a further negative influence on the students’ perceptions. There were also many scientists who might appear to be a stereotypical scientist, but who might make excellent mentors.

The Culture of Science in the Classroom

Cathy bases her interpretations of the culture of science in the classroom upon her prior experiences, both as a student and as an observer in classrooms. In her writings, she distinguishes between the culture of science from the culture of science in the classroom, based on her experience with the contextual science research course, as demonstrated in this statement, “In contrast, the culture of science in the classroom, as I have experienced it, is mostly textbook-oriented and not really hands-on.” Cathy further explains in her writings, “The culture of science
in the classroom differs from my experience in the [contextual research course] classroom because most teachers rely on textbooks to teach students what is science.”

In these passages, Cathy realizes that the culture of science that she has experienced in her research experiences is different from the traditional approach she experienced in the classroom. By participating in a hands-on approach, Cathy is able to see this difference from the traditional approach and then to make decisions on how to change her own classroom. She writes, “In fact, everyone that I met from DEP was excited about their work and explained their research enthusiastically. In turn, I became excited about the work I was doing.”

I took into consideration Cathy’s suggestion, mentioned in her chapter, about assuring that the research was “authentic” and not free labor for the science facility. When planning for future science research experiences, I gave this recommendation critical recognition, as the whole intent of the summer research was to immerse the pre-service teachers into an authentic science research experience.

Teaching Practices

While Cathy mentions little about her teaching practices in this chapter, she speaks of her beliefs with conviction. She frequently discusses forming collaborations with scientists in the classroom. She plans to move away from the traditional manner of teaching science and plans to implement contextual learning experiences, experiential learning, and more hands-on science. She discusses engaging students, incorporating meaningful and real-life science, and giving her students a voice in her classroom. In doing all of this, she wants to make learning science fun and interesting for her students. I see the beginnings of a teacher who will allow for constructivist-based learning in her classroom.

Constructivist-Based Teaching

Cathy was somewhat familiar with the theory of constructivism. We discussed this idea on several occasions. She believes constructivist-based teaching has many parallels to an inquiry-based teacher. She also feels that her participation in the contextual research courses helped her to construct meaning from the experiences. This helps her to better understand the concept. She writes, “It was explained to us later that because the project is constructivist-based, we were not told exactly what to do because we were to construct our own learning and develop evidence of this learning.”
Cathy wrote this passage in response to the absence of a detailed syllabus for the first summer of the contextual research course. When I later explained that the course was constructivist-based, she was satisfied with the explanation, as she was familiar with the term constructivism from her science methods course. Perhaps this was the first time she had experienced a course guided by constructivism, however.

**Contextual Learning**

Cathy, in general, writes of positive experiences through her participation in the contextual research courses in both summers. Her frustrations with the lack of a detailed syllabus the first summer and the inaccessibility of the main science researchers appear to be negated by the encouraging comments she offers in her writings. She writes, “My experience working in the laboratory and in the field with DEP was wonderful.” I believe that Cathy thoroughly enjoyed her laboratory and field experiences within the context of science. In her chapter, she writes, “Prior to my first summer with the CO-LEARNERS program, the only research experiences I had were in college laboratory classes.”

Prior to her involvement with the CO-LEARNERS program, Cathy was not involved with other contextual learning experiences. Traditional college laboratory classes often do not recreate the context of science. Rather, they constitute pre-existing findings based on procedures repeated year after year. Cathy writes of her research with the water fluoridation project:

I feel like I learned the content better than if I had read it and then was tested on it in a traditional learning situation, because I actually needed to know the background information before we began running the tests and assisting with the report. This is a classic example of contextual learning. Her immersion into the context of the fluoride study allowed her to learn much more about the science than she might have if she had been in a regular college lecture-driven course, or in a laboratory, which would most likely have used the standard cookbook type of experiment.

Based on her own positive experiences and on her possible empathy with her students as learners, I believe that Cathy will provide some form of immersion opportunities for her own students. Her classroom will be one in which students will be able to learn within the context of a variety of science topics. She writes, “Teachers need to get their students out of the classroom and get ‘dirty’ sometimes. Students are pretty resilient.” In this passage, while she does not use the term *contextual*, she implies the need for taking students out of the traditional classroom and placing them into the context of what is to be learned. She also writes, “Students have little
opportunity to work in laboratory settings where they can apply what they learn in the classroom to real-life experiments."

Nine passages in the text describe Cathy’s desire to engage her students in science. I think that through her own engagement in this contextual science research course and through the subsequent feeling of empowerment that she gained from participation in the sea grass study and the fluoride research, her experiences ignited her interest to the extent that she is now considering providing similar opportunities for her own students. She writes, “Student involvement in planning activities could make students feel more ownership of their learning.”

Cathy asserts, in her chapter in regards to her own experience, that she “learned the content better” than if she had just read about it. I believe that she understands the theoretical concept behind contextual learning, although she might not be familiar with the terminology. She also implies that she has plans to incorporate this type of teaching in her own classroom. She writes, “There is a lot to be learned from expanding the classroom from the traditional four walls.”

Need for Contextual Science Research in Pre-Service Programs

There are nine passages in the text in which Cathy expresses a need for a contextual science research course in a teacher preparation program. Cathy does not believe that the existing programs include enough laboratory and field experiences for the pre-service teachers. In this example she writes, “Teacher education students need more field and laboratory experiences.” Cathy also writes, “A prospective science teacher should be required to perform research and tests in a laboratory setting before graduating.” Near the end of her first year of teaching, Cathy states, “Definitely my summer research experiences and science methods course have impacted how I teach science more than any of [my pre-service course or experiences in my teacher preparation program in college]” (Interview, May 6, 2003).

Transfer of Contextual Experiences to Classroom

As Cathy experiences this type of learning, her empathy for her students begins to transform. Not only does Cathy anticipate offering more contextual learning experiences for her students, she plans to use some of the actual experiences in which she was involved during the science research. She writes, “What I learned from participating in my first summer research project can easily be implemented in my classroom.” Another benefit of contextual learning, like the ones offered in this course, is that the enthusiasm for science can be contagious. This feeling,
too, can ignite her desire to “transfer experiences to class.” She writes, “However, working with people who love what they are doing made me want to bring that feeling back into the classroom.”

At least one of the assignments for the research course was to design a lesson plan to be used in the middle school classroom. The pre-service teachers designed a lesson plan based on the science content studied in the research. The practicing teacher collaborating with the pre-service teacher was to make sure that the lesson plan could be easily transferable to the secondary classroom, taking in consideration materials, expense, classroom management, and age appropriateness. Cathy writes:

Lesson plans can be developed to help students understand pH, the scientific method, strengths of different solutions, and what the terminology ‘parts per million’ means. Students can bring in water samples from their houses to test the pH, color, smell, and taste.

In discussing the possibility of having her own students become involved with the sea grass restoration project, Cathy realizes what an impact it could make on her students. She writes, “Students could return months or years later to see their work making a difference in the environment.” This is an example of the empathy of a teacher, which I previously discussed in Chapter 2. Cathy expresses her own pride and accomplishment about knowing that she was instrumental in helping to establish the sea grass restoration project. Now, she is considering transferring that experience to her own students.

**Forming Collaborations**

Cathy, overall, is enthusiastic and receptive to her collaborations during the two summers of research. In the QSR analysis of Cathy’s chapter, there are 48 passages (15% of the total) and 43 passages (8% of the total) from the interviews under collaborations. Cathy writes, “Pre-service teachers, practicing science teachers, and science researchers truly learn from one another.” In the following sections, I discuss my interpretations of what Cathy says about her collaborations with the practicing teachers and the science researchers.

**Practicing Teachers**

I believe that Cathy’s collaborations with both of the practicing teachers were very positive experiences for her. Cathy writes about the first summer, “Pam, as the experienced teacher on my team, was excited and helpful in suggesting ways to implement various ideas in the classroom.” Again, in her chapter, Cathy’s says of her collaboration from the second
summer, “Sandy informed me of many useful points and ideas. I feel comfortable asking her questions.” As an observer of the interactions between Cathy and both of the practicing teachers with whom she worked, I found great synergy among each pair of CO-LEARNERS. The camaraderie was there, as genuine friendships developed. Cathy still maintains a friendly, as well as professional relationship with the practicing teachers with whom she collaborated during the summer research experiences.

Science Community Resources

Based on her writings, Cathy appears to be eager to access the science community. Because she was only in her first year of teaching when she wrote this chapter, she writes about accessing the science community resources and scientists. For instance, Cathy writes, “Having contacts in the science community is beneficial for practicing and prospective teachers.” During my own first three years as a practicing teacher, I did not make community science contacts outside the classroom. The option to do so never occurred to me. Based on peer discussions, I find this same thing happens to novice science teachers. After involvement with in-service programs, I became aware of what was available to me, and I learned that the science community was much more willing to assist than I had previously realized. This illustrates an excellent argument that immersing pre-service teachers into the culture of science may help initiate early collaborations with scientists.

To teach for so many years without even realizing that the science community would assist you could put some teachers and their respective students at a disadvantage. Cathy writes, “Knowing that people in the community are willing to contribute to science education makes my job easier.”

Scientists

Cathy speaks very highly of the scientists with whom she worked. Her enthusiasm for future collaborations is evident in her chapter, “The scientists and staff at the DEP were very supportive.” She writes, “The scientists were helpful and excited about helping me to learn about their fields of science.” I can echo this sentiment of Cathy’s. As coordinator of the project, I can vividly recall how excited the participating scientists were when I asked them if they were interested in helping science teachers. On the first day of the project when I introduced the teachers to the scientists, a warm air of enthusiasm enveloped the laboratory. I truly believe that scientists want to help the science education community as much as possible. As one of the
scientists told me during an organizational meeting for the CO-LEARNERS project, “The students in the classrooms of today are our future scientists of tomorrow. We need to make sure that they are as excited about this field as we are” (Interview, May 12, 1999).

The Research Experience

Cathy did, however, lament on the inaccessibility of some of the scientists during the research stage of her involvement in the second summer. We remedied this by adding another scientist, who did have the time and flexibility to work more closely with Cathy and her colleague. As Cathy immersed herself into the culture of science, she realized the complexity of the scientists’ jobs, duties, and commitments. She writes, “While the researchers were willing to work with us, volunteered their time, and were committed to helping teachers with bringing science into their classrooms, they were very busy researchers.”

Cathy appeared frustrated with the lack of accessibility to the researcher. This is easy to remedy in a project such as this, as most research scientists have a team of peers who are familiar with their work. A thoughtful delegation of duties in a participatory program such as the contextual science research is necessary. I do not believe that the lack of accessibility of the lead researcher hindered Cathy’s learning, however, because other staff members provided the needed guidance. Even Cathy writes that this should not affect the establishment of such a program or course for pre-service teachers, “This [scheduling difficulty] should not be considered as a barrier to establishing such programs to allow pre-service teachers the opportunity to experience science research prior to their classroom teaching assignment.”

Surprising Results

As Cathy expressed such enthusiasm over forming collaborations with the science researchers with whom she worked, I was surprised to find that she did not follow through with her plans during her first year of teaching. Based on her writings and her later interviews, I feel that Cathy may eventually develop some type of collaboration between the scientists with whom she worked and her science students. While I did not observe these interactions during the first year, she talked about a few instances in which she made a contact that she utilized in the classroom. Cathy demonstrates her plans for collaboration when she writes, “DEP scientists were willing to visit my classroom to discuss what they do and to show students how the environment can be improved.” With the limited budget of the classroom, community science resources can
provide the novice teacher with materials and ideas for activities, which provide an excellent foundation in establishing the teacher’s classroom teaching materials.

Field trip possibilities are another benefit of collaborating with the science community. Cathy writes in her chapter, “I also can take students on a field trip to the DEP laboratories and greenhouses where they could plant their own sea grasses.” Without Cathy’s participation in the summer research, she might not know anyone at the DEP, let alone know about the sea grass restoration project.

In my own classroom, I plan projects that enable my students to participate in beach restoration projects. I became acquainted with collaborating scientists through various workshops and in-service meetings, but these collaborations emerged later in my teaching career. My own first two years of teaching were spent mostly trying to maintain discipline in my classroom and developing lesson plans that would include the required curriculum. I felt empathy for Cathy and the other novice teachers, as I remembered the joys and struggles of being a first year teacher.

Making Connections Between Mathematics and Science

While Cathy does not elaborate on making connections between mathematics and science, she does cite many instances in which she uses a great deal of mathematics in her research. She includes several examples of measuring, graphing, calculating, and conducting chemical testing, during the process of her research experiences. Cathy writes:

Several tasks were developed for this project, including assessing the concentration of fluoride and the pH of area waters and ground water wells, analysis of hydrofluosilicic acid to be added for metals, contamination, and analysis of the environmental fate of the fluoride ion by laboratory simulations.

Inquiry-Based, Hands-On Science Activities

It appears that Cathy’s desire to include more hands-on experiences in her classroom was ignited early in her own educational process. Therefore her familiarity with hands-on learning, problem solving, and discovery-based lessons did not emerge from her summer science research experience alone. Thus, she was able to draw from past experiences and construct new meaning with respect to how she wishes to teach in her own classroom.

While it is unclear whether Cathy understands the distinction between hands-on science and inquiry, she does understand that hands-on is a more desirable approach to teaching than textbook-driven instruction. Hands-on does not always mean minds-on or inquiry-based. Hands-
on can be limited to a textbook-generated or a pre-designed activity with a specific beginning and ending, and not necessarily inquiry-based. An inquiry-based lesson is usually hands-on, but may or may not have a specific beginning or ending.

According to the NSES (NRC, 2000), “investigations can be highly structured by the teacher so that students proceed toward known outcomes” (p. 10). The NRC also says, “or investigations can be free-ranging explorations of unexplained phenomena” (p. 10). Depending on the teachers’ goals for the students, highly structured and more open-ended inquiries both have their place in science classrooms.

While Cathy may need to elaborate on her understanding of hands-on science and further expand how she will implement these types of activities, she has at least expressed a willingness to initiate this process. She writes, “I will implement as many hands-on science learning activities as possible to help my students better understand what they are learning and how it applies to their world and surroundings.” Although this is not entirely a new belief, this immersion in science, combined with her past experiences and beliefs, helped to re-ignite Cathy’s beliefs that science should include less textbook and lecture-oriented teaching. Using more hands-on experiences and making science applicable to the students’ lives are Cathy’s goals.

**Making Science Fun and Interesting**

Cathy’s QSR analysis has 15 passages referring to making science fun. In one example, she writes, “Science education needs to be applicable, interesting, and hands-on if teachers and students are to maintain interest and develop a love of learning science.” I believe Cathy is deeply committed to making science fun for her students. She writes, “As a teacher, I want to make science fun and interesting.” I feel this is a belief that Cathy had upon entering into this study because she had prior experiences in her own schooling that were fun. While she also had many others that she did not consider fun, these fun experiences were the ones that stood out for her. While Cathy has pre-existing beliefs about making science fun for her students, I believe having fun in the laboratory and in the field during her own contextual science research helped to cement the fact that she could make science fun for her students.

**Meaningful Science**

Cathy is very concerned with creating science lessons and activities that are meaningful to her students. Her summer research influenced her attitude in two ways: (1) Her participation in
the sea grass project gave her a sense of pride and accomplishment, and (2) Her research made her realize that she needed to be better informed about issues that affect her and her students, such as the addition to fluoride to the water supply.

Cathy writes about how she experienced meaningful science during and after her summer science research experience with sea grasses, “In fact, the DEP has begun a huge sea grass restoration project based on our initial research.” Of her second summer of research, Cathy writes, “My research has helped me realize that I need to keep informed about what is going on in the world and what new things are being done to help our society. I didn’t even know that our water would be fluoridated until I started the project.”

Cathy’s chapter includes 10 passages on meaningful science. I think that the knowledge she learned concerning sea grasses in her own environment and the water fluoridation study in her community had great meaning for her. Therefore, she truly understands the term meaningful science. She writes, “I realize that students and I need to get as much as possible out of what is being learned and taught.”

Real-Life Science

Cathy is very concerned with teaching students real-world science. Her own experience with real-world science may have influenced her beliefs on this topic. From Cathy’s text, there are 19 passages discussing real-life science. Cathy believes strongly in a need for real-life science for her students. I interpret this to mean that Cathy feels the information students learn in their science classes cannot be applied to anything that relates to their everyday, or real-life. However, a real-life connection is of critical importance when working with young adolescents (Irvin, 1992). I think Cathy understands that this need is a relevant issue. She writes, “Allowing students to work in groups for research and laboratory activities enables student to change previously held science misconceptions and discover that science exists in the real-world outside of a textbook.”

Students’ Stories and Voice

Cathy frequently mentions that she wants students to be able to freely express their learning. For instance, she writes, “I also want students to share with their classmates what they discover and help each other understand and explain various concepts.” In observations, I noted that Cathy encourages her students to share, and she shows them that she values their opinions. Listening to and valuing the students’ opinions is an attribute that all good teachers should
possess. Encouraging students to voice their opinions and their learning is critical for constructivist-based teaching practices because it allows students to construct their own meaning.

Gaining Science Content Knowledge from the Science Research Course

In her chapter, Cathy discusses the science content related to her experience with ease and comfort. I believe this indicates that Cathy’s science content knowledge emerges due to her experiences in the contextual science research courses. Seventy-four passages of text include science content knowledge learned from the science research course. Cathy describes her newly learned information very eloquently and convincingly.

Her discussion of sea grasses, cloning, and habitat restoration demonstrate science content acquisition. While she was somewhat familiar with the topic, her knowledge increased. The scientific language Cathy used in her descriptions of the research flowed fluently and passionately. I recall from my observations of Cathy in the field, and as I worked with her on the editing process of writing her chapter, that she needed very little assistance with the science content. I was very impressed with the level of her knowledge on this subject, which seemed to intensify each time I spoke with her. On one occasion, she writes, “I didn’t even know that our water would be fluoridated until I started the project. This project was a good experience because I learned what water fluoridation is and factors for its safety and benefits for communities.”

From her research experience, Cathy demonstrated some gains in science content on the subject area under study. Without this program, neither the gain of knowledge nor the research experience might have taken place. She later confided to me that she was extremely grateful for having the opportunity to learn about the fluoridation of drinking water. She was not aware how this topic has ignited so much controversy in her community, prior to her involvement with CO-LEARNERS.

Gaining Pedagogical Content Knowledge

Cathy’s writings express a strong dislike for classrooms dominated by a textbook and/or involve teaching by lecture. This fact is evident from the title of her chapter: Science: Not Your Typical Textbook and Lecture-Based Class Anymore.

The Lecture-Driven Classroom

Based on my observations of Cathy in her first year of teaching, while she does use lecture, I sense that she prefers having the students do activities that are more engaging. She seems uncomfortable in the role of lecturer. Other factors, such as standardize testing pressures,
covering the material, and classroom management appear to keep Cathy from putting these beliefs into practice during this first year of her teaching.

Again, I believe that her situation as a first year teacher is a constraint. The work of Dawson (2002) supports this idea. Dawson reports that first year teachers have unique needs such as time for reflection, building mentoring relationships with peers, and obtaining support in order to gain confidence and feel competent as a teacher. First year science teachers have the additional demands of understanding difficult content, obtaining and preparing laboratory materials for the classroom, and helping students understand these difficult scientific concepts.

**Textbook-Driven Method**

Cathy often expresses a strong aversion to the overuse of textbooks in the classroom, as her text includes eight passages on this topic. In one example, she writes, “Why major in science education and go into the classroom just to teach out of a textbook that most students have trouble comprehending?” While Cathy acknowledges that textbooks have their place, she believes too many science teachers rely too heavily on the textbook. She writes, “Teachers should use textbooks as only one of many resources.” Cathy has excellent insight into why the overuse of textbooks is not the most beneficial for students when she writes, “Well, most of what a student reads or tries to read in a science textbook is incomprehensible because of students’ reading level and interest in reading.”

In an interview following her second summer of research, Cathy says, “[science classrooms] are mostly textbook-oriented and not really hands-on” (Interview, August 16, 2000). Cathy writes, “Students who lack prior knowledge face such difficulties with textbooks.” She also expresses, in her writing, a plan to remedy this, “I will not have my students read one chapter after another and answer questions at the end of the chapter. I do not learn that way.” In Chapter 8, I describe Cathy’s method for integrating the textbook without placing too much emphasis on the textbook. Because K-12 classrooms tend to rely heavily on textbooks, she probably developed this opinion throughout the course of her entire education. Perhaps her immersion into a pre-service teaching practicum allowed Cathy to observe what goes on in the classroom. Regardless of her past experiences, Cathy appears to be determined to limit the use of textbooks in her own classroom based on her writing.
Teaching Inquiry in Science

Cathy does not discuss inquiry in science directly, but some of her other statements imply that she encourages inquiry teaching. In one example, she writes, “Using discovery-based lessons and asking open-ended questions makes students think about what they are learning and gives them the opportunity to develop communication, research, and technical skills.” In another example, she writes, “I want them to develop their own questions and then research the answers.”

While Cathy does not discuss inquiry teaching, she describes some of the characteristics associated with classroom inquiry. Using Table 6-2, the essential features of classroom inquiry include:

Table 6-2

<table>
<thead>
<tr>
<th>Essential Features of Classroom Inquiry</th>
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<tbody>
<tr>
<td>1. Learners are engaged by scientifically oriented questions.</td>
</tr>
<tr>
<td>2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.</td>
</tr>
<tr>
<td>3. Learners formulate explanations from evidence to address scientifically oriented questions.</td>
</tr>
<tr>
<td>4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.</td>
</tr>
<tr>
<td>5. Learners communicate and justify their proposed explanations (NRC, 2000, p. 25).</td>
</tr>
</tbody>
</table>


Through my observations and discussions, as well as her writings, I believe that Cathy strives for a classroom that encompasses these features; but she is struggling with her perceived constraints, which limit her ability to do this.

Confidence with Science and Teaching Science

Cathy acknowledges that her involvement with the experiential science and mathematics course will benefit her teaching and ultimately her students when she writes, “I learned valuable information that will help me be a better science teacher.” The pilot project in which Cathy was a part during her first summer of science research has evolved into a major environmental effort, receiving great praise from the community. The visible results of the efforts of Cathy and the
other participants in the CO-LEARNERS project can be seen in our community in this program
dedicated to sea grass restoration called Project Greenshores (DEP, 2004). I know that Cathy’s
pride will continue to influence her teaching in the classroom. She writes,” I felt a great sense of
accomplishment and pride. Today, two years after planting the sea grasses, the impact from my
efforts to help the environment is still seen.” Of her second summer fluoride study, Cathy writes,
“My research has helped me realize that I need to keep informed about what is going on in the
world and what new things are being done to help our society.” This feeling of accomplishment
is very significant for both teachers and students. When I see former students who were involved
with my own class’ beach restoration projects, they always comment on how much fun the
projects had been and how making contributions to the environment were important to them.
This gives me a great feeling of accomplishment, as well.

Assertions About Cathy’s Beliefs and Practices Through Her Writing

I believe that both of Cathy’s summer research experiences were positive with regards to
her teaching beliefs and her future practices. While this writing reflects her thoughts on the
summer research experiences and her beliefs about science and science teaching during her first
year of teaching, she had yet to implement all of her ideas into her teaching practices. However, I
believe there is evidence that Cathy’s experiences influence her beliefs about science and science
teaching. I offer the following assertions based on my interpretations of Cathy’s writings:

1. She acknowledges that her perceptions about scientists quickly changed from the
   stereotypical image of the scientists after her collaborations with scientists who
   were opposite of this stereotype and were excited about their work.
2. She realizes that science was perhaps tedious and detailed at times, but not boring.
3. She distinguishes between the culture of science and the traditional culture of the
   science classroom. She believes the culture of science is more about discovery
   and that it is exciting, while the culture of the science classroom is mostly
   textbook-driven and not exciting.
4. She wants to make science fun for her students, as she had fun “doing science,”
   thus she expresses empathy for her students.
5. She has a strong desire to use less textbooks and less lecture and implement more
   hands-on science.
6. She wants to introduce more meaningful and real-life science into her classroom.
7. She wants to welcome scientists to her classroom and develop collaborations with the science community.

8. She wants to give her students the opportunity to express their voices in their learning; to listen to their interests and why they are important to them; and to encourage them to ask questions and find answers.

9. She might not fully understand the constructivist epistemology, but Cathy reflects bits and pieces of this philosophy in her writings. Given time, along with practice, she may emerge as a science teacher willing to incorporate constructivist-based principles into her teaching.

10. She feels that this program was of value to her and she feels strongly that this type of program should be a part of pre-service teacher preparation programs.

Cathy acknowledges in her writing, that these experiences will “help me be a better science teacher.” Any experience that can generate this belief among pre-service teachers is worth considering.

In Conclusion

This QSR analysis of Cathy’s chapter revealed that Cathy greatly enjoyed her contextual science research experiences. Through her own immersion into science, Cathy expresses an understanding of the need for students to become involved with science and that real-life science is of critical importance for her to use in her own classroom. While Cathy expresses that her experience with contextual science research has impacted her beliefs about science and how she will teach science, there is little evidence in her first year of teaching that her practices reflect these beliefs and these statements.

When Cathy wrote the SERC@SERVE chapter during her first year of teaching, her beliefs had yet to be “put into action,” at least according to her writings. I did, however, observe portions of an inquiry-based, hands-on lesson on mold growth during her second year of teaching. I discuss this lesson in Chapter 8.

During her first year of teaching, through her writing, my observations, and my interviews, Cathy does not appear to experience praxis regarding her teaching practices. While she expressed these beliefs in her writings, she appears to have difficulty acting upon these beliefs. Rather, her classroom actions indicate a priority for classroom management and job security. This could be due to Cathy’s status as a first year teacher. NRC (2000) states,
“Research indicates that teachers have a fairly pragmatic approach to teaching. They tend to focus on what works to involve students or manage their classrooms, rather than on melding theory and practice” (p. 140). Cathy’s teaching position in a private, parochial school demands a certain disciplinary standard, as well as emphasis on vast amounts of content for standardized testing.

If the NRC (2000) statement reflects all teachers, then I acknowledge that first year and novice teachers must deal with additional stresses of classroom management, curriculum mandates, standardized testing, and maintaining employment. With all these constraints, combined with the above statement about teachers in general, it is little wonder that Cathy did not perform to her own standards.

Cathy demonstrates the qualities of an excellent science teacher, possibly a “natural.” While I would like to think that her contextual science research experiences were instrumental in her development as a teacher, her abilities are innate, as she is a caring and dedicated teacher. Her experiences with contextual science research have been somewhat influential in Cathy’s beliefs with respect to her perceptions of science and scientists and teaching meaningful science. She reflects these influences to a much lesser degree in her practices during her first year. I anticipate that Cathy’s pedagogy may reflect more of her beliefs as she gains experience and confidence with her job status, as my interviews indicate that she is sincere about being a good teacher and making science fun and meaningful for her students. I can easily envision Cathy being the teacher she so wants to emulate. Her immersion into science research appears to have influenced her beliefs about what it takes to be a motivating science teacher.

Chapter 8 looks further into Cathy’s teaching practices during her second year of teaching. This chapter includes my interpretations of Cathy’s transformation as a teacher and whether or not her experiences with the contextual science research influenced her belief and practices during her second year.
CHAPTER 7: SCIENCE FROM A DIFFERENT PERSPECTIVE: THROUGH THE EYES OF A MATHEMATICS TEACHER

The following chapter contains a modified version of a paper that “Rob” originally submitted to me, as the instructor, for partial fulfillment of the requirements of the contextual science research course. The original paper details Rob’s research experiences in the science course. During Rob’s first year of teaching, Rob edited the paper to include some of the highlights from his classroom. My major professor, the staff and I further edited Rob’s paper and then published it as a chapter in the SERC@SERVE monograph entitled, Experiential Learning for Pre-Service Science and Mathematics Teachers: Applications to Secondary Classrooms.

The first section of Chapter 7 is Rob’s chapter from the SERC@SERVE monograph (Wark, 2002). Following Rob’s chapter is my QSR analysis of Rob’s chapter. In this section, I look for patterns in Rob’s words, as they relate to my research questions, and for any influences that Rob’s experience with contextual research have on his beliefs and practices, as they relate to my research questions.

Rob: An Immersion into Science

This chapter details both Rob’s experiences in the contextual science research course and how he has been able to bring his experiences to his classroom. I edited Rob’s chapter to fit format guidelines for a dissertation, and to change names of the participants to pseudonyms.

Science from a Different Perspective: Through the Eyes of a Mathematics Teacher

A New Career

Unlike the average novice, I am a 52-year-old, first-year teacher. Retiring after 24 years in the United States Navy, I decided to embark on a new career. Two years of technical school and a year and a half of junior college finally led me to the path of becoming a teacher. Eventually, I became a middle-school mathematics and social studies teacher.

My summer as a “scientist” proved to be the first step in my process of experiencing hands-on learning. I like to think that I might eventually evolve into the type of teacher who provides my students with many hands-on experiences and opportunities for inquiry. This is what
the current research (Gilmer, 1999) and my recent education courses stress for optimal student learning. If I learned to appreciate the importance of hands-on learning, then I would realize that my students would also like to learn in ways other than by the book. So far, that style of teaching presented a steep learning curve for me.

Making Science and Mathematics Connections

Science is a learning evolution just like any other discipline. Based on my own schooling, I always believed that a lot of hard work and hours of study are required to earn a degree in science. I chose, instead, to major in mathematics and social studies. I had even taken enough hours to become certified in language arts. I was a bit intimidated at the thought of being “immersed” in science. However, when I was asked to participate in a summer research project at the university, which would also count as a course for credit towards my degree, I was intrigued.

What better way is there to experience and learn a different discipline than in an actual laboratory setting? I was told that a middle-school science teacher, a middle-school pre-service teacher, and a research scientist would be teamed together to experience real-world science research. We would learn through the execution of experiments and the analysis of results. The project, entitled, CO-LEARNERS Program, was funded through a National Science Foundation grant. This team of learners would collaborate and decide on ways that science could be brought into our classrooms. I felt that I needed more experience with hands-on learning in the classroom. I needed to learn science content as well. Since mathematics and science go hand in hand, I felt that this would be very worthwhile in my teaching and would ultimately benefit my students.

I had two reasons for participating in this scientific project. First, the activity enabled me to experience an unfamiliar discipline while working together with a teacher and a researcher. According to the Third International Mathematics and Science Study (TIMSS) (Gilmer, 1999), high school students from the United States lag dramatically behind other countries in science and technology. Practicing teachers strongly adhere to the belief that to learn science, teachers and students must also have a connection to science (Gilmer, 1999). I felt that this experience would prepare me for interdisciplinary teaching and help my future students through my own connection to science. The second purpose of my participation was to get a three-hour credit in mathematics, as I wanted to graduate as soon as possible and pursue my new career.
Forming a Team

Why would a pre-service and a practicing teacher team with scientific researchers? We could gain knowledge, build confidence, and acquire skills. According to Gilmer (1999), teachers who are given the opportunity to practice methods of science and experience inquiry will come to experience the culture of science. Science no longer means abstract “facts” but a way of understanding the world.

I was teamed with a middle-school science teacher, Martha, at the Wetlands Research Laboratory, located at the University of West Florida. Martha and I worked closely with Jane Martin, the laboratory manager. We were originally placed under the guidance of Dr. Joe London, a biology professor and Acting Director of the Wetlands Research Laboratory. Because of his multiple duties, Joe was unavailable for in-depth collaborations. We learned the demands upon the time of a true researcher. Jane worked closely with us, however, in all aspects of our research.

Our Investigation

In the Wetlands project, Martha and I tested the waters in the area near Pensacola, Florida, for levels of fecal coliform bacteria. Fecal coliform bacteria come from the intestinal tract of humans and warm-blooded animals. Contamination of water supplies or bathing areas by sewers, septic tanks, or animal feces may increase the level of fecal coliforms present. Consumption of or contact with water contaminated with feces may cause gastrointestinal distress and, in severe cases, death. Local, state, and federal agencies contract with the Wetlands Research Laboratory to test the waters in the Pensacola area in order to monitor environmental health or to meet permit requirement.

Utilizing Science in the Investigation

Prior to our actual research investigation, Martha and I read the literature and procedures involved with such a study assigned to us by Joe and Jane.

There are five steps in the process used to test for fecal coliform bacteria in the waters: sampling, dilution, inoculation, incubation, and the reading of the results. The first step, the sampling process, involves going to the site and collecting the samples. The procedure is discussed in another section of this chapter. The second and third steps involve the serial dilution and inoculation of the sample. We pipetted portions of the sample into test tubes containing bacterial growth media specific for growing fecal coliforms. As a control, we mixed
sterile water at the same dilution with the growth media. We prepared three serial dilutions (undiluted, ten-fold, and 100-fold) if we collected the sample during normal weather and four dilutions (up to 1,000-fold) if we collected the sample after a rain. Rainwater run-off from upstream usually increases the amount of fecal coliform. Therefore, the sample must be further diluted to enable the final count falls within the counting range. After the media are inoculated with the sample, any fecal coliform bacteria, if present, should grow.

There are many types of media, but the one used mostly by the laboratory for fecal coliform testing is called A-1 medium. The laboratory also tests for Enterococcus bacteria, which uses three different media: azide dextrose broth, bile esculin azide agar, and Brain-Heart infusion broth. I helped Martha mix Brain-Heart media on two occasions, but the A-1 media is one I used most often.

The fourth step in the process is the incubation of the samples. Martha and I placed the test tubes in an oven incubator for 24 hours after which we checked for the presence of bacteria. Using the A-1 broth medium, the positive test for bacterial growth is the presence of a gas bubble in an inverted tube inside the sample tube. The method used is called multiple tube fermentation. This test provides an estimate of the most probable number (MPN) of bacteria per 100 milliliters of sample as determined from the number of test tubes in which gas bubbles form after incubation. The last step is to record all positive and negative test results on a chart.

I wondered what the gas bubbles were, so I asked Jane. She said:

The multiple tube fermentation method is based on the fact that fecal coliforms, along with some other bacteria, ferment lactose (milk sugar or \( \text{C}_{12}\text{H}_{22}\text{O}_{11}, \) a disaccharide, or galactose linked \( \beta 1 \rightarrow 4 \) to glucose). When the bacteria are grown in a medium (agar or broth) containing lactose, they will produce gas by fermentation, as if you were making champagne. The A-1 test for fecal coliforms uses a small inverted glass tube inside the culture tube. The inverted tube captures gas released by the bacteria. Any bubbles collected in the tube are considered a positive result for the presence of fecal coliforms in the sample.

Her description helped me connect to my prior knowledge; I remember from a biology class that I had taken that the final products of fermentation are carbon dioxide and water, so the gas must be carbon dioxide (\( \text{CO}_2 \)).

\[
2 \text{C}_{12}\text{H}_{22}\text{O}_{11} \text{(aq)} + 24 \text{O}_2 \text{(g)} \rightarrow 24 \text{CO}_2 \text{(g)} + 22 \text{H}_2\text{O} \text{(l)}
\]

or

**Lactose (in solution in water) + oxygen gas \( \rightarrow \) carbon dioxide gas + liquid water**
I also wondered what Brain-Heart media meant, so I asked Jane about it. She replied:

The full name of what we use as the third medium for the old Enterococcus multiple tube fermentation (MTF) test is ‘Brain Heart Infusion’ broth. I believe it is a dehydrated broth infused with brain and heart material, probably bovine. Think of the basic chicken broth agar we all used in school. Any growth medium involves a nutrient source, and brain and heart tissues are rich with nutrients. A selective growth medium also involves other components that kill or inhibit certain types of bacteria, thus selecting against them. You put together the right series of selective growth media and you can select for almost any specific bacteria by inhibiting the growth of some other types of organisms at each stage until you have only one left. We add 6.5% salt (i.e., plain old sodium chloride) to the Brain-Heart infusion broth at the last step of the test because Enterococcus is one of the few bacteria in the environment that can tolerate that much salt, which is why it grows so well in the marine environment. An earlier step in the Enterococcus MTF test involves use of sodium azide (bile esculin azide agar), which is lethal to most higher living organisms, but Enterococcus tolerates a certain amount of salt too. It’s a tough group of bacteria.

Here again, I remembered something from my biology class. I remember that azide is a potent killer. I looked it up, and it is a killer because it blocks the electron flow, which a eucaryotic cell needs to generate significant energy from metabolism. Apparently, the azide in the growth medium blocks higher order cells from using the lactose as an energy source. Therefore, any growth must be prokaryotes such as bacteria.

By adding salt to this medium, scientists put another block on most forms of bacteria, so they cannot survive under those conditions. Because the Enterococcus is able to grow in a medium containing salt, the presence of gas bubbles indicates a group of microorganisms that will tolerate salt and multiply. I guess that these organisms must be able to grow in various concentrations of salt in the area where we collected them, as the water we tested was infused with salt water as the tides from the Gulf of Mexico come into the Pensacola Bay. Pretty neat stuff! I can bring this to my students who live here in the area around the Pensacola Bay!

Using Mathematics to Analyze the Data

I used the Standard Methods for Examination of Water and Wastewater, (19th edition American Public Health Association and the American Water Works Association, 1992) to convert our results on the data chart to the Most Probable Number (MPN) of bacteria present in each sample. There are several agencies that contract the laboratory for sampling. The Wetlands Research Laboratory gives the agencies the MPN values for their site based on its findings. The Environmental Protection Agency (EPA) sets the MPN standard for safe water, and the business
or agency will use the MPN to determine if the water is safe or not. If the data do not fall within the parameters of the standards book, there is an equation that can be used to determine the MPN.

Not long after we participated in this summer project, Jane wrote,

Since the time that Martha and you were here, we changed our Enterococcus test to a new, much simpler version. It is a plate method called membrane filter analysis, which involves filtering a water sample through a membrane filter, which catches the bacteria on the filter and putting the filter on a plate of mEI agar. Instead of taking five days like the previous test, it takes 24 hours. After 24 hours of incubation, the researcher counts the number of blue colonies and reports the number directly in CFU (colony forming units) per 100mL. No statistics or tables.

My Part...as a Scientist!

Kielborn endorses the idea of “teacher as researcher” to proclaim professionalism and professional development in teaching (Kielborn, 1999). As we were teamed, Martha was the science person, and I was the mathematics person. Because mathematics is such an integral part of science, I was eager to be part of this project. I helped with collecting the data for the science projects and even more with the mathematical calculations involved with the investigation.

My mathematics studies during this summer, coupled with this project, made me realize how much of the computations required in the science laboratory are actually taught at the middle-school level. Ratios, proportions, percent by weight, and parts per million are used every day in mixing chemicals needed to carry out the projects at the Wetlands Research Laboratory. Other areas in which I observed and assisted involving mathematics were in finding an MPN from a formula and interpolating MPNs from the standards book.

Enjoying the Field Trip

Probably the most exciting part of this research experience was the collection of water samples. We took along bottles to store the samples, a depth sampler, and an instrument that recorded water temperature, oxygen levels, and the pH of the water. We prepared all the bottles necessary for the sampling prior to the trip. On the morning of the trip, I loaded the bottles into ice chests according to the order of sample sites. I was also placed in charge of the sample bottles during the trip. Five of us launched an 18-foot boat into the Pensacola Bay. It took us about 20 minutes to reach the first sampling position. The boat captain used a portable GPS (Global Positioning System) direction finder to locate the exact sampling spot. The GPS (United States Coast Guard Navigation Center, 2002) uses satellites to coordinate the exact position of
latitude and longitude anywhere on the globe. As with any scientific experiment, the results must be replicated from the same position as previous sampling. With the GPS, the boat captain could anchor within ten feet of the desired location.

We collected samples at four locations from three depths: bottom, middle, and top. Martha was in charge of lowering and raising the instrument that measured the temperature and oxygen levels. After collecting data at the first site, I began recording the measurements that Martha gave me and took care of the sample bottles. As soon as we returned to the Wetlands Research Laboratory, we began the testing procedure that I described earlier. The trip was educational and fun, but very hot on that summer day. Such is the life of a research scientist! This field trip opened my eyes to the importance of getting out of the classroom every once in a while.

Teamwork in Science and Mathematics Education

Based on her own research experiences and later classroom applications, Hahn (1999) states that teacher preparation programs should involve more activities in the laboratory to enhance student learning in science. Hahn asserts those teachers of other disciplines benefit from experiential activities, as well. For instance, art teachers experience art as artists before they become teachers, and music teachers generally know how to play three or four instruments before teaching. However, science teachers (especially new ones like me) often have not experienced scientific research first-hand, as I did that summer. If teachers are to teach inquiry, they need to experience it first-hand.

Jane planned all the samplings and test schedules. He showed Martha and me how to set up and run the tests for fecal coliform. From the beginning of the project, Martha and I had planned how we would apply what we were learning in this summer research experience during the semester in which I would undertake a teaching practicum with her as part of my undergraduate teaching program. I planned to co-teach an integrated, interdisciplinary lesson on ratios and proportions. I would review and teach the mathematics necessary to complete the science projects that Martha would have her students do. We scheduled this science investigation for the following spring semester.

I conducted a lesson on ratios and proportions and related how I had used it during the summer research program with the Wetlands Research Laboratory. The students were interested in hearing about my experiences as a “scientist” and wanted to know more about fecal coliforms
in the waters. This is a good example of bringing students closer to science and helping to establish a connection between mathematics and science. Once the students began to see how science and mathematics affected their lives, the topics became more interesting to them.

Classroom Applications

Making Lemonade

As a student teacher the following fall, I taught Pre-Algebra and Algebra to eighth graders. The Pre-Algebra course called for ratios and proportions. My favorite ratios and proportions lesson to use in the classroom involves making lemonade. A 29-ounce canister of lemonade mix will make 48 servings. Assuming everyone drinks two servings and 100 people are expected to be there, I asked how many canisters of lemonade are needed. I did not tell them that this related to science, but I do feel that it is a very good real-life example.

Making Houses for the “Hurricane Project”

After being hired as a middle-school mathematics teacher, I have taught ratios and proportions similar to what I used in my research that summer. Last year as a first year mathematics teacher at the middle-school level [in a teaching internship], I used these lessons to help prepare students for the Florida Comprehensive Assessment (FCAT) test (Florida Department of Education, 2002). The FCAT test results are used to help grade each school in the state of Florida and to determine the level of individual students.

I also used a lesson in ratios and proportions for the last project of the school year. The project involved students designing and building model houses that could withstand hurricanes. Living in Florida, this is certainly applicable and relevant to these students’ lives. The Hurricane House project lasted two weeks. I divided the students into groups of five and gave them exact standards that were to be met. Each group had to design and build a house that they thought would withstand a hurricane. The main criterion was that the house had to have a floor area of 400 cm$^2$. Most of the groups chose to go with a square house, as it did not require a great deal of mathematics to lay it out. However, there was at least one group every class period of the school day that designed and built a round house. The round house required the students to use formulas for the circumference and area of circles. One group designed and built a six-sided or hexagonal “star” house, and another group designed and built an eight-sided or octagonal house.
The first two days of lessons involved the drawing of floor plans for a hurricane-proof house. The students had to use scales and ratios to draw their houses to fit on the paper. Doing ratios was fairly easy for the students because we had learned that process earlier in the year. Establishing what a scale was and how to use it was a little more difficult for some of the students. The students had fun drawing either their own homes or a house that they wanted to live in.

This project was hands-on at its best. The students were given exact directions for what to use, but the groups had to decide what they would build. The other seventh-grade mathematics teacher and I collaborated on the project. We answered student questions and posed others on how they could possibly improve on what they had, but we never told the students how to construct their houses or what to do next. The last day of building construction was a flurry of activity. At the beginning of the day, only one or two houses were complete in each period. By the end of the day, all the houses were prepared. The anticipation was building.

Students Calling, “Over! Over!”

The last day of the project was the actual hurricane day. All the houses were built on stilts and were blown with a leaf blower to see if they would fall over or collapse. The houses were graded on the following criteria:

1. If they had all their shingles or not
2. If they had a door on each side
3. If there were windows on all four sides of the house
4. If the house was six inches off the ground

A parent volunteer prepared the leaf blower so that the wind velocity out of the blower was just over 100 miles per hour. He would then aim it at all sides of the house. The house had to withstand a total of four minutes of the hurricane force winds. Each house would lose points for shingles that were blown off and any other part of the house that went flying.

The students became so excited every time a house was put to the test. If a house started to shake, the class would begin chanting, “Over! Over!” The more the house shook or came apart, the louder the chant would get. The students were very motivated by this project and were seldom off task. This was an exciting end to the school year.

What Did I Learn from the Summer Research Experience?
This hands-on experience made learning fun and also raised the following question: Do my students have fun in class learning just from books? Every once in a while, teachers need to step back into the role of student to remind themselves that learning needs to be fun. Learning also needs to be hands-on and pertinent to students’ everyday lives. The CO-LEARNERS Program provided me with this experience.

The relationships that teachers and scientific researchers develop in a project like CO-LEARNERS should promote the students’ learning of science and mathematics, as well. Hopefully, either the student can visit the research facility and see a real-life laboratory, and/or the researchers can visit the classroom and enhance the teacher’s lesson.

Should all teachers do research in their own field? Absolutely! The only way that a teacher can truly know what is happening in his or her field is to experience it first-hand. Add a student teacher, and all areas of the community are covered. Because of my own experience, as well as the trend in education today to incorporate more interdisciplinary teaching, I believe that teachers and students should be paired with experts in other fields.

QSR Analysis of Rob’s Reflections on his Summer Research Experiences

Rob represents a unique case study of a pre-service teacher and a novice teacher, because teaching is Rob’s second career. He entered the teaching profession in his early fifties after serving in the military and working in a factory job during his college studies. His perspectives on science and science and mathematics teaching are different from Cathy’s perspectives. Cathy is more representative of the typical pre-service, college student and, later, novice teacher entering teacher in her early twenties.

Beliefs About the Culture of Science and the Culture of Science in the Classroom

In this section, I discuss some of Rob’s beliefs about the culture of science and the culture of the science classroom. Several beliefs emerged as significant with respect to Rob, including Rob’s belief that science is intimidating and that he prefers mathematics to science.

“Intimidated by Science”

In his chapter, Rob admits to being “intimidated” by science. This could perhaps be related to his early discussion on his own schooling, which was mostly textbook-based learning.
Without having positive learning experiences in science, it is little wonder that he might be intimidated by science.

Because Rob was not comfortable with his background in science, his beliefs revolved around his prior knowledge of science. He writes, “Based on my own schooling, I always believed that a lot of hard work and hours of study are required to earn a degree in science.” This type of belief led me to believe that Rob thought that his learning in science might be unattainable. Rob stated prior to his involvement with the science research, “I was a bit intimidated at the thought of being ‘immersed’ in science” (Interview, May 12, 1999). I believe that he felt differently after his experiences, based on his evolution as a scientist, as well as a teacher.

**Choosing Mathematics over Science**

In pursuing a teaching field, Rob chose to teach mathematics because he thought science to be somewhat akin to a foreign language. One of his objectives in participating in the summer science research course was to receive the course credit hours that he needed. However, he also wanted to learn science, a subject that had perhaps been a source of anxiety. Rob was honest in giving his reasons for taking this course. First, he wanted help with forming connections between science and mathematics in his classroom; and second, he needed a three-hour credit in mathematics for his degree.

**Teaching Practices**

Two themes emerged from the analysis of Rob’s chapter relate to his teaching practices. These themes are transferring constructivist-based, contextual, and inquiry-based, hands-on experiences to the classroom, and making science and mathematics connections.

*Constructivist-Based Teaching*

In discussing his testing of bacterial growth, Rob encountered the formation of gas bubbles in the test tubes after incubation. He was curious about them and asked the researcher about the bubbles. Rob later talked about how her description helped him to “connect with his prior knowledge.” This is an excellent example of constructivism for Rob. He is beginning to understand constructivism-based learning and how it applies to him. This is a critical first step for Rob to be able to transfer his research experiences into his own classroom. Rob mentions several other instances where he used prior knowledge to help him understand the science content. For example, he writes, “Here again, I remembered something from my biology class. I
remember that azide is a potent killer…” Rob used his prior knowledge to help him figure out an answer to a question he encountered during his research. Understanding the importance of prior knowledge through his own experiences will help him understand how his students use prior knowledge.

**Contextual Learning**

How much influence does Rob’s experience with the contextual science research have on implementation of his lessons? During both of the lessons that I observed during his first year of teaching, Rob incorporated a discussion about the connection between mathematics and science, as Rob was teaching mathematics. He then mentioned that he believed that the real-life lessons were so much more meaningful to the students and that he appreciated his own real-life study of water quality. When writing his chapter about his contextual science research experiences, he discusses two of his lessons under the heading, “Classroom Applications.” I interpret this to mean that these were examples of his ability to transfer his experiences from his contextual science research into his own classroom.

**Transferring Experiences to the Classroom**

Rob illustrates two good examples of how he was able to indirectly transfer some of what he learned during his summer research experience back to his classroom. While the actual content is different, since Rob teaches mathematics not science, the science and mathematics concepts that demonstrate the connections that Rob seeks are critical to show.

Fortunately, I had the opportunity to observe Rob’s classroom for the hurricane lesson he described in his chapter. For this lesson, Rob collaborated with a science teacher in his school. It was a very interesting and dynamic lesson. The students were very engrossed with the design and structure of their houses. I observed the actual “hurricane” day, with the hurricane in the guise of a leaf blower. It was a very exciting day; the students completely immersed themselves in the experience. They had ownership of their houses, they designed them, they built them, and then they tested them to see if they could withstand a “hurricane.” The anticipation grew as each team tested their house.

While I was there to take photographs for the SERC@SERVE publication, I also took notes on the interactions, which were very interesting to watch. The students were very intense when designing and building their houses. The cooperative learning groups were also fascinating to watch. I did not observe any disciplinary problems; but rather, I only noted constructive
discussions and interactions. The students were on task and eager to complete the project. Rob circulated around the classroom, giving assistance only when asked. This activity involved inquiry, constructivist-based teaching, real-life and meaningful applications, and collaborations among the students. This, too, would be a lesson recommended by the NRC (1996, 2000) because it involved the elements conducive to student learning in science.

I agree with Rob, as this was a very exciting lesson to observe. This is a perfect lesson for students who live in a hurricane prone area of Florida. The lesson incorporates hands-on learning, inquiry, and meaningful science and mathematics. The lesson is contextual in that Rob places the students in the context of designing a hurricane proof house and testing it under hurricane conditions. Although this was not in actual hurricane conditions, it is an excellent modeling of hurricane conditions. I would equate this lesson with a contextual learning environment.

Collaborations

In this study, Rob engaged in collaborations with practicing science teachers and science researchers. I believe that these collaborations helped to put Rob more at ease with science. I discuss Rob’s collaborations with the practicing science teacher and the scientists.

Practicing Teacher

Rob writes of his collaborations with Martha, the practicing science teacher with whom he worked along with the science researcher:

As we were teamed, Martha was the science person, and I was the mathematics person. Because mathematics in such an integral part of science, I was eager to be part of this project…the activity enabled me to experience an unfamiliar subject while working together with a teacher and a researcher.

Rob expressed his gratitude for the opportunity to work with a practicing teacher and a science researcher to help him learn what he describes as an “unfamiliar subject.” Rob experienced a very productive collaboration with the practicing teacher, Martha.

On several occasions, I observed Martha and Rob working with their collaborating scientist. I observed that they formed a very strong team of co-learners. On the day that I joined them for fieldwork, they conducted a water sample collection, performed measurements, and carried out testing procedures. I was impressed because they performed this collection seemingly without effort and as though they had been doing it for many years. Rob’s feeling of intimidation with science was not apparent on that day.
Scientists

Initially, Rob and Martha encountered difficulty with the availability of their assigned researcher. Fortunately, the laboratory manager was able to work closely with the team. From Rob’s writing, I assert that he was very enthusiastic about the opportunity to work with a scientist and a practicing teacher in a laboratory setting. He was, after all, hoping to learn some science content and ways to connect science and mathematics. Up until this contextual science research course, he had not been afforded such an opportunity in his college courses.

While Rob had mentioned that he felt a bit intimidated, he obviously wanted to learn science and have a chance to be a scientist. In fact, the title of one of his sections read, “My Part…as a Scientist!” I think Rob felt as though he had nothing to lose, but a lot to gain from this experience. The fact that he worked alongside a science researcher and a practicing teacher gave him the confidence to go forward. An isolated experience working in the laboratory might not be as comfortable for Rob. The CO-LEARNERS concept, however, made him feel more secure.

Making Science and Mathematics Connections

Rob writes about why he wanted to participate in the contextual science research course, “Since mathematics and science go hand in hand, I felt that this would be very worthwhile in my teaching and would ultimately benefit my students.” There are 19 passages specifically discussing making connections between science and mathematics. I believe that Rob is aware of the connections, but lacks the first-hand experience to understand the degree to which science and mathematics are truly connected.

His summer research experiences helped to illuminate these connections for Rob. He writes, “My mathematics studies during this summer, coupled with this project, made me realize how much of the computations required in the science laboratory are actually taught at the middle-school level.” Rob proved successful in integrating science and mathematics through his lessons that he describes in his chapter. He writes about sharing his own research with his students, “This is a good example of bringing students closer to science and helping to establish a connection between mathematics and science. Once the students began to see how science and mathematics affected their lives, the topics became more interesting to them.”

Inquiry-Based, Hands-On Science Activities

Prior to his experiences with the contextual science research, Rob writes, “If I learned to appreciate the importance of hands-on learning, then I would realize that my students would also
like to learn in ways other than by the book. So far, that style of teaching presented a steep learning curve for me. He expressed that he wanted more experience with hands-on so that he could incorporate this style of teaching into his own classroom. In an interview during his actual science research, Rob said, “This hands-on experience made learning fun and also raised the following questions: Do my students have fun in class just learning from books?” (Field notes/Interview, June 13, 1999).

Rob also writes, “Every once in a while, teachers need to step back into the role of student to remind themselves that learning needs to be fun.” Rob writes of his experience, “Learning also needs to be hands-on and pertinent to students’ everyday lives. The CO-LEARNERS Program provided me with this experience.” Rob refers to hands-on teaching eight times in his chapter. This is significant as each time he writes about hands-on teaching, he stresses the importance of this type of instruction and often mentions inquiry with it. Rob writes that he would like to “eventually evolve” into the type of teacher that provides his students with hands-on experiences and opportunities for inquiry. I feel that he is on his way.

Making Lemonade

In the lemonade lesson, Rob used ratios and proportions much like what he used in the laboratory during his contextual science research. This activity was a fun, real-life experience for the students. The lesson involved hands-on learning with inquiry, constructivist-based teaching, and meaningful and real-life science. According to the NRC (1996, 2000), this activity with the lemonade is the type of inquiry-based lesson needed to help students succeed in science. I cannot say for sure that Rob transferred his contextual experience to his classroom via this lesson.

Real-Life Science

Rob implemented this lesson because it had real-life connotations due to the fact that each year hurricanes threaten the students’ communities and affect their lives. Rob appears to be concerned with integrating more real-life lessons at this point in his teaching. Although Rob does not say that he carried out this lesson solely due to the influence of his own contextual learning and enjoyment of it, I do feel that he was more comfortable than he might have been otherwise because he had experienced a similar learning experience himself.

Gaining Science Content from the Science Research Course

Because I am aware of Rob’s insecurities with science, I was excited to witness his growth in science. In my journal, I noted that from the first day of introductions in the laboratory
to several weeks into the research, Rob’s comfort level with the science content and familiarity with the laboratory setting increased. He began to use the language of science, to demonstrate what he has learned in science content, to relax within the culture of science, and to fully engage in using the equipment in the laboratory.

I wrote the following in my journal:

Rob and Martha worked great together on the boat collecting the water samples. Jane is very knowledgeable about the water testing and is doing a great job of teaching the information to Rob and Martha. Rob was able to answer almost all of my questions about what they were doing. They were all laughing and having a great time. It was one of the hottest days of the summer day and they were working, doing water testing, but they seemed to be having fun learning. (Field notes, June 23, 1999)

Gaining Pedagogical Content Knowledge

Rob frequently refers negatively to the use of textbooks. Rob writes that he wanted to learn to appreciate the “importance of hands-on learning” so that he could realize that his students “would also like to learn in ways other than by the book.” From his writing, he generally prefers the use of hands-on, inquiry-based instruction. From the types of lessons he describes and that I observed, I would make the assumption that Rob is implementing the type of PCK that research (NRC, 1996, 2000) tells us is the most effective in helping students to learn science. He has shown tremendous gains with respect to his early goals during this first year of teaching.

Gaining Confidence in Science

Rob’s use of language in describing his learning experiences is very colorful, as evident in the following passage from his writing, “Pretty neat stuff!” Rob said this when referring to his budding knowledge on saltwater organisms living in his own community. He is eager to bring this knowledge to his students. I am very impressed with Rob’s use of the language of science. From his writings, I believe that Rob learned a great deal about this subject. Rob’s comfort level with science has progressed from being “intimidated” to being “comfortable.”

Assertions About Rob’s Beliefs and Practices Through His Writing

Like Cathy’s experiences, I believe that Rob’s summer contextual science research experiences were positive with regards to his teaching beliefs and future practices. I believe there is evidence that Rob’s experiences with the contextual science research positively influenced his
beliefs about science and science teaching, and, to a lesser extent, influenced his teaching practices. I offer the following assertions based on my interpretations of Rob’s writings:

1. He acknowledges that he is intimidated at the thought of an immersion into science. I believe Rob’s experiences with scientists, immersed into the context of science, have helped minimize this intimidation factor, as expressed through his writings.

2. He wants to make science fun and to provide more hands-on science, as he acknowledges that he had fun himself.

3. He believes that learning should be pertinent to students’ lives.

4. He understands the need for hands-on learning, even in mathematics and hopes to gain some experience with that type of teaching.

5. He feels that this program was of value to him and he feels strongly that this type of program should be a part of pre-service teacher preparation programs.

6. He demonstrates confidence in science through his writings; therefore, I would assert that this confidence is also evident in his classroom.

7. He wants to prepare for interdisciplinary teaching and to help his mathematics students through his own science connection. He was able to immerse himself in situations that were rich for making connections in mathematics and science. He demonstrated that he could successfully implement these types of lessons in his classroom.

8. He believes that he can transfer similar types of experiences into his own classroom in the future through some of the lessons that I observed during his first year.

In Conclusion

This QSR analysis of Rob’s chapter provided me with some preliminary answers to my research questions. Based on his writings, Rob has gained some confidence with science and science teaching. Although he teaches mathematics, he felt that it was important to understand science and show his students some real-life applications of the connections between science and mathematics. He has succeeded, as demonstrated by some of the activities in which he engaged his students during his first year of teaching.
These activities, the lemonade lesson and the hurricane houses, provide evidence of Rob’s success with implementing hands-on, inquiry-based lessons. Rob also appears to have gained some science content from his experiences. He writes his chapter on the science research experience with understanding and authority.

At Rob’s school, his students were well behaved and eager to learn. The science teacher with whom he collaborated was willing to work with Rob on designing and implementing a lesson that connected science and mathematics principles and engaged students in hands-on, inquiry-based learning. These coherences allowed Rob to move to his desired outcome of evolving into the type of teacher, described in his writing, who provides “students with many hands-on experiences and opportunities for inquiry.” His lessons on lemonade and the hurricane houses are evidence of this. His experience helped him to realize this, as evidenced by the following statement. Rob writes:

Every once in a while, teachers need to step back into the role of student to remind themselves that learning needs to be fun. Learning needs to be pertinent to students’ everyday lives. The CO-LEARNERS provided me with this experience.

I did not find any influences from the contextual science research on Rob’s desire to form collaborations with the science community or individual scientists. Although he expresses enthusiasm over his own collaborations with the practicing teacher and the scientist, Rob does not express in his writings that he has any plans to initiate any collaborations with scientists in his classroom. This might be explained by the fact that he teaches mathematics instead of science. However, when I look at this finding in a critical vein using cultural-historical activity theory, I find this to be a contradiction. Rob wanted to help form connections with science and mathematics, yet has not sought scientists, who could help demonstrate these connections to students, to bring into his mathematics class. This might be further explained by the contradiction of Rob’s status as a novice teacher (Dawson, 2002) who finds the induction years (Klepper & Barufaldi, 1998) to be a difficult time to develop and plan activities not specifically addressed in the required curriculum. Although Rob’s students were well behaved, there still was the pressure of standardized testing and covering the material to be tested.

In Chapter 9, I look at Rob’s second year of teaching for any evidence of influences from his contextual science research.
CHAPTER 8: THE SECOND YEAR: CATHY

In Chapter 8, I focus on Cathy’s second year of teaching and use an interpretive qualitative analysis of observations of her teaching and interviews to understand her beliefs and practices about teaching. In order to organize what I observed and what I heard from Cathy, I used an outline based on my original research questions. I then broke this outline down into the 50 specific categories, or nodes, from the QSR analysis, which can be found in Table 5-2.

The First Year Revisited

Although I periodically observed Cathy during her first year of teaching, I mostly assisted her in preparing her chapter for the SERC@SERVE monograph. This interaction mainly involved taking photographs of her classroom for the monograph, helping her to decide what to include in the monograph, and helping her to edit her chapter. During that first year, I also did some informal interviews to follow up on her contextual research experiences and to see how she was bringing her experiences into her classroom.

When SERC@SERVE presented the opportunity for Cathy, Rob, and me to participate in the monograph, we decided to focus on that endeavor because it was a great opportunity for all of us to enhance our professional growth. We elected to postpone lengthy observations and interview follow-ups until their second year of teaching. We also determined that some observation time and interviews would be agreeable in order to keep a focus on the study. Additionally, at this point, I did not have my prospectus completed as I was trying to focus my questions on certain aspects of the participants’ teaching. New issues continued to emerge, and I was unable to narrow my focus until I began to look at the study from a novice teacher’s perspective as opposed to my own, as a practicing teacher. I discuss this more in Chapter 10.

We decided that the first year was a difficult transition period for any novice teacher and that my observations, in addition to those by supervising teachers and administrators, would be very distracting for the teachers and their students. The work of Dawson (2002) confirms that the first year of teaching is difficult, particularly for the science teacher who must contend with difficult subject content, obtaining laboratory materials, and dealing with the general trials of being a first year teacher. Thus, we focused our attention on the SERC@SERVE monograph and
conducted a minimal amount of observations and interviews during the first year of Rob and Cathy’s teaching.

There is additional research to support the notion that the induction years of teaching are most difficult in terms of stress (Klepper & Barufaldi, 1998), due to constant observations and classroom management issues. Outside interference for classroom observations and interviews may be too distracting and time consuming for the first year teachers. We made the decision to wait until the second year of teaching to do the more in-depth observations and interviews in order to observe and analyze what influences their experience might have on their teaching.

During her second year of teaching, I visited Cathy’s classroom over a period of nine weeks during the fall of 2002 and, again, in the spring of 2003. I also spoke with and visited Cathy several times during the spring of 2004 for follow-up interviews. Cathy was on maternity leave from the fall semester of 2003 through the spring semester of 2004. In early summer of 2004, I met with Cathy for in order to clarify my interpretations. I found her eager to return to work in the fall semester of 2004, where she will teach at the same parochial school.

I asked her to read my dissertation to make sure everything was correctly interpreted. I consider this length of time to be adequate prolonged engagement to observe Cathy’s teaching and to conduct follow-up interviews, without interfering too much with her teaching and planning time, as well as her personal and family. The following section details observation, interviews, and interpretations of my findings.

A Glimpse Inside Cathy’s Classroom: The Second Year

The goal of my first observation of Cathy’s classroom during her second year of teaching was to catch a glimpse of what I would see in the months to come and to gain insight into the direction that Cathy’s teaching would go. On this first observation of Cathy’s classroom during her second year of teaching, I wrote the following:

The students flew into the classroom dropped their books, and immediately ran over to the windows, shelves, and the floor where different sizes and shapes of plastic containers ranging from Tupperware to recycled liter soda bottles were located. I heard “oohs,” “aahs,” and a few “oh gross!” comments. I wondered what they were looking at. (Field notes, September 26, 2002)

As Cathy began to teach, I discovered the students had designed and observed the growth of mold. In the interview after the lesson, I asked Cathy, “Today’s lesson was very interesting. I
wish that I had seen the start of this experiment. Describe to me what has been happening,”

Cathy responded:

Students brought in different foods like leftover bread, crackers, and stuff, and put them into plastic containers. Then they put a little water into them and watched them grow. They kept a log and made daily observations. They would come in everyday to look at them. They would be so excited. It was fun. They would ask, “Can we open them?” And I would have to say, “No,” even though it would have been interesting. But I didn’t want mold all over the classroom. (Interview, September 26, 2002)

The students were very excited about the project. They seemed very enthusiastic about what they were doing. I overheard some impressive use of scientific language. One student used descriptive language about his mold as he gave out his measurements in centimeters and used the terms hypothesis, testing, and controls. I also overheard a group of three students talking about controls in their experiment. One of the three was scolding another student because he did not know what his variables were. Another offered to help explain to his companion his variables by showing him a graph with water and sunlight as examples of variables. This appeared to help the other student understand the concept of variables.

When I asked, “Why do you think that the students enjoyed it so much?” Cathy responded, “Well, they like talking about them (the mold terrariums) and watching them change. In addition, they could speak and give their own opinions about what was happening. They were very engaged in what we were doing” (Interview, September 26, 2002). Cathy told me that they had been working on these for about a week and a half and that they would probably finish up at the end of this week making the duration about two weeks total. The students also appeared to know what they were doing because they entered the room and headed straight to their projects to check on them. Cathy had to give very little instruction.

When I asked Cathy if she was able to use any of the techniques that she had used in any of her summer research experiences, she replied,

Yes, at the DEP with the sea grasses. We had to do so much procedure and it didn’t always follow the steps that they teach you. It wasn’t as rigid or in order. I wanted them to have more ‘hands-on,’ be more involved, and not just read about mold from their book. (Interview, September 26, 2002)

Cathy and I discussed how the students were finding that the steps of the scientific method were not always in this order: problem or question, hypothesis, procedure, results, and then conclusions. She replied:
Yes, we did much more procedure with the sea grasses, and the results were more long term than right then. Of course, the mold did have a beginning and an end, but I did want them to understand that that isn’t always the case. So, we’ve talked about it and will probably talk more about it before the lesson is over. (Interview, September 26, 2002)

I asked Cathy if she thought that her summer research might have helped her and her students to realize that idea. She responded, “Yes, because up until then I had only done labs in school that did have a beginning and an end. Labs from a book are usually that way. They are not real-life” (Interview, September 26, 2002).

The term real-life emerges as a significant finding in Cathy’s teaching as it relates to this study. There were numerous times when I heard Cathy mention something about real-life to her students when she was explaining certain scientific concepts. She gave her students examples of real-life science, and then gave them the opportunity to tell *stories* about real-life science. In interviews when she and I discussed her summer research, she talked about real-life science and how much she enjoys learning about something that is meaningful to her.

**QSR Analysis of Cathy’s Interviews**

Using the QSR node listings on Table 5-2 as an outline, I generated the following analysis of Cathy’s interviews. Using categories from the QSR analysis to look for patterns and frequency of discussions on the various topics, I noted several areas that appear to be more heavily influenced by Cathy’s participation in the contextual science research course by finding evidence to support this through my observations and her answers to my interview questions.

While this chapter focuses on her second year of teaching, I refer to prior experiences to help me understand Cathy’s transformation from pre-service teacher to second year novice teacher. In this chapter, I frequently refer back to E-mail communications, interviews and/or observations with Cathy prior to her involvement with the contextual research course during the summer of 1999, during her second summer of research in 2000, during her internship year (2000-2001), her first year of teaching (2001-2002), and, finally, her second year of teaching (2002-2003).

There were 523 passages of texts as this was a year long series of interviews in her second year of teaching, with many varied topics related to teaching and learning, ranging from Cathy’s own learning as a secondary student to her two summers of research experiences to her own teaching beliefs to her actual practices in her classroom.
The questions I posed to Cathy are the same or are similar to the ones found in Appendix A. I also used additional questions, as some did not always apply, and other questions emerged through the observations of Cathy’s classroom. In Chapter 9, I utilize this same procedure of analysis for Rob’s interviews. There are similarities and differences between the two novice teachers with respect to their experiences and prior knowledge and how their experiences influenced their beliefs and teaching practices.

Beliefs About the Culture of Science and the Culture of Science in the Classroom

In this section, I discuss Cathy’s beliefs about the culture of science and the culture of science in the classroom.

Beliefs About the Culture of Science

Cathy came into the contextual science research course with certain pre-conceived notions about the culture of science. She believed that others perceived science as “boring.” Cathy, too, expected the work that she would be doing as part of the contextual science research course would be boring. However, through her two summers enrolled in the contextual science research course, and now in her second year of teaching, Cathy’s beliefs appear to have changed. In her writings, as well as her interviews, Cathy writes about some of the procedures being “tedious” and “detailed,” but overall she enjoys the experiences tremendously and gains a new insight into science. Cathy now believes that science can be fun. She says, “My science research has taught me how much fun learning in science can be” (Interview, May 6, 2003). After completing both of her experiences with the contextual research, Cathy now sees the culture of science in a different vein. She says, “The culture of science is anything that requires you to search for an answer by running tests/experiments, asking questions, forming hypotheses, problem solving, inquiring, and going into the field” (Interview, August 16, 2000).

The Culture of Science vs. the Culture of Science in the Classroom

Cathy’s beliefs about the culture of science in the classroom, however, remain the same throughout the study. Her initial perceptions, most likely based on her own schooling, were that the culture of classroom science has teachers placing too much emphasis on the textbook. Dawson (2002) finds that supporting novice teachers in science and mathematics improves student learning, teacher success, teacher morale, and teacher retention. Cathy supports this idea when she says, “The culture of science in the classroom differs [from the culture of science] because most teachers rely on textbooks to show students what science is all about’” (Interview,
August 16, 2000). Cathy says of the classroom, “Again, the [traditional] culture of science in the classroom lacks excitement and interest” (Interview, August 16, 2000). During her second year of teaching, I asked Cathy a question about how the culture of science in her classroom compares to the culture of science, Cathy replies:

The culture of my science classroom is the same [as the culture of science]. It is my responsibility to make sure students do not accept something just because someone say it’s true. (Interview, December 6, 2002)

While Cathy continues to express strong beliefs about transforming the culture of science in her own classroom so that it is not the traditional classroom, she is not implementing many contextual or constructivist-based lessons. While I initially observed the mold experiment, the subsequent observations were mostly textbook-based lessons. Cathy states:

As a result of my science research experience, I haven’t implemented anything [specifically related to the research in which I was involved] in the classroom yet, but I am motivated to do whatever is needed to make the culture of science in the classroom meaningful, fun, educational, and interesting. (Interview, December 6, 2002)

I think that motivated is a key word here. I believe that through her contextual research experiences, Cathy has, at the very least, been motivated to do something about changing the way the culture of the science classroom has traditionally existed. While the constraints that accompany being a novice teacher might be hindering her ability to put into action many of her ideas, Cathy at least feels motivated to bring these types of activities into her classroom. However, is she acting on her beliefs?

Teaching Practices

During a classroom observation later in the school year, I noted the following in my journal:

Upon entering the classroom, the students were abuzz that they were now doing science and seemed excited. Cathy is obviously a good science teacher who promotes this excitement among the students. (My journal, April 8, 2003)

The lesson today was on gravity. Students were reading from the book to review the chapter for an upcoming test. Students were also learning to graph the distance an object falls over time. Cathy had students dropping items of different masses, to demonstrate that they fall at the same speed. (My journal, April 8, 2003)

In this lesson, Cathy incorporated several teaching strategies, including reading from the text, telling stories, teacher demonstrations, and student demonstrations. However, she also included
textbook-based instruction. She makes a few recommendations for improvement, which I will discuss at the end of this section.

Constructivist-Based Teaching

I observed the mold experiment, previously discussed in this chapter, which was an excellent example of the type of teaching that should be done in middle school science. This lesson was inquiry-based, constructivist-based, and incorporated many hands-on activities. I observed her several times more during her second year of teaching, but did not observe any constructivist-based, other than the mold experiment. However, based on some of her comments, I believe that Cathy understands constructivist-based teaching, but appears to be mostly concerned with covering the required curriculum. While she does modify her teaching practices, her focus appears to be content, facts, and information.

Contextual Learning

As previously mentioned, I found little evidence that Cathy employed contextual learning strategies in her classroom during the first year of her teaching. However, the mold project that I observed during the first observation with Cathy in her second year of teaching was an excellent example. The students started the mold terrariums with their own original design, watched them over a period of time, and made their own conclusions based on what they had found about mold from doing research from the library. This is as close to a contextual science research experiment as one can do in an ordinary classroom, which is not even a designed as a laboratory. Cathy allows her students to be immersed into the context of being surrounded by mold terrariums of all shapes and sizes. As the students observe, gather information, collect samples, take notes, conduct literature searches on mold, they are actively immersed in the context of the mold terrariums and the mold growth.

On the day I observed Cathy’s class, I overheard conversations from the students who were fully engaged in observations and discussions about mold, which included terminology and scientific description, such as comparing mold growth in the dark and in the sunlight. Cathy refers to how the contextual experience influences her teaching either directly or indirectly in 32 out of 523 passages, or 6% of her interviews.

Transfer of Experiences to Classroom

I see empathy as a type of catalyst for a teacher to be able to transfer segments of their own experiences into his/her classroom in order for their own students to enjoy the same positive
learning experiences. I believe that Cathy begins her teaching career with great empathy due to her youthful age, to the fact that her own school experiences are still with her, and to her love of children. I also believe that Cathy’s contextual science research experience further reinforces this empathy and yearning to make her own students’ experiences in science always positive.

McLoughlin and Dana (1999) assert that it is difficult for teachers to teach science as an active process with relevance to the students’ lives, if they are not engaged in learning science as an active process in their educational programs. Participation in actual scientific research places the pre-service teacher in a position of experiencing real science and of being able to relate to that personal experience. This may translate into classroom experiences for his/her future students.

Prior to Cathy’s participation in the summer contextual science research course, Cathy stated, “I would like to work in a science research facility to learn science hands-on and later carry what I learn into my own classroom” (Interview, May 12, 1999). During Cathy’s second year of teaching, I asked her about bringing experiences into her classroom:

My study of science has changed in that I now know how important it is to apply what I learn to experience [Cathy means that she needs to give examples of her own experiences to illustrate scientific concepts so that they are easier for students to understand and relate to]. When teaching science, I ask students to use what they’re learning and apply it to some experiences they’ve had. (Interview, November 17, 2002)

On several of the observations that I conducted in Cathy’s classroom, I observed that she employed a teaching strategy in which her students told stories related to what they were studying. Cathy initiated this by telling her own stories and then by having her students tell their own. I will discuss more on the stories in a later section.

Forming Collaborations with Scientists and the Science Community

_Collaborations with Scientists_

Cathy gave 37 passages, out of 523 total passages, or 7% of her total discussions, in the transcribed text of her interviews, related to questions about collaborations with the practicing science teacher and scientists, as well as with the science community, in general. This may seem like a low percentage, but over a period of a year with many, varied topics of discussions, this was significant as Cathy speaks about such collaborations through her writings and her E-mails on numerous occasions. Many of these responses address having scientists come to her classroom and taking her students out into the community to involve them with various science
projects. She speaks very enthusiastically about these collaborations. I was quite confident that this would be a resource that Cathy would utilize to the fullest capacity.

Cathy gave the following responses during her second year of teaching:

I want to invite scientists from the community into my classroom so students can learn what their options are in the future. (Interview, November 17, 2002)

How we can do that [make science more fun and exciting for students] is plan more laboratory exercises, bring community scientists into the classroom to answer questions and promote interest, and take the time to plan better lessons. (Interview, November 17, 2002)

However, after two years of teaching, Cathy has yet to invite one of the scientists to her classroom or to plan a field study at the scientists’ research facility. This is discouraging for me as a researcher, as Cathy is so enthusiastic about forming collaborations with the scientists with whom she has worked. I still believe that at some point, Cathy will begin to form these collaborations in her classroom, as she begins to feel more comfortable in her classroom.

Later in the year, when I asked Cathy about any science collaborations, she gave the following response:

I have not contacted Evan [the science researcher at the DEP] since my summer research. I’m sure that if I wanted to plan and implement a project, I would contact him or other professionals in the community for support [with a science related service project] such as with sea grasses. (Interview, May 6, 2003)

I consider this statement to be a contradiction as it indicates that Cathy has not yet contacted the scientist with whom she worked during one of the summer research courses. However, she does imply that she would contact him or others if she does conduct a service learning-related project.

One of the original goals of the pilot study was to place the teachers in a learning community with a science researcher who would be willing to work with the novice teacher’s students during the school year beyond the summer research. This type of collaboration could generate field trips for the students with access to the researcher and his/her research site. Although this type of collaboration did not materialize, possibly due to the classroom constraints of the novice teacher (Dawson, 2002), I do not believe that Cathy was being deceptive in telling me that she was going to do these things to appease me as the researcher. I believe that the time is going by so quickly; she has numerous other obligations and does not get around to doing the things that she had planned. This happens to all of us with the best of intentions.

However, the possibilities for the future are encouraging. When I recently asked Cathy, who is now on family leave, if she still plans on forming collaborations, she replied, “Yes, I will
most likely contact them [the collaborating scientists] when I return to teaching next fall. I’m excited about it” (Interview, May 29, 2004). Although Cathy has yet to invite one of the scientists to her classroom, or to involve students with projects outside of the classroom, she does utilize some of the resources that she gained during her contextual science research course.

I have received booklets and activities from the DEP, which I have used in the classroom. The DEP is great about giving out resources and activity books. They are great because they include science and mathematics activities. (Interview, September, 24 2003)

Although Cathy has yet to utilize her newfound community science resources, she may do so when she returns to teaching in the fall of 2004 after her maternity/family leave. As she begins to feel more comfortable in her own classroom, she will, perhaps, take advantage of her contacts in the science community. She may, at some point, implement projects within the science community with the assistance of some of her contacts at the DEP. Her contacts at the Wetlands Research Laboratory will also play an important role, but to a lesser degree, since her experiences at that site did not make as much of an impact on her with respect to a true immersion experience as those at the DEP did. In an interview following her second summer research course, she states, “My experience with the DEP was the most valuable to me because of the ‘hands-on’ experiences I was involved with” (Interview, August 16, 2000).

Connections to the Science Community

Being discouraged by Cathy’s lack of collaborations with the researcher with whom she worked, I wrote this is my journal following an observation of Cathy:

I started thinking about what types of collaborations that I did when I was teaching the first couple of years. I really didn’t do anything until about my third year of teaching. And that was after finding out through in-service meetings in the district that there were science related industries in town that were willing to provide guest speakers and donate materials. If I had known earlier, I might have started earlier. At least Cathy knows. (My journal, May 6, 2003)

Therefore, Cathy, because of her experience and her contacts, is able to lay a foundation to form relationships with these scientists in her community. She knows what resources are available in her community with respect to teaching science. Many novice teachers, including myself at that stage of my teaching career, are not aware of the many resources that are available or of the many scientists who are more than willing to help promote science in the classrooms. The initiative is up to Cathy, as the science researchers are very willing to participate. In fact, Project Greenshores (DEP, 2004), the project Cathy originally studied in her first summer of
research, also in its Pilot Study year, has developed an on-going educational field study available to classroom teachers and their students.

When I was organizing the CO-LEARNERS pilot study, I was pleasantly surprised to find that every scientist at the university and at the state funded organizations I contacted, were more than willing to be involved with a project that would enhance science education. If funding for the salaries for the practicing teacher and tuition reimbursement for the pre-service teacher had not been a limiting factor, I would have had many more teams of CO-LEARNERS, as the scientists were eager to be involved with no compensation.

If contextual, science research work experiences yield no other results than providing the novice teacher with the knowledge for establishing community science partnerships, then the experience is of some value. I’ve know many science teachers who have been teaching for years without asking for help from the science community because they simply “did not know” that they could. This skill is not usually taught or discussed in undergraduate, teacher education programs. While my study did not provide any evidence of any influence on the participants, the participants are connected to their science community.

According to the TIMSS (1997), unlike new US teachers, new Japanese and German teachers undergo long-term structured apprenticeships. The TIMSS finding pinpoints specific areas in which American education can be improved. This includes better teacher preparation and increased opportunities for professional development for teachers. In order to learn and appreciate science, teachers and students must also have some connection to science.

Since Cathy is fully aware of the opportunities, it might take some time for her to come to a point in her teaching where she has the time and opportunity to infuse these resources into her classroom. Klepper and Barufaldi (1998) state that the inductions years for science teachers can require “coping skills for surviving the first five years in the classroom” (p. 11). With Cathy entering her third year of teaching following maternity leave, she might have some more of these induction years ahead of her, but at the very least she has some strong beliefs about what she would like to do in her classroom.

I have categorized some of the “positive” responses as contradictions, as on several occasions Cathy discusses having scientists come to her classroom as guest speakers, or making plans to develop some collaborations within the community to do projects with her students. However, she has not yet initiated collaborations at this point.
Making Connections Between Science and Mathematics

Cathy is able to see science and mathematics connections through her experiences. Although, Cathy’s intent was to be a science teacher, she did teach mathematics and science. Her experiences, which involved a great deal of mathematical measurements and calculations, have apparently helped her in her classroom. She said, “My second year was teaching science and mathematics. My hands-on experiences in the summer research really helped” (Interview, September 24, 2003).

Cathy taught one mathematics course, in addition to science. During several of her science lessons, she incorporated mathematics skills. During my observations in which she was teaching simple physics concepts, Cathy used mathematical equations and measurement on numerous occasions. During the mold experiment, she required the students to keep graphs of the mold growth. Rob, who is a mathematics teacher, incorporated science into his mathematics courses. I will discuss more on Rob’s teaching in Chapter 9. However, this does illustrate that, both, Cathy and Rob used methods to integrate science and mathematics. Cathy completed a required methods course on integrating mathematics and science as part of her teacher preparation program to become dual certified in teaching science and mathematics. This could help explain the strength of her prior knowledge entering into the contextual science research course, and ability and interest with integrating science and mathematics lessons. Rob, because his major was in mathematics and social studies, was not required to take this particular course.

Inquiry-Based, Hands-On Science

Research tells us that while hands-on activities can increase the probability that students’ thinking will be focused on the right things and that learning will occur (NRC, 2000), the use of materials does not guarantee that students are engaged in inquiry or that students are learning. The teacher must pay close attention to whether or not the chosen materials and hands-on activities incorporate the five essential features of inquiry. Table 6-2 gives these five features of classroom inquiry.

At the end of her second summer, Cathy stated that because of her science research experience, she would implement as many hands-on science-learning activities as possible. Although I did not observe as much hands-on as Cathy implied, I believe that she will do more at some point in her teaching career. I consider this inability to implement more hands-on activities, however, to be a contradiction according to the cultural-historical activity theory model.
described in Chapter 3. Her lack of collaborations with scientists thus far, is also a contradiction. Additionally, her inability to gain confidence in her first year of teaching, having to contend with many obligations and duties, and political pressure for her students to succeed on standardized testing can all be considered contradictions. I assert that the limitations of the induction years (Klepper & Barufaldi, 1998) might contribute to those contradictions for Cathy.

Lack of Facilities

During an observation of Cathy’s classroom, I hear her tell a student, “you will do that in lab tomorrow” (My journal, October 18, 2002). I was curious about this, so I asked her what she meant. She replied,

Students in grades K-8 go to science lab once a week. Every week, according to what the class is learning, I give the [lab] teacher a lab that corresponds to my lesson plans. I research various sources to find appropriate labs. (Interview, October 18, 2002)

After some discussion, I found out that there was only one science laboratory in the whole school and that all laboratory experiments, due to safety issues, must be done in that laboratory by a designated “lab teacher.” Because Cathy is in a poorly equipped, standard classroom, she is limited in the types of hands-on, laboratory experiments that she can implement. However, she does have access to the laboratory when it is not in use by the lab teacher. In addition, Cathy teaches a lot of physical science and many of the inquiry-based, hands-on activities in the physical sciences can be done safely without a laboratory.

Initially, I felt her situation to have strong contradictions preventing her from implementing hands-on activities. However, I decided that while it is a contradiction under the tools component of cultural-historical activity theory, there are many activities that can be done without a laboratory and she can use the laboratory at almost any time. More than the limitations of the laboratory, Cathy is limited because of her status as a novice teacher. She is still at that critical stage where she feels the pressure to adhere to school policies, maintain classroom management, and introduce the required content. As the new teacher, she may feel powerless to utilize the laboratory more often, or to make the decision to the laboratory experiments in her classroom, provided they are safe to implement.

As I previously stated, Cathy’s inability to put into action many of her beliefs may be due to the difficulties faced by many novice teachers. Klepper and Barufaldi (1998) find that two of the prerequisites for successful teaching are a caring attitude and a desire to play a role in the development of children. While outside forces or constraints may hinder her development, I
believe that Cathy has the necessary personal and philosophical characteristics necessary to become a successful science teacher.

Making Science Fun and Interesting

Klepper and Barufaldi (1998) also find that another characteristic of a successful science teacher is to have the belief that science should be fun. Cathy expresses both of these philosophies on many occasions. In fact, there are 30 out of 523 in the text of Cathy’s interviews discussing her desire to make science fun. Cathy states, “I know that learning science and teaching it to children has to be fun and interesting” (Interview, September 26, 2002).

In discussing the mold experiment, Cathy describes her students’ reactions, “They would come in everyday to look at them. They would be so excited. It was fun.” I was very fortunate to have the opportunity to observe Cathy’s students expressing some of this excitement for learning. They were indeed having fun, and Cathy was having fun with them. Cathy declared, “I love it when students interact and are excited about learning” (Interview, September 26, 2002).

On the day that I observed the students conducting the mold experiments, I could see the excitement on their faces as they each looked at their mold. Cathy had difficulty calming them down to move on to the next part of the lesson.

Meaningful Science

It is also very important for Cathy to make science meaningful to her students. According to the Klepper and Barufaldi (1998) making science relate to students’ lives is another characteristic of a successful science teacher. Cathy explains how important it was for her to make science meaningful to her students in 21 out of 523 sorted statements.

During one of my last observations of Cathy, I wrote the following:

The lesson today was on force and motion. This subject is often boring for many elementary and middle school students. As I looked about the room, the students were keyed into the topic, although a bit lackadaisical about the readings from the book.

That is until the real-life examples were allowed into the discussion. Having two students bump into one another created great interest and fun. Another great example was when Cathy mentioned that her sister was in an automobile accident and was not wearing a seatbelt. The students were very interested in hearing about this real-life example. I was relieved to hear that her sister was fine after the accident even though the other car was traveling faster than her sister’s 30 mph. This was an excellent example of the law of inertia and forces acting upon one another. Students actually could visualize a “force” even thought that is a difficult concept to visualize.
A student also brought up an example of a girl hitting a tree on a bicycle, and seemed to nod in agreement and understanding that the tree was the actual “force” that stopped her. (My journal, April 15, 2003)

I asked Cathy about the demonstrations in which students were bumping into one another. I told her that they appeared to be having a great time, and at the same time were learning about forces and equal and opposite reactions. I asked Cathy about the lesson and she replied:

Knowing what a force is can be hard to visualize. Yes, I am a visual learner. So what I mean by that is [as a visual learner] I have to be able to “see” something to understand it. And so are many of my students. (Interview, April 15, 2003)

I overheard some students talking about a laboratory activity in which they used toy cars in the class, so I asked her about it. Apparently in this laboratory exercise, the students crashed toy cars into each other. In the same conversation, they also talked about seat belts. This intrigued me, as the students seemed genuinely interested in the experiment. Cathy replied, “In that lab, the students learned about forces and what happens when cars collide at different speeds. They came back understanding that for every force there is an equal and opposite force. They really enjoyed that lab.”

Cathy goes on to discuss how important a laboratory of this nature is with respect to meaningful science. She discusses how every student in her class travels in an automobile and has the opportunity to wear or not to wear a seat belt. She hopes that through a laboratory experience such as this, wearing a seat belt will make much more sense than before. She states, “Also, if we want students to have positive attitudes about science, then we must make what they are learning useful and applicable in the real world.”

During each of the observations with Cathy, I heard stories told by the students. These stories, whether real or made up, were funny, although sometimes a bit troubling as someone might be injured. However, they were always interesting and informative with respect to the content under study. The concept under study was brought into the story at some point, and as Cathy stated, “They did seem to be getting a little carried away with the stories, but at the same time a lot of light bulbs were going off.”

Real-Life Science

Prior to her research experience, Cathy held strong beliefs about what she calls real-life science, which is similar to meaningful science. During the research, she developed stronger beliefs about real-life science and began implementing the use of such science into her
classroom. In her interviews, Cathy gave 54 responses out of 523 total responses related to real-life science.

I wrote the following in my journal during one of my classroom observations during Cathy’s second year of teaching.

Although I could have told Cathy to do a lesson on what she learned during her summer science research that would not have been the reality of her classroom. The reality of her classroom is that she must teach according to a planned curriculum. While it would certainly help with my research if she taught what she learned, how she learned it, and had similar results to her own learning, that is not the reality. She was told to teach gravity at this time in the school year, and this is what she was teaching.

What I did observe with this first observation, however, is that real-life science is an important part of her teaching, and it appears to have been influenced by her experiences with science research. I will investigate this further.

Throughout the entire lesson, Cathy mentioned many examples of real-life science. This was interesting as I heard Rob mention that [real-life science] on some of my observation days in his class. I was noting a pattern [in the two teachers I am studying]. (My journal, April 8, 2003)

Throughout this three-year study doctoral study (five including the Pilot Study years) (Table 5-1), Cathy’s beliefs about using real-world examples to explain science concepts remained strong. While she initially held these beliefs, I assert that her own immersion helped to solidify these beliefs. Cathy says, “It is my job to take a difficult concept/idea and make it applicable to their world. We weren’t going to build a space shuttle; that is not our life.” I believe Cathy is saying that while learning other types of science might be interesting, it is not something to which her students can relate. She prefers bringing in more real-life examples and stories to help them learn the material with more ease and interest.

Students’ Stories

I was fortunate to observe Cathy using some real-life examples and doing what she stated above, taking a difficult concept and making it applicable to the students’ world. I wrote the following notes during my last observation:

Another strategy that Cathy incorporated in her teaching was the use of “stories,” which I have mentioned. Cathy’s students loved to share their stories with the class. Of course, the stories had to be related to the science concepts under study. That was really the only requirement that Cathy mandated to her students. The beauty of the stories was that before the science concept, the stories were just stories that they, their family members, or friends had lived. But now these stories made sense and the science was real to them. (My journal, May 6, 2003)
Cathy says of her students and their stories, “my students are always willing to offer real-life experiences of their own which solidifies the concept in their mind.” She also says, “Yes, they love those stories [like the friend who jumped off the roof onto the trampoline and bounced back so high the friend hit a tree]” (Interview, May 6, 2003). The story to which Cathy refers was told during a physics lesson on equal and opposite reactions. In my journal, I wrote about this study:

The friend [of one of the students] jumped off the roof on to a trampoline, and due to the height of the jump, the “reaction” was that the friend bounced back up so high that she hit a tree. (My journal, May 6, 2003)

Fortunately, the friend was not seriously hurt, but the class loved the story, and I believe that they could envision the “action/reaction” of the jump.

On the occasions that I observed Cathy, I always enjoyed hearing her students’ stories. As evidenced in this following quote, Cathy always encouraged her students to ask questions, critique what they read, and freely express their understanding of science concepts. “I will always encourage student involvement in learning and explaining science [because of the change in my thinking from my own summer research]” (Interview, May 6, 2003). During one very lively classroom observation, Cathy’s students were particularly vocal in a discussion lesson about Newton’s laws. Cathy said, “My students love to talk, so they are more than willing to let me know why something relates to them. Learning is always more interesting when you can relate what you’re learning to you personally” (Interview, May 6, 2003).

Cathy encouraged her students as they gave their stories or offered input. On several occasions, some of the students give very lengthy explanations, and sometimes Cathy did have to end the discussion, for the sake of time and antsy students waiting for the conversations to end. She allowed the students to talk, and gave an opportunity for the others to ask questions. She hesitated in giving an answer as she was trying to get the students to answer and then question the answers and on and on until they reached a consensus. Only then did she give an “answer,” if needed. Cathy stated, “[Their stories] are their experiences, especially with physical science. They would say, ‘I did this,’ and I would say, ‘well, why did it happen?’” Cathy proudly said of her students:

It’s amazing watching a classroom of students go from shy and introverted to expressive and curious during the year. I’ve heard some great stories this year!
But their stories are real. By this I mean that their stories help them to understand and appreciate science because they are real. They are not from a science book, but from their own lives. (Interview, May 6, 2003)

Irvin (1992) writes that in order for schools to be responsive to the needs of the young adolescent and to help prepare students for the new century, curriculum and instruction at the middle level needs to be: (1) more process-oriented, (2) more integrated, and (3) more relevant to the lives of students. One key word here is “relevant,” I believe that this is something Cathy strives her in her classroom. This list echoes the research by Klepper and Barufaldi (1998) who find that the novice teachers believe that the characteristics belonging to a successful science teacher include relating science to the students’ lives.

*Giving Students a Voice*

Not only does Cathy allow her students to offer stories related to what they are studying, but she also encourages them to give their opinions about what they are learning. I found it refreshing to see a teacher who allows her students to express their opinions, to question, and even to argue. All too often teachers take on the role of the “expert,” and they will defend the book as always having the correct information. In this regard, Cathy says, “Also they could speak and give their own opinions about what was happening. They were very engaged in what we were doing. I want my students engaged and having their own opinion” (Interview, May 6, 2003).

I believe that Cathy wants to be the type of teacher that many of her teachers were *NOT*. She wants her students to enjoy science, not fear it. She wants her students to think of science as fun, not hard or boring. Having her students tell stories and have open discussions provides them with the opportunity to ask questions in a non-pressured environment. These stories and open discussions also allow Cathy’s students to see that science is all around them.

*Gaining Science Content Knowledge*

The following remarks from Cathy are very encouraging with respect to how a contextual science research course can influence the science content knowledge of the participants.

Working in a science laboratory for two summers was a great experience. I learned more about hands-on science than I did during my four years at college. I enjoyed the people I worked with and felt comfortable in the laboratory almost immediately. I gathered a lot of information and ideas to use in the future. (Interview, August 16, 2000)

Throughout Cathy’s interview, as well as the SERC@SERVE chapter that she wrote, Cathy demonstrated the use of the language of science within her particular areas of study. During her
first and second years of teaching, I periodically asked Cathy about her research. She was always able to tell me exactly what she did and had no difficulty remembering either the details of the laboratory experience, or the science content. Therefore, I believe that she has retained the content and it remains with her over this length of time. Fortunately, as a teacher, she recognizes that her ability to retain the content over a period of time is most likely due to her immersion in science rather than listening to lecture and reading it from science texts.

Cathy says following her second summer of research, “By doing research, I am able to learn more [content] than in a lecture course” (Interview, August 16, 2000). I think Cathy confirmed this belief through her own experience in which she was able to retain more information than in more traditional types of courses. Overall, Cathy has positive things to say about her research experiences, with particular attention to the amount of science content that she learned in the two research areas in which she participated.

**Gaining Pedagogical Content Knowledge**

This section looks at PCK, or how to teach. The use of textbooks and lecture are the basis for teaching practices associated with traditional pedagogy. Other types of pedagogy are more innovative employing constructivist-based pedagogy incorporating more inquiry-based, hands-on, and contextual learning strategies, which I have previously discussed. In this section, I discuss Cathy’s changing views on the more traditional forms of pedagogy, and how her experiences with the contextual science research may or may not have influenced these views. I also look for evidence that Cathy’s beliefs are put into action more often during her second year as compared to her first year of teaching. I also look at confidence in science teaching, as I feel that confidence plays a key role in how science teachers teach their subject. My belief, based on my own experiences, is that the more confident the teacher, the more effective and innovative the teacher will be.

**Textbooks in the Science Classroom**

Cathy has very strong beliefs about teachers relying too heavily on science textbooks, as noted in her SERC@SERVE chapter (also Chapter 6) and in her interviews. Ironically, on several of the occasions that I observed her during her second year of teaching, Cathy was using the textbook. I believe this occurs because of the administration’s emphasis on the content coverage and standardized testing. The pressure to do well on standardized testing is very
ingrained in the schools, especially in a private parochial school where Cathy teaches. I am sure that Cathy, too, feels this pressure.

Both [my summer research experiences and science methods courses] will have a long range of effect on me because I don’t want to be that teacher who has students read and read and read out of a science textbook and expect them to understand everything. How boring! (Interview, August 16, 2000)

While Cathy expresses that she does not want to have students just read out of textbooks, this is mostly what I observed Cathy doing in both the first and second years of teaching. However, I do note that Cathy utilizes a more interactive approach when using the textbook. Rather than have students read silently or read aloud, Cathy reads aloud with them. As they each take a turn to read a section, she has them reflect and ask questions. Then she gives examples and has them answer their questions, drawing from their own stories and real-life examples. This is a much better technique than just having students read the information. Simply reading from the text would represent the more traditional form of teaching that Cathy rejects. Tobin et al. (1990) suggest the “the major curriculum challenge for teachers is to focus on student learning with understanding rather than to stress content coverage only” (p. 7). In other words, Tobin et al. recommend a limited use of textbooks, as Cathy would like to do. When I asked Cathy about the strategy that she had developed, she replied:

While teaching this unit, I made sure to incorporate as many hands-on and real-life experiences as possible because many of the concepts are difficult to understand. Reading big words from a textbook doesn’t help students fully understand the concepts. They just read the words but don’t bother understanding what they are reading. So, we took our time going through each concept and vocabulary word. (Interview, April 15, 2003)

Less Lecture

I did not observe the overuse of lecture in Cathy’s classroom. Rather than a monotonous lecture, she employed more discussion and encouraged participation from her students. This was also evident from observations that I conducted throughout the two years. Cathy says, “As a direct result of my science research experience, I plan on using less lecture, more hands-on activities, research, and student participation” (Interview, August 16, 2000). Cathy also tried to use as little textbook laboratory experiments as possible. Instead, she designed many on her own because she feels she could design more meaningful laboratory experiences for the students that she teaches. She states, “Yes, because up until then [my first year of teaching] I had only done
labs in school that did have a beginning and an end. Labs from a book are usually that way. They are not real-life.”

By the term real-life, I believe that Cathy is saying that her students can relate to real-life laboratories in their own lives, which in turn will be more meaningful for them. This, she believes, will motivate the students to learn the concepts beyond the real-life lessons. Also, when referring to laboratory experiments from books having a “beginning and an end,” Cathy implies that she wishes to incorporate more inquiry-based laboratory experiences that may or may not have “an end,” that pose many questions, and that have many solutions.

Confidence in Science Teaching

About confidence, after her first summer of research, Cathy says in an E-mail correspondence, “I left that [science research] experience with confidence and an enthusiasm for learning science” (E-mail correspondence, August 11, 1999). I believe that Cathy is saying that upon leaving her first science research experience, she gained confidence and enthusiasm. There are 22 out of 523 passages from Cathy’s interviews under the “confidence with teaching science” node. I divided Cathy’s discussion about “confidence with teaching science” into two areas: (1) professional growth and development, and (2) teaching practice.

In looking at her professional growth, Cathy had the opportunity to attend two teaching conferences, where she gave presentations on her research experiences. In addition, she published a chapter in the SERC@SERVE educational monograph. Cathy also realized that her summer research experience gave her confidence with teaching. She said, “Doing the two summers of research boosted my confidence in my ability to teach science to students” (Interview, September 26, 2002).

Cathy apparently gains confidence with regards to working in a laboratory setting. Many science teachers feel uncomfortable in a laboratory situation with students, due to safety issues and classroom management. Therefore, novice teachers need an extra boost of confidence in this area. Cathy expresses the following, “I became more knowledgeable in my field and confident in a lab setting” (Exit Interview, September 24, 2003). I do note a contradiction here, however. While Cathy states that she feels more confident in a laboratory setting, I only observed one lesson that incorporated the use of a laboratory setting.

I would also like to note, however, that from Year One to Year Two of the observations, Cathy appeared to be much more comfortable with classroom management. Given this change, I
anticipate more interaction and the implementation of more hands-on activities in the classroom; but unfortunately, I did not observe any.

**Interpretations of Cathy’s Second Year**

Based on Cathy’s observations and interviews from her second year of teaching, I find some evidence to support several influences from the contextual science research on her beliefs and, to a lesser extent, in her actions in the classroom. First, I used the QSR NVivo software to help me categorize and interpret Cathy’s beliefs and practices for any influences from her contextual science research involvement. After organizing the results from the qualitative analysis, I used the cultural-historical activity theory model (Figure 10-1) to find contradictions and coherences with respect to the influences from the contextual science research course on Cathy’s beliefs and practices as a novice teacher.

**Contradictions**

Two areas in which Cathy held strong beliefs, but which were not apparent in her classroom practices are (1) Collaborations with scientists and the science community, and (2) Limiting the use of science textbooks in the classroom.

**Collaborations with Scientists and the Science Community**

Initiated by the science research and throughout the study, Cathy is very enthusiastic about bringing scientists into her classroom in a collaborative effort. However, I did not observe this during the two years of working with Cathy. During subsequent interviews, I also found that these collaborations did not occur. She does, however, use some of the resource materials from one of the collaborations. I was very surprised to discover this contradiction, as Cathy expressed such commitment to the possibility of forming collaborations with scientists in her community.

**Limiting Science Textbooks in the Classroom**

While Cathy still uses the textbook, she adapted the way that she uses the textbook in her classroom. One reality that Cathy realized was the pressures of standardized testing. Due to the emphasis on vocabulary, I believe that Cathy feels she must go over the vocabulary of science more often than she might have earlier believed was necessary. Cathy states:

I found this strategy [reading with them] to work because some students were either not reading anything or were reading the material but not understanding what they’re reading. With this strategy, the students are more willing to ask questions when confused and enjoy telling stories related to what we’re learning. (Interview, May 6, 2003)
Cathy mentioned to me during an interview that standardized test time was a “big deal” (Interview, October 18, 2002) at her school. I assert that, faced with expectations from her school administration and from parents for her students to excel on standardized tests, Cathy felt that she must reinforce the vocabulary and content from the textbook. I believe this is why she still relies heavily on the use of the textbook, with her modifications. In some ways, Cathy has maintained her beliefs but has altered her practices to adhere to rules and schemas of the school in the form of standardized tests expectations. Cathy said of textbooks:

You just can’t read something out of a book and expect all types of learners to understand. That is why I don’t assign an entire chapter for students to read and expect them to come in the next day ready to explain that they have learned. (Interview, May 6, 2003)

Constraints

Several constraints contribute to Cathy’s inability to bring collaborations to fruition and limit the use of textbooks. I address each of the constraints associated with Cathy’s teaching practices.

Curriculum Constraints

Curriculum constraints require certain amounts of material to be covered within a certain period of time, which can limit a teacher’s creativity in the classroom. Usually these curriculum mandates revolve around standardized testing. This often equates to the overuse of textbook in order to ensure that the teacher covers the material on the standardized tests.

In their study, Klepper and Barufaldi (1998) find standardized testing and the attempt to cover all the content to be a few of the barriers for novice teachers to fully develop a creative curriculum. Often times, this leaves little time for extracurricular types of enrichment, as teachers, specifically novice teachers, feel the pressure to perform because standardized test scores help determine the grade for the school. The administration often holds teachers accountable for these grades. The reality is that for novice teachers, without a continuing contract or tenure, standardized testing can be a major source of frustration for the novice teacher. Trying to decide to implement exciting and fun teaching strategies, or to just “teach the test” can be a dilemma for the novice teacher who wants to be re-hired the following year.

Financial Constraints and Limited Classroom Facilities

The lack of financial resources can also limit field studies within the community. Obtaining a school bus to transport students to field trip locations outside the classroom can be
limited as use of the bus creates an additional cost, whether at a public or private school, as the bus driver must be paid. However, there are creative ways to overcome this constraint, such as grant funding, community donations, fundraisers, and/or the use of parents to transport students. Unfortunately, these alternatives require a great deal of time and coordination. A novice teacher does not have a tremendous amount of time to do much else besides worrying about keeping his/her job. Klepper and Barufaldi (1998) find that “[t]he first years of teaching are periods of constant evaluation, compromise, and adjustment” (p. 2). It is little wonder that a novice teacher finds difficulty in doing everything that they have the best intentions of doing.

The science department at Cathy’s school is limited to one science laboratory. While this laboratory is well stocked, one science laboratory may limit the amount of time teachers have the opportunity to use the science facilities, which in turn, may limit the amount of hands-on instruction.

**The Induction Years**

The greatest contradiction to Cathy’s actions, I believe, lies within what Klepper and Barufaldi (1998) call the induction years. While Cathy might not have utilized her access to the science community resources during these first two years, I believe that she plans to use them in the future. Because her first two years, part of the induction years (Klepper & Barufaldi 1998), were mostly getting comfortable in her role as a classroom teacher, the years ahead will offer her more opportunity to diversify her teaching tools and methods. At least, she has the background knowledge and knows what to do when the time is ready to implement different strategies that might deviate from the curriculum mandates, standardized testing, classroom management issues, and limited resources.

Additionally, I believe that in time she will begin to access the science community and will incorporate scientists in the classroom or in partnership with community-based projects, such as a sea grass study. Cathy gave some indication that this was her plan. In an interview Cathy stated, “I think students would really enjoy planting sea grasses in the area and learning about how sea grasses help the environment” (Interview, May 6, 2003).

Cathy expresses positive attitude about the scientists with whom she collaborated in this statement, “I know scientists and teachers in the community would support the education of future science teachers “ (Interview, August 16, 2000). Given time, I believe that Cathy will adapt and realize that bringing scientists in the classroom can actually supplement the material
she needs to cover rather than create time conflicts. When I asked Cathy if she would contact the scientist with whom she collaborated in the CO-LEARNERS project, she replied, “Yes, I will most likely contact them in the future when I return to teaching science“ (Interview, August 16, 2000).

On the use of textbooks, Cathy expresses that she would like to use as little textbooks as possible. Yet, she uses the science textbook quite often. This could be due to the emphasis on standardized testing she mentioned earlier, which comes with an implied requirement of having to cover certain facts and information. Cathy does, however, modify the way that she uses textbooks in the classroom. She reads with her students and is careful go over each concept until each student seems to understand. She also re-writes or uses different laboratories for many of her lessons, as she described the textbook laboratories as not being real-life. I also feel that when Cathy gets past the induction years of teaching, she will begin to implement more of the practices that best fit her beliefs about teaching and learning science.

Using the cultural-historical activity theory model as a guide, I conclude that curriculum constraints related to standardized testing, financial constraints of a limited budget, the limited science laboratory facilities at Cathy’s school, and the emotional constraints associated with the inductions year (Klepper & Barufaldi, 1998) created contradictions that inhibited Cathy from going to her outcome, putting her beliefs into practice, or praxis.

Coherences

However, there is some evidence of influences with regards to beliefs and actions from Cathy’s involvement with the contextual science research experience in other areas. Cathy demonstrated a change in beliefs, with regards to:

1. gaining a better understanding of the culture of science, as well as the culture of the classroom science,
2. gaining confidence with teaching science, and
3. gaining science content from the experience.

Cathy’s influences from the contextual research have influenced Cathy’s teaching practices with respect to:

1. incorporating real-life and meaningful science activities in the classroom,
2. increasing her desire to give her students a voice in the classroom, and
3. increasing her desire to make science fun.
To a lesser extent, Cathy’s influences from the contextual research have influenced her teaching practices with respect to:

1. gaining the ability to transfer contextual and constructivist-based methodology into the classroom,
2. implementing inquiry-based, hands-on science, and
3. incorporating mathematics and science connections.

**Understanding the Culture of Science and the Culture of Classroom Science**

Prior to her participation, Cathy held the belief that science was boring, hard, and that scientists were nerdy. After her experience in the laboratory setting, Cathy’s perceptions have changed. After the first summer of research, Cathy stated, “I expected the people I worked with to be boring and nerdy. I also expected the work to be boring, but it wasn’t” (Interview, August 11, 1999). Her perceptions on the culture of the science classroom remained fairly constant. However, her beliefs and goals for her own classroom have evolved to be more consistent with the true culture of science in that she wants her classroom to promote a desire for learning. She wanted her students to learn new things and to ask questions and not accept something just because someone says it is true.

While she held these beliefs about her own classroom prior to her experiences, I believe that her experience with the contextual science research helped to solidify these beliefs and might enable Cathy to continue to put them into action, as she has already done somewhat in her classroom. I believe that as Cathy finds more confidence in her teaching, she will continue to do even more in the years to come.

**Gaining Confidence**

Cathy expresses, in several interviews, that this experience has boosted her confidence. When I speak with her, I find her to be very confident about her teaching and her knowledge of the subject matter. She has also exhibits a boost of confidence within a laboratory setting. The cooperation from the university research facilities and the DEP provided the opportunity for Cathy to gain this confidence.

**Gaining Science Content**

Cathy discusses her science research experiences very eloquently and factually. I believe that the content she gained has remained with her, and will continue to do so.
Incorporating Real-Life Science

Cathy’s experiences using real-life science seem to have increased her awareness of her students’ needs. Because her experiences during both summers were meaningful to her, Cathy better understands the need for meaningful, real-life science. The sea grass study was meaningful in that Cathy’s work, as well as the work of many others at the DEP, has led to a huge restoration project in our community. Cathy is proud of this, and it was meaningful to her because she was concerned about the environment, especially now that she has her own child.

In her study of fluoridation, Cathy was not even aware of the study until her involvement. Again, after having her first child, learning about fluoridation in the water is very important to her. In retrospect, in a later follow-up interview, Cathy was thankful to have had the opportunity to become better informed about the fluoridation of the area’s water supply as she is now a new mother.

The opportunities afforded Cathy in the summer research provided coherence to her understandings that real-life and meaningful science are of great value to the students that she teaches. Cathy is very successful in incorporating examples of real-life and meaningful science into her classroom. I observed Cathy on numerous occasions providing such examples to her students, as well as allowing her students to voice their own stories in her classroom. She discussed both techniques at length in her interviews. These terms, real-life and meaningful science, extend to laboratory experiences, as well as discussions. Many of her laboratory experiments or demonstrations could also be described as real-life and meaningful science.

For example, when her students were learning about forces and what happens when cars collide at different speeds, Cathy provided opportunities for the students to give examples in their own lives relevant to the topic. Students enjoyed hearing about others’ real life science and how it applies to their lives, as well.

Cathy states:

I use as many personal experiences as possible. Usually, I think of ways to explain various concepts off the top of my head. Plus, my students are always willing to offer experiences of their own which solidifies the concept in their minds. (Interview, April 15, 2003)

Giving Students a Voice

Through her own experiences, Cathy had the opportunity to ask questions and to conduct tests within a laboratory setting. Cathy wanted her students to have similar opportunities. I
believe that what Cathy was truly hoping that her students would not just accept what they hear as truth. She wanted them to question science, and to realize that what scientists know is almost always changing. She gave her students voice through their stories.

Making Science Fun

Cathy entered the study with a desire to make science fun. Before, during, and after her summer research, Cathy still wanted to make science fun. The big difference is now Cathy knows that science *can be* fun. Before her contextual research experience, Cathy believed in the commonly held perception that “science was boring,” but she still wanted to make it fun for her students. Now, she knows that science is and can be fun, so Cathy speaks about science with more conviction.

Transferring Contextual and Constructivist-Based Experiences

Because Cathy experienced both contextual learning and a constructivist-based learning experience, I believe that she will offer these experiences to her own students. The feeling of empowerment, the increase in confidence, and the learning of content made an impression on Cathy, and I believe that she has a desire to emulate these experiences for her students. She is doing this to some degree, and may continue to do so more often as she becomes more comfortable with her role as classroom teacher.

Implementing Hands-On

Again, Cathy maintains a desire to incorporate a considerable amount of hands-on science. Now that she has experienced hands-on science in the true sense of the word, I believe that Cathy understands that hands-on might not always be minds-on. Cathy gained a new insight from her experience. Now, her conceptualization of hands-on science has expanded into more real-life, more meaningful science. In other words, science that is not straight from the textbook. It also includes more inquiry-based experiences that are more open-ended with more questioning and problem solving.

Incorporating Mathematics and Science Connections

Using the mathematical skills of measuring, graphing, and computing in her science research, Cathy was able to experience first-hand the connections between science and mathematics and to see that she could teach the subjects together using integrated lessons. Since she teaches both science and mathematics, this was an important experience. During the mold
observation, Cathy’s students did a great deal of measuring. I asked Cathy about the mathematics involved with the science lesson, she replied:

This lesson includes so much mathematics, that it really is both [science and mathematics]. They have to make graphs of how their mold is growing because they measure it. They are using metric measurement and doing the graphing, so there is a lot of mathematics. (Interview, September 26, 2002)

Incorporating Inquiry into the Classroom

Cathy never mentions the actual word, “inquiry,” but she does talk about questioning and problem solving in science, as well as incorporating hands-on science. I interpret this to mean inquiry.

Cathy’s Recommendations

I would like to see more science methods classes offered, more science practicum [courses in which pre-service teachers work alongside practicing teachers; similar to student teaching but for a much shorter periods of time] offered, and more research opportunities for future science teachers. (Interview, July 26, 2000)

Through discussion with many of her fellow teacher education classmates, Cathy finds that many of them expressed an interest in doing what she had been able to do during her summer research. She says, “I know that if the opportunity [the collaboration of a scientist, a practicing teacher, and a pre-service teacher who is pursuing a career in science and/or mathematics teaching] is available, university students will definitely participate” (Interview, July 26, 2000).

Cathy enrolled in the course for two consecutive summers, so I am confident that she was enthusiastic about the contextual science research aspect of the course. In this regard, she said, “I don’t think science content courses should be replaced but the research experience could coincide with whatever science [content] courses the university student is taking” (Interview, August 16, 2000).

While Cathy enjoyed the course and learned from it, she did feel that it could not replace all content courses. This was not the intent of the course, so I do not consider this a contradiction. I offered the course as an option to replace only one required content course. Since Cathy enrolled for two summers, she substituted two of her content courses, so perhaps she was somewhat confused on the intent of the course. However, Cathy’s idea for the contextual course to coincide with a content course is a good one.
Findings from the Second Year

There are 10 specific areas, based on the original research questions in this study, in which Cathy’s participation in the contextual science research course seem to influence her beliefs and/or teaching practices during her second year of teaching. In order from positive influence to some to minimal influence, these are:

1. **Positive**
   
   a. understanding the differences between the culture of science and the culture of science in the classroom,
   
   b. gaining confidence with science teaching,
   
   c. gaining science content,
   
   d. incorporating real-life and meaningful science in the classroom,
   
   e. forming a desire to give the students voice in the classroom, and
   
   f. forming a desire to make science fun.

2. **Some**
   
   a. transferring experiences with contextual and constructivist-based methodology classroom, and
   
   b. making science and mathematics connections.

3. **Minimal**
   
   a. incorporating inquiry-based, hands-on activities into the classroom.

Two areas in which her participation in the contextual science research appears to have No influence are forming collaborations with scientists and the science community and limiting the use of the science textbook. From her interviews, her beliefs in these areas appear to be positively influenced, but not her teaching practices.

As discussed in Chapter Two, Klepper and Barufaldi (1998) find that the during the first years of teaching, novice teachers are constantly undergoing periods of evaluation from their peers, parents, students, and administrators, compromising their own needs and beliefs, and adjusting the their classroom needs. This time-period also influences and helps to establish teaching behaviors and beliefs about practice. The school administration, the school district, and to an extent, the parents all evaluate Cathy. She must compromise and adjust on a daily basis to accommodate school policies, special events, student disruptions, parental requests, and so on. Cathy’s prior learning experiences, including the contextual summer research, her current
teaching situation, and her plans for the future influence her beliefs and practices from many
gles. I believe that she is torn between doing what she feels should be done and what she “has
to do” to make it through her first years.

In Chapter 9, I look at Rob’s second year of teaching using the same type of interpretive
analysis. Using the interpretive analysis of the participants’ writings found in Chapters 6 and 7,
and the analysis from each participants’ second year of teaching, I will make my final
interpretations, discuss the implications of this study, and make recommendations for
improvement and future studies, in Chapter 10.
CHAPTER 9: ROB: YEAR TWO, A TIME OF TRANSITION

In Chapter 9, I look at Rob’s second year of teaching through an interpretive analysis of my observations of his classroom and interviews with him during his second year of teaching. In order to categorize my observations and the interviews, I dissected my original research questions to generate an outline to create specific sections related to Rob’s teaching. I also used these sections to develop my node listings for the QSR analysis found in Table 5-2, as I did in Chapter 8 with Cathy’s second year of teaching. Rob’s categories deviate slightly from Cathy’s, as he exclusively teaches mathematics. In addition, Rob’s prior experiences with science were at a different level from Cathy’s, which resulted in diverse experiences and areas of influence from the contextual science research for Rob.

Building a Stronger Science Background

After retiring from a military career, Rob chose to specialize in mathematics and social studies. He did, however, wish to participate in the CO-LEARNERS Pilot Study and contextual science research course because he felt that he needed a stronger science background. He also wanted to learn how to integrate science and mathematics into his teaching. In addition, he needed a course credit for his teacher preparation program. Rob was aware of the existence of the connections between mathematics and science, but he had never directly experienced these connections. Prior to his participation in the contextual science course, Rob had never done any hands-on, research type experiments within a laboratory setting. Science intimidated Rob, so he had not previously taken many science courses, other than college biology. Before the science research course, Rob wrote, “Yes, I am nervous about doing the science. This is my very first experience with doing science research.” This was about to change for Rob. As with Cathy’s observations and interviews, I completed the observations and interviews for this chapter, mainly at the beginning of the fall semester during Rob’s second year of teaching. I did, however, continue with a few additional observations and interviews during Rob’s spring semester of teaching. Unlike Cathy, who participated in both summers, Rob only participated in one summer of the contextual research course.
The First Year Revisited

Looking back at Rob’s first year, I recall several highly student-oriented classroom activities that included many of the elements necessary to promote inquiry and student achievement. During this year, Rob taught at a middle school located in a suburban, waterfront community in northwest Florida. The students were well behaved and consistently scored high on standardized testing scores. Rob’s lessons incorporated hands-on science and mathematics activities, along with inquiry-based activities in a constructivist-based, contextual learning environment.

Year Two: A Transition

Rob’s second year of teaching proved to be a year of transition as he changed schools after his first year of teaching due to funding cuts at his former school. He transferred to an older school located in a lower socioeconomic, rural area, whereas, his previous school was a new facility located in a higher socioeconomic, suburban neighborhood. The student populations at Rob’s second school were more unruly than the students at Rob’s first school. Rob now faced working with low achieving students with behavioral problems. Because of those constraints, Rob’s attention focused on classroom management issues and improving standardized test scores. Teaching in a different school with a low-achieving student population, working with outdated facilities, and facing a lack of collaborations among teaching peers, inhibited Rob from implementing the types of hands-on lessons he was able to conduct during his first year. I discuss these hindrances later in the chapter.

QSR Analysis of Rob’s Interviews

In the following section, I used the QSR software to analyze the data from Rob’s classroom observations. I used the same qualitative, interpretive process for Cathy’s analysis in Chapter 8. To help illustrate Rob’s growth as a teacher, in this chapter I refer back to interviews with Rob prior to and during to his involvement with the contextual research course during the summer of 1999. I use E-mails, interviews, and observations notes from my journal. I continue to cite Rob through his final year of coursework and his practicum experience in his teacher preparation program (1999-2000), his teaching internship year (2000-2001), his first year of teaching (2001-2002), and his second year of teaching (2002-2003) (Table 5-1). I recently asked Rob to read chapters from my dissertation for feedback, in true hermeneutic dialectic fashion, to help me clarify my interpretations and assertions on his writings, observations, and interviews.
While I received feedback throughout the study, this closing feedback allowed Rob and Cathy to see the whole picture before the final submission of the dissertation. I wanted them to know how important their participation and voices were in my study.

During his second year of teaching, I visited Rob’s classroom over a period of nine weeks during the fall of 2002 and, again, in the spring of 2003. I also spoke with and visited Rob several times during the spring of 2004 for follow-up interviews. In early summer of 2004, I met with Rob briefly to get his permission to use his SERVE chapter. I also asked him to read my dissertation draft, in order to clarify my interpretations. I was excited to hear that he had received his tenure, which is generally given at the end of the third year of teaching. I told him that there was a possibility that the DEP would fund a summer of CO-LEARNERS during the summer of 2005. He was very interested in working with the project, this time as the practicing teacher. Cathy expressed an interest in participating, as well. I gave Rob copies of the chapters from my dissertation for a final member check.

Beliefs About the Culture of Science and the Culture of Science in the Classroom

In this section, I look at Rob’s beliefs about the culture of science and the culture of science in the classroom. I discuss Rob’s beliefs both before his involvement with the contextual science research course and then after his completion of the course. I also discuss Rob’s beliefs during his first and second years of teaching as his growth as a teacher evolves.

**Early Beliefs About the Culture of Science**

Rob’s initial beliefs about the culture of science held that science was intimidating and difficult to understand. Mathematics, on the other hand, was more logical to Rob. Prior to his involvement with the CO-LEARNERS pilot study in the summer of 1999, Rob stated, “Science [the culture of science] is scientists and lab technicians in laboratories looking for something. That something could be either a cure for a major disease or bad bacteria in water” (Interview, June 14, 1999). Early in the study, Rob made that initial connection between mathematics and science. Since he enjoyed mathematics, he wanted to expand his knowledge to get a better feel for designing laboratory experiments that would tie mathematics to science. Rob made the following observation in the summer of 1999 during his science research experience, “The culture of science is the discovery of how things work using math” (Interview, August 11, 1999).

It was exciting to see how enthusiastic Rob became while doing these water collections and laboratory testing for fecal coliform bacteria. Rob thoroughly enjoyed his experience in the
laboratory, as well. Following his research experience, he stated, “Yes, working in a science research facility met my expectations, it was a well laid out laboratory” (Interview, August 11, 1999). Rob realized that while what he experienced was rewarding and valuable, there was much more to be learned. He said, “I only saw a very small slice to science” (Interview, August 11, 1999). Here Rob acknowledges that he had only been involved in an abbreviated research project. This realization, I believe, has helped him to develop a greater appreciation for science and what scientists do.

Second Year Beliefs about the Culture of Science

Before his participation in the contextual research course, Rob acknowledged that science intimidated him somewhat. In one observation during Rob’s second year of teaching, I observed that Rob seemed very comfortable in his science discussions. I asked Rob if he thought that his experience with the summer contextual science research course made him feel more comfortable with and less intimidated by science. Rob replied, “Yes, I always knew that math and science went together, but I think the experience helped to cement it together” (Interview, November 13, 2002).

Rob mentioned that mathematics and science go hand in hand and that one of the students agreed with him that you could not do science without mathematics. I asked him if this was something that he discussed with his students frequently. Rob answered, “Not constantly, but whenever I cover something that I know the science teacher has covered I make sure that my students understand that without math there would be little science” (Interview, November 13, 2002). I asked Rob if there was something in his background that convinced him that this was true. Rob told me that, “in high school, I took biology, chemistry, and physics. Then in college, I took biology. I know that without math there can be no chemistry or physics” (Interview, November 13, 2002). Rob had the basic knowledge about the interrelatedness between mathematics and science, but because of limited science research experience, he had not seen this connection in action until his contextual science research experience.

Teaching Practices

Constructivist-Based Teaching

There were no notable influences of constructivist-based teaching practices reflected in Rob’s classroom practices during his second year of teaching, particularly when compared with those that occurred during his first year.
Contextual Learning

I believe that Rob’s overall experience with the contextual science research was beneficial to him in several ways. In this section, I discuss how Rob’s involvement influenced his confidence with science and his ability to transfer his experiences into his classroom to some degree.

A Lesson on Spending Money

While I observed several exciting contextual learning activities during Rob’s first year of teaching, I was surprised that there were so few during his second year. There were, however, some good lessons that his students seemed to enjoy. These lessons were mostly mathematical in nature, and they were not as integrated with science as those that I had observed in the first year.

During Rob’s second year, one activity I observed dealt with something he called Word Bucks. These Word Bucks, funded by Rob, were something that students could earn for homework completion, good grades, good behavior, and so on. The students could then redeem these bucks for prizes. I considered this a contextual learning activity in mathematics because it placed the students in the role of a consumer in which they had to “earn” money and then spend it wisely. The students seemed to enjoy the whole concept, and they learned from their actions, especially how to keep “track of their money.” As Rob explained:

I can’t say how I came up with the idea. It just came to me just before we went on break after the first nine weeks. Completed homework is worth $200, an ‘A’ on a test is worth $500 and a ‘B’ is worth $300 on a test. A 110 on daily work is worth $200 and a 100 on daily work is worth $100. They must exchange their money at the school store. It takes $3,000 of my dollars to equal $1.00 in the store. (Interview, February 12, 2003)

I then asked Rob if this process helped any of the students with money management. He replied, “I don’t know for sure, but they sure keep track of their money. They keep coming up to me and exchanging their money for larger bills so they do know how to keep track of money.” (Interview, February 12, 2003). Rob applied his own contextual learning experience to an idea that was an excellent example of contextual learning and of real-life, as it helped students learn to keep up with their money and to develop better spending habits.

Transference of Experiences to Classroom

With Rob’s hesitance to incorporate science activities during his second year of teaching, I was unable to determine how much of his contextual experiences with science he was able to transfer to the classroom. I did observe, on several occasions, a transfer of experiences in the
form of some contextual science lessons during his first year. While Rob was successful in transferring some of his experiences to his classroom the first year, he was not successful in his second year of teaching. I assert that Rob’s transition to a different school compounded by the difficulties of being a novice teacher (Klepper & Barufaldi, 1998; Dawson, 2002) proved to be too many contradictions, and prevented Rob from moving towards his desired outcomes.

In an interview, Rob stated, “I think the summer research was useful but not necessarily in what I teach in the classroom” (Interview, November 13, 2002). This belief is, of course, due to the fact that Rob teaches mathematics, not science. Rob, however, does feel that his experience was useful in regards to his confidence with science and to the connections between mathematics and science in the classroom.

During his first year, there were several lessons I observed in which Rob used some of the mathematical techniques that he had used in his science research. In the hurricane house lesson and in the lemonade activity, Rob used ratios and proportions, similar to those he had used during the contextual science research course. Similar to the experiences during his research experience, both of Rob’s lessons were based on real-life science and mathematics. There were no observations of student hands-on, inquiry-based activities during the second year of teaching, but Rob discussed and demonstrated many examples of science and mathematic connections during this year.

Rob spoke favorably towards this type of contextual research course, even though he was not a science teacher. After the completion of his contextual science research course, I asked Rob whether he thought contextual science research experiences should be included in teacher preparation programs, and he responded, “How can someone teach [science] effectively if they have never experience real-life science? So, yes, I believe it should be included in a teacher preparation program” (Interview, August 11, 1999).

**Forming Collaborations**

**Scientists in the Classroom**

While Rob seemed to enjoy his experience in the contextual research, he felt there were a few issues that could have been improved. At the end of the summer research experience, I asked him how he enjoyed working with the scientist at the Wetlands Research Laboratory, he replied, “I never worked with a scientist. I worked with lab technicians in the science process. I feel that scientist is too high a term for this experience.” In this statement, Rob referred to the fact that he
had trouble accessing the lead researcher on his project. However, the laboratory manager at the
Wetland Research Laboratory, who does hold a Master’s degree in science, worked with Rob
and the practicing teacher, Martha. I believe that the laboratory manager, Jane, did an excellent
job working with them. While Rob might have been disappointed that the lead scientist, who is
also a biology professor at the university, was unable to work with them more, I think that Rob
enjoyed working with the laboratory manager, as well. On the day that I joined Rob, Martha, and
Jane on the research boat to conduct water testing, I noted a positive working relationship
between Rob and Jane, as well as Martha. Jane was very concerned with helping Rob and Martha
to learn. I noted the following:

   Jane is very knowledgeable about the water testing and is doing a great job of teaching
   the information to Rob and Martha. Rob was able to answer almost all of my questions
   about what they were doing. (Field notes, June 23, 1999)

   Rob did not express as much enthusiasm for making science contacts in the community
   as Cathy had expressed. This is most likely due to the fact that he is not teaching science. I asked
   Rob if he had contacted or utilized any of the science contacts that he had made during his
   summer research to come speak to his students or collaborate on any activities. Rob replied, “No,
   I haven’t contacted any of the science people that I worked with. And don’t plan to at this time
   since I don’t teach science right now” (Interview, November 13, 2002).

   If Rob were teaching science, his attitudes about the collaborations might be different,
   and he might pursue them more aggressively. He did agree that the collaborations with scientists
   and the science community would be beneficial to future science teachers, especially with
   respect to laboratory experiences. Following his summer research experience, Rob said:

   I would say that the collaborations would be wonderful in helping a university student in
   how to use the lab when they start to teach. I don’t think college prepares the [pre-service
   teaching] student to train students in the lab. (Interview, August 11, 1999)

The Science Community

   Following an observation of Rob’s classroom, I wrote the following reflections in my
journal:

   I doubt that Rob will seek out science collaborations with anyone from the science
community. I really thought that he had developed a very professional working
relationship with Jane [in the Wetlands lab] and that they would collaborate at some point
on some math and science lessons. I suppose that Rob is feeling a little overwhelmed at
this point because of his new school and is a little afraid to add one more thing to his
plate. It might be a little different IF he were teaching science, and maybe if he were still at the other school. (My journal, March 19, 2003)

Since Rob is not actually teaching science, I am not sure if he will ever form any collaborations with the science community. Perhaps in the future, however, he will realize that he can utilize this resource to do science-related mathematics projects in class. I think that over time, he will realize that by inviting a scientist into his mathematics classroom, he can open up a whole new perspective for his students to see the connections between mathematics and science. As Rob gains more comfort with his role as a classroom teacher and as he begins to use his new lens with respect to mathematics and science connections, he may begin to use his access to the science community to benefit his mathematics students.

**Collaborating with a Practicing Teacher**

When I asked Rob how his experience with the collaborating teacher helped him to envision his own classroom, he replied: “Yes, the teacher I worked with believed in hands-on and they [the students] seemed to enjoy science more” (Interview, May 28, 2003).

**Science and Mathematics Connections**

At the start of the project, Rob’s primary interest revolved around making connections between mathematics and science within his own classroom. When I analyzed his interviews from his second year of teaching, this proved to be a major theme in his second year of teaching. There were 72 out of 317 passages, 23% of the total, in the text of his interviews related to forming mathematics and science connections. This was significant and anticipated, as Rob is a mathematics teaching seeking to integrate science into his teaching practices.

**Real-Life Science and Mathematics**

During my first observation of Rob in his second year of teaching, I wrote the following in my journal:

> Throughout the entire lesson, Rob mentioned many examples of real-life mathematics that students would use, and demonstrated this through use of such examples as the weighted grading system. (My journal, November 13, 2003)

Since it was a recurring theme in both Rob and Cathy’s classrooms and interviews during the second year, I asked Rob about what he meant by real-life. He said, “When I talk about real-life I am referring to life outside the school room” (Interview, November 13, 2002). Rob’s definition of real-life differs from Cathy’s definition in that Cathy also uses the term *meaningful*. I think Rob’s definition has more to do with helping students to succeed. Both are very important to
students’ lives, as they want to know how things affect them. Real-life applications also help the students to make connections between science and mathematics. Rob said, “They [the students] all want to know how any math, especially Algebra, will help them in every day life” (Interview, November 13, 2002). Rob also talked about how the students view mathematics, “Right now they don’t see how important mathematics will be to them as they grow older” (Interview, November 13, 2002).

Some of the types of real-life science and mathematics examples that I observed later in Rob’s second year of teaching involve Rob’s discussions with his students about how to repair bicycles, measure distance, and drive automobiles. Rob explained, “One of the problems that the students were assigned to do involved finding the radius of a circle was to find the distance around the running track was a real-life example” (Interview, March 19, 2003). This lesson is another example of one of the science and mathematics connections that Rob helped his students to solve. I also asked him about the bicycle activity during which I heard such terms as forces and work discussed during the lesson. Rob replied, “On the example that dealt with a bicycle repair we talked about forces and work, well, these are some of the types of activities that we do in mathematics that have some science related background” (Interview, March 19, 2003).

As I continue to make my observations of both Cathy and Rob, a pattern emerges with respect to discussion on real-life science and mathematics and its importance to their students. I made the following observation early during Rob’s second year.

After going over the worksheet, Rob introduced the concept of “weighted values.” He demonstrated this through the method that he uses to calculate their grades for his class. His system gave 50% to test grades, 40% for homework, and 10% for FCAT practice. The students seemed very interested in knowing this. He also gave examples from the book that students could relate to easily such as school gift-wrap sales. (My journal, November 13, 2002)

On the day of this lesson, I asked Rob if he could recall introducing to his class any mathematics that he had used during his research. He replied, “Yes, the weighted averages for their grades. The solutions that were necessary to do the testing had to be mixed using a weighted average” (Interview, November 13, 2002). I noticed that when Rob brought up the weighted grading system, the students seemed to enjoy hearing about it. I asked Rob why he decided to include that as part of his lesson. Rob said, “I keep getting questions about their grades. For some reason no matter how many times I tell them how I arrive at their grade I keep
getting some tell me that I figured their grade wrong. This way I taught a lesson and got my point across” (Interview, November 13, 2002).

I noted the following in my journal:

… I noted that the lesson a weighted grades garnered most of the interest among the students. My guess would be that this was because the mention of it in the classroom had the most impact on several of the students who were frantically trying to figure out his/her grade. What I did come away with from this first observation, however, is that “real-life” mathematics applications were important to Rob as they were frequently mentioned during the lesson. (My journal, November 13, 2002)

“You Can’t Prove Science Without Mathematics”

In an observation, during Rob’s second year of teaching, I heard Rob tell the students in his class, “You can’t prove science without mathematics” (My journal, December 11, 2002). Then he discussed his summer experiences. The class seemed genuinely interested in his work at the Wetlands Research Laboratory, especially with the discussion of fecal bacteria count. I asked Rob if he discussed this with all of his classes and if the interest level was as high as this class’ interest seems to be. Rob said, “Once in a while. They are interested in what I discuss but usually it evolves down to the word fecal and what it means to them in water quality” (Interview, December 11, 2002).

The issue of fecal count in the water is certainly an example of real-life science and mathematics for his students as they drink, boat, and swim in the waters around their community. I asked Rob if this was one of the examples of real-life that he discussed with his students. Rob replied, “Yes, they are very interested in what affects them” (Interview, December 11, 2002). I found this statement very similar to some of what Cathy and I had discussed about real-life, meaningful science and how her students were interested in what affects them.

During the last part of the class period, I heard Rob mention to the class that he hoped that they could use science and mathematics. I wondered what he meant by that, so I asked him to explain. Rob replied, “Usually a student will really like either science or math but not the two together. If they don’t embrace them both, it is hard to get ahead in either” (Interview, February 12, 2003). Perhaps what Rob means is that since the higher-level science courses contain a great deal of mathematics, if students are to do well, they must see those connections. Likewise, the higher-level mathematics courses contain many science examples.

I asked Rob about how he plans to demonstrate to his students the importance of mathematics in science research. Rob replied:
I would say that the only other math that I have taught [that I used in my summer research] is using ratios and proportions. There have been many instances that I have reinforced what the science teacher has taught. One of the primary formulas that I teach and that science uses is distance equals rate times time (d = rt). I also try to include some metric measures to help the science department. (Interview, November 13, 2002)

During Rob’s contextual science research, he completed a project on water testing at a local marina. The owner of the marina hired the Wetlands Research Laboratory to determine the water quality. Rob assisted with this project and said of his experience:

I did not think about how things like this (the water testing) are so much math-related until I did this. We have to use so many percentages to make dilutions. This certainly takes math to a higher level of understanding and meaning than say College Algebra. I think that my summer experience has influenced what I think in that I think science and mathematics should go hand in hand. (Interview, November 13, 2002)

During Rob’s first year, I observed the hurricane house and the lemonade activity, both projects that integrated science and mathematics with hands-on and inquiry-based instruction. However, during Rob’s second year, I did not observe any science and mathematics integrated lessons, such as these, in which Rob’s students conducted hands-on, inquiry-based activities. I did observe the use of calculations involving a money managing game of sorts using “Word Bucks,” the use of weighted grades, and science- and mathematics-related discussions.

“Driving” an Example

During one observation, Rob provided many examples to his students that dealt with driving. He later told me that he uses many real-life examples that deal with cars because these particular students were in the 8th grade and many of them would get their driving permits soon. These examples of driving were especially good because instead of using the textbook examples of distance, speed, and forces in mathematical terms, Rob adapted these concepts into ideas that the students could relate to once they started driving. For example, one of the examples involved a large pick up truck colliding with a small sports car. The question was: Which would you rather be driving and why? Rob says of this lesson:

Yes, these were my examples. The text has a lot of good examples but because the class will be driving soon I thought it would be a good exercise. Sometimes, I ask my students, “Why do we need to know this?” (Interview, March 19, 2000)

When I asked Rob how he selected his topics for study to cover a certain mathematical concept, he replied, “My students are very interested in what affects them” (Interview, March 19, 2003). Again, this echoes what Cathy said of her students.
Inquiry-Based, Hands-On Science Activities

Early in the program, Rob admitted that he had difficulty with doing hands-on instruction because he preferred being in control of his classroom. One of the reasons he wanted to participate in the research course was to learn how to be a “better hands-on teacher” (Interview, May 12, 1999). In this section, I look at Rob’s teaching practices to see if he achieved this goal.

As I previously stated, there were fewer hands-on activities during Rob’s second year than his first year of teaching. Although I observed less and heard about less, Rob still seemed to feel that he had done more than he thought that he would ever do, given his past beliefs about teaching. He stated during his second year of teaching:

My summer science research makes me realize students need more hands-on. I’ve already done more hands-on [the hurricane project and the lemonade project from the first year, and more mathematics related ones the second year] than I thought that I would. (Interview, November 13, 2002)

Rob is rather surprised at himself for including more hands-on instruction than he believed he would be able to do, considering his discomfort with it. He admits that he likes to do the talking in the classroom. “In math I like to do all the talking” (Interview, November 13, 2002).

This is an interesting contradiction. Rob often talks about wanting to incorporate more hands-on science, yet he admits he likes to “do all the talking.” I do note that this statement was made during his second year of teaching. He did not mention liking to “do all the talking” during his first year of teaching.

Gaining Science Content

Prior to his contextual science research experience, Rob stated:

I am not planning on teaching science, just math, but I would like to get more comfortable with science. I work in a chemical plant, but I don’t get involved with any of the science, but I’ve always been curious (Interview, May 12, 1999).

On one of the observations in Rob’s classroom, I noticed a chemistry-related mathematics problem on the chalkboard in the back of the classroom. I asked Rob if this was a problem from the mathematics textbook or one of his own. He replied, “This particular one was from the textbook. I had used one of my own the day before.” I asked if he was incorporating more science with mathematics since the last interview. He told me that it was “about the same,” but that he was “always reinforcing what the science teacher has taught” (Interview, February 12, 2003).
This implies an increasing comfort level with science content knowledge. I asked him if his principal asked him to teach science the next day, how would he feel, what methods would he use, and what would his comfort level be. He replied, “If my principal told me I had to teach science, I feel that I could do it. It would take studying on my part but I feel I could do it” (Interview, February 12, 2003). I doubt that Rob would have given the same response during his first year of teaching.

Gaining Science Pedagogical Content Knowledge

Confidence with Teaching Science

In my analysis, I want to answer the question: What is happening inside Rob’s classroom? Rob discusses how his “students were interested in hearing about my experiences as a ‘scientist’ and wanted to know more about fecal coliforms in the waters” (Interview, November 13, 2002). This is an excellent way for Rob to demonstrate to his students that he is a scientist; therefore, he is the expert in his classroom. This should greatly help his confidence with science.

As I previously stated, Rob entered the contextual science research course with some reservations about being immersed into science. He expressed the desire to learn more science so that he could integrate science into his mathematics classes. Prior to the contextual research course, he lacked the confidence to do this, as he perceived his science background and experiences to be minimal. He still held the belief that science was a difficult subject, which generated some anxiety for him.

During his first year of teaching, Rob appeared anxious on the first day that I observed his classroom. Although Rob’s comfort level with teaching increased from the first year to the second year of his teaching, I believe that he was “playing it safe.” While he appeared more confident and comfortable in his role as a teacher during his second year, his lessons were more cautiously implemented with respect to hands-on instruction. I believe that this contradiction was due to the fact that Rob’s first teaching position was cut; and thus, he was overly concerned about job security. Without a continuing contract, this often happens. Fortunately for Rob, another school hired him almost immediately.

I asked Rob if he thought he was able to use more of the experiences that he encountered in his pre-service program during his second year of teaching than in his first year of teaching. He responded, “Yes, I felt more comfortable [in] the second year because I was familiar with the
lessons I taught.” I asked him what he thought made the difference between the first and second years of teaching, and he said, “time and experience” (Interview, November 13, 2002).

**Professional Confidence**

Concerning Rob’s feelings of self-efficacy and confidence in himself and in writing the monograph chapter, Rob stated, “The monograph is my first published work, but I’m not really sure what it is, but people seldom get published for any reason. It is an honor” (Interview, November 13, 2002). Rob, initially, did not know what a *monograph* entailed, which explains the above comment. He knows what it is now, and he is very proud of his accomplishment. In this respect, his involvement with the contextual research has benefited his professional growth and confidence. He now says of the monograph chapter, “I feel pretty good about the chapter I did in the monograph” (Interview, November 13, 2002).

**Interpretations of Rob’s Second Year**

During an observation of a large mathematics class in Rob’s second year, I wrote the following:

As Rob began class, he started class with six algebra problems on the overhead for the students to solve. He called this activity, “Six Minute Math.” It seemed like a great idea to get them settled and get class started. They seemed eager to begin this way. There were 31 students with one student absent. This classroom was so crowded and in contrast with the private [school] classroom of Cathy who had much less students. At this school, he was more comfortable being around the students, more comfortable with his subject matter, and his job security. (My journal, February 12, 2003)

I wrote this observation before realizing Rob’s concern over classroom management. I did not learn of this concern until the interview following this observation. When I interviewed Rob early in his second year of teaching, I asked him about the differences between his first and second year of teaching, he replied, “I am more relaxed. I know that I can handle emergencies when they come. The first year I was learning what to do” (Interview, November 13, 2002). I, however, observed Rob to be more comfortable during his first year. I assert that Rob is more comfortable with teaching, but maybe not with the students he teaches and the classroom management. In the next section, I discuss more contradictions to what Rob says he will do and what he actually does.
Contradictions

Hands-On Science

With respect to his experience with science, I believe that Rob has gained some confidence overall. Rob stated, “I would say that the first year I taught I would shy away from science related items, but this year I have embraced it as it came along” (Interview, May 28, 2003). This statement, although encouraging with respect to his confidence, is a contradiction, as I did not observe any evidence that Rob embraced science in terms of hands-on activities during his second year of teaching. Rather his discussions about science were more eloquent and had an air of confidence. Perhaps this is what he means. Rob stated the following, “I have my feet wet and feel more confident to bring just about anything into the classroom” (Interview, December 11, 2002).

The lack of hands-on science and mathematics activities in Rob’s second year relates more to his concern about discipline problems than his confidence with integrating science. If Rob were still teaching at the first school, he probably would have continued to infuse science and mathematics connections and incorporating hands-on approaches.

Transferring Contextual Experiences

As with the hands-on experiences, in his second year, I did not observe the types of contextual experiences that I had observed during Rob’s first year. This, too, appears to be related to issues of classroom management, as a contextual situation involves more freedom of movement and a student-oriented environment.

Incorporating Inquiry-Based Hands-On Activities into the Classroom

I did not observe much inquiry-based, hands-on teaching in Rob’s second year. As with the contextual learning environments, I assert that Rob’s main concern was classroom management and standardized testing scores. Maintaining classroom management and focusing on the standardized testing materials, in turn, relates to job security for Rob. The irony is that the NRC (1996, 2000) recommends that standardized testing include testing students for inquiry.

Pedagogical Content Knowledge

I believe that Rob’s early schooling, as well as his early career in the military; have influenced his own beliefs about how a classroom should be managed. I think he is having a difficult time dealing with classroom management issues and has encountered some
contradictions as to the most effective way to teach for understanding versus classroom control. He says that he likes to do all of the talking, so he uses mostly lecture for his teaching. However, he believes that students need more hands-on instruction. Even though he claims he is against the overuse of textbooks, he still uses textbooks a great deal in his classroom. “Bookwork is necessary but not the end to all things” (Interview, May 28, 2003). These appear to be contradictions according to the cultural-historical activity theory model.

One encouraging result is that Rob says that his involvement with the contextual science course influenced him to do less teaching from one textbook. “Also, (I will do) less teaching from one canned textbook as a direct result of my science research experience” (Interview, August 11, 1999). As Rob has demonstrated, during his first year of teaching and to a lesser extent during his second, he is trying to incorporate more hands-on experiences and to do some integrated lessons with science teachers. By the end of his second year of teaching, Rob still believes that, “to create an interest in science, teachers should give students more experiments and give them exercises that they can discover something on their own that does not have a set answer” (Interview, May 28, 2003).

During one observation during his second year of teaching, I noted that some of Rob’s students were peer teaching one another. I asked him if this were a teaching strategy or if the students were simply helping one another. He replied,

In math, I like to do all the talking. I do let students teach their peers from time to time. Lately, in algebra I have had the students read the lesson and be prepared to teach a section to the rest of the class. It has made a big difference in their study habits. (Interview, February 12, 2003)

While Rob still demonstrates a penchant for lecture, he has transformed his classroom into one that allows peer collaboration. He sees the effectiveness of this strategy, as he says that the peer collaboration strategy helps to improve his students’ study habits. Perhaps because Rob participated in peer collaborations during his science research experience and was able to gain science content knowledge, he opted to try this strategy in his own classroom.

As Rob becomes more comfortable with classroom management and job security, he may employ some of the same science- and mathematics-integrated lessons from the first year. Rob’s opportunity to enhance his PCK from his contextual science research experience could prove to be more a coherence if Rob continued to teach at his first school. However, based on his second year of teaching there are more contradictions to this assertion.
Constraints

Classroom Management

Applying Rob’s case study to the cultural-historical activity theory model, classroom management appears to be a major contradiction for Rob to go to his desired outcome, which is to integrate more science and mathematics by using a hands-on approach. While Rob does bring science-related, real-life examples into his teaching, I did not observe the level of inquiry-based, hands-on, learning activities during Rob’s second year of teaching as I had observed during his first year of teaching.

I believe that classroom management issues can help explain Rob’s inability to experience praxis, an emancipatory move to bring from beliefs into practice. I asked Rob about the classroom management problems during his second year, and he replied, “I don’t know how to make the teacher preparation program better, but one of the things no first time teacher is ready for is classroom management” (Interview, May 28, 2003).

One perceived constraint that held Rob back from implementing more hands-on type of experiences for his students was that Rob felt like the class was out of control when he implemented these types of activities. Rob’s public school classes were considerably larger and more disruptive, compared to those of Cathy, who taught in a private school. This could also be one of the factors that hindered his desire to bring in science guest speakers. Rob acknowledges his failure to fully engage his students in the kind of learning environment that he believes that he should have, “You can have all the ideas you want, but until you get your own classroom you don’t have a clue about what to do” (Interview, May 28, 2003).

According to Klepper and Barufaldi (1998), lack of discipline on the part of students is a common problem for novice teachers. One of the participants in the Klepper and Barufaldi study felt that uncooperative and apathetic parents, too, were a “quicker turn-off to teaching than any other factor” (p. 7). With this in mind, it is little wonder that Rob was hesitant to make major changes with regards to his teaching strategies. He, perhaps, felt it best to play it safe for the first few years with lecture and textbook assignments. Rob said that his practicum was “his first exposure to a really tough middle school environment” (Interview, May 28, 2003). Ironically, a practicum lasts for only a few weeks. This is not enough time to expose pre-service teachers to the realities of the classroom. An internship is considerably longer, usually five months.
Classroom management did not appear to be an issue during the first year of Rob’s teaching. I observed several different occasions where Rob’s students were actively engaged in science and mathematics integrated lessons. At this school, Rob formed collaborations with a science teacher, and they created wonderful lessons demonstrating the connections between science and mathematics. The lessons were inquiry-based and reflected real-life science and mathematics connections.

Rob incorporated contextual learning as he placed students in an imagined context of the situation. In one context, he placed some students as structural engineers designing a hurricane proof house. He placed the others in the context of “hurricane” in the form of a leaf blower. In the lemonade project, he placed students in the context of making and selling lemonade for the most profit. The students were very well behaved, and they truly enjoyed the experiences. Rob spoke positively of this year of teaching; “My involvement with the science classroom made an impact on the students in the classroom because the teacher that I worked with believed in hands-on and they seemed to enjoy science more” (Interview, May 28, 2003). However, when Rob transferred to the second school, he did not find any similar collaboration. This could be due to the discipline problems or to the fact that Rob was unable to find a science teacher willing to collaborate. Further, this lack of collaborative lessons among the faculty might be due to the discipline problems at the school.

During his second year of teaching, I reminded Rob about his very first experience with doing the science research and how he felt a little nervous about doing the science. I told him that he seemed much more comfortable with the science now. I asked Rob if he felt that his contextual science research had anything to do with it or if it was more to do with gaining experience as a teacher. Rob replied:

I have my feet wet and feel more confident to bring just about anything into the classroom. It is easier to teach during my second year, because I know it better but it has been a frustrating year because the students are not willing to spend the time on their own to understand it. (Interview, May 28, 2003)

Having students in the classroom who do not want to do their work, represents a common frustration among novice teachers and teachers in general (Tobin, 2000). From Rob’s statement, I do not think that integrating mathematics and science with contextual learning is his first priority. I believe student motivation and discipline are more on his mind right now. Tobin
(2000) reveals that discipline problems can hinder what pre-service or veteran teachers can or cannot do in the classroom.

**Standardized Testing**

Another constraint to teaching practices is the emphasis that schools place on standardized testing. Rob’s situation in a low achieving public school is representative of this dilemma. Rob says of standardized testing, “Yes, I have to think about how a lesson relates to FCAT (local standardized testing) every day” (Interview, May 28, 2003).

In a study on the impact of large-scale standardized testing and its effect on curriculum and science teaching at the high school level in British Columbia, Wideen (1992) links standardized testing to a narrowed curriculum, psychological pressures of taking the tests, and a decline of creative teaching practices. The study also asserts, based on their evidence, that the grade 12 standardized testing has greatly affected the progress of innovative teaching practices in 12th grade science.

**The Induction Years**

The induction years described by Klepper and Barufaldi (1998) involve getting comfortable with teaching and dealing with curricular mandates, standardized testing, classroom management issues, and limited resources. For Rob, classroom management and emphasis on standardized testing weigh heavily in his induction years. The fact that Rob is already teaching in a different school in his second year of teaching further compounds his concerns. He does not want to lose this position by doing anything that might seem to compromise classroom management or distract from a focus on improving standardized test scores.

**Coherences**

**Understanding the Culture of Science and the Culture of Science in the Classroom**

Prior to his involvement with the contextual research, Rob believed that the culture of the science classroom was not very exciting. He said, “[Students in] most classrooms learn with books and no enthusiasm” (Interview, June 14, 1999). Rob also stated, “The culture of classroom science is the science of books… mostly books with some labs included. The labs are preconceived to get a preconceived answer” (Interview, June 14, 1999).

Prior to his summer research experience, Rob did not reflect on his ideal conception of the culture of science within his own mathematics classroom. Initially, his main concern seemed
to be with having his students learn the basics of mathematics, rather than learn about its connections with science and its real-world applications. Later, in his second year, Rob realized that he did, in fact, want his students to learn how mathematics, as well as science, could be beneficial for students’ real-life needs and interests. Rob said in reference to the culture of his classroom, “The culture of my classroom is the learning process that helps students with math and science as they go up in grade level” (Interview, May 28, 2003).

**Integrating Science and Mathematics**

Based on some of my observations of Rob, I believe that he is making a concerted effort to demonstrate as many examples of mathematics and science connections as he can. He said:

As a direct result from my science research experience, I try to encourage the students in the importance of math in their science and try to get them to understand how to do formulas so they won’t have problems in science (Interview, May 28, 2003).

**Gaining Confidence in Science**

Rob’s experience with the scientific research helped to alleviate some of his fears about science. During my observations of Rob in the summer research course, I noticed that he began to feel at ease as the research progressed. I was particularly impressed with Rob’s interest and engagement in what he was doing during the fieldwork. He said, “The best of the experience was the day that I got to go along to help in getting the water samples” (Interview, August 11, 1999).

During one observation, in Rob’s second year of teaching, he discussed his summer research with his students. They appeared to be very interested in his research. Students would ask questions about the fecal coliform levels in the waters surrounding their community. There were plenty of “oohs” and “grosses,” but mostly they were interested and engrossed in the discussion. Rob spoke with authority and gave excellent examples and information to the students.

I think working with the pre-service science teacher, the science researcher, and the laboratory assistants in the contextual science research course helped Rob to feel more at ease with science. Later in Rob’s second year of teaching, I asked him what pre-service experience has proven to be the most valuable in his teaching. Rob stated:

I think the most valuable pre-service experience and most valuable to my teaching is, I think, camaraderie. No matter what field you get into, getting to know your peers helps you along the way. It is the same in science as in teaching. You need someone to talk to and get help. (Interview, May 28, 2003)
Rob’s statement resonates with the findings of Klepper and Barufaldi (1998) and Dawson (2002) with regards to how novice teachers need a great deal of support during those first critical years of teaching.

**Gaining Science Content**

Based on Rob’s gains in confidence with science, I believe that his science content level has increased, as well. While his second year of teaching does not reflect a great deal of science in his teaching, he does speak to his students about his experiences. In an observation, I heard Rob discuss his water testing experience. During this lesson, he was trying to stress the importance of mathematics in science and vice versa. His increase in content knowledge was evident, as his students appeared to be very interested in hearing about the research he conducted.

**Incorporating Real-Life Science**

Like Cathy, Rob frequently refers to real-life science. Their experiences with the contextual science research appear to influence this emphasis on real-life, as both participants experienced real-life science through their experiences. For Rob, especially, his prior experiences with science were very limited. The chance not only to experience science, but also to become involved in *real* research played an important role in the way Rob now envisions science. He feels limited in his approaches to real-life science because he is a mathematics teacher. Nonetheless, on the many occasions that I observed Rob I heard and saw real-life science emerge in his mathematics lessons. This was important to Rob, and I assert his own real-life experiences in science influenced his incorporation of real-life science and mathematics into his teaching practices.

**Findings**

While I have not observed Rob during his third year of teaching, I have contacted him several times. From our conversations about his classes, he seems to be having a good year. He is currently teaching at the same rural school as he did during his second year of teaching, and he seems more relaxed than in the previous year. Perhaps he has resolved some of his classroom management issues. He is excited and relieved to know that will receive his teaching tenure this year.

Several themes related to his contextual science research experience emerged from Rob’s observations and interview during his second year of teaching. During my observations, I noted
that Rob’s students seemed to be learning the various concepts that he introduced in the classroom. Another theme that emerged from my observations and interviews involved Rob’s confidence with science and teaching science in his mathematics classes. A third theme, although minimal during his second year, was his ability to implement inquiry-based, hands-on science and mathematics lessons.

In order from positive influence to some to minimal influence, these are:

1. **Positive**
   a. incorporating real-life science and mathematics,
   b. integrating connections between science and mathematics,
   c. understanding the differences between the culture of science and the culture of science in the classroom,
   d. gaining confidence with science teaching,
   e. gaining science content, and
   f. incorporating real-life and meaningful science in his classroom.

2. **Some**
   a. incorporating inquiry-based, hands-on activities into the classroom,

3. **Minimal**
   a. transferring experiences with contextual and constructivist-based methodology into his own classroom

Two areas in which her participation in the contextual science research appears to have No influence are forming collaborations with scientists and the science community and limiting the use of the science textbook. From her interviews, her beliefs in these areas appear to be positively influenced, but not her teaching practices.

Overall, I believe that Rob’s contextual research experience had some influence on his teaching with respect to, incorporating real-life science and mathematics, integrating science and mathematics, confidence with science, and providing hands-on science and mathematics lessons. He has a way to go before he experiences praxis in his teaching beliefs and practices, but fortunately, he has started his journey. Once the contradictions make way for more coherences, Rob might be able to see more of his desired outcomes reflected in his practices.

Although Rob faces several constraints (i.e., classroom management, and standardized testing pressures), I believe that in time Rob may implement more of the practices that he now
believes are important, such as more hands-on science- and mathematics-integrated lessons. I think that the change of schools and student population played a key role in stymieing his incorporation of his beliefs into his teaching classroom. Given time, I believe that Rob may begin to transfer more of his experiences into his own classroom. Rob, himself, believes this, “I think what has made the difference is time and experience. I feel very comfortable with my classes. I think that over time I understand what needs to be done and do it” (Interview, May 28, 2004). In referring to how his experience with the summer contextual science course may influence other teachers in their classrooms, Rob said, “It may not help the first year or two but sooner or later it should” (Interview, May 28, 2004). He perhaps is describing himself, as well.
CHAPTER 10: FINDINGS

Lessons Learned

My original goal for this study was to immerse pre-service teachers into a contextual science research experience that I believed would positively influence their beliefs, as well as their teaching. Beyond this, I anticipated that these influences would empower them, as novice teachers, to strengthen their beliefs to the extent that they are able to transform their practices to include similar experiences for their own students, or to experience praxis, an emancipatory change in both beliefs and practice (Lather, 1986; Grundy, 1987; Peterman, 1993) with regards to science teaching and learning.

Peterman (1993) asserts that teachers can experience praxis in an active engagement by “doing, reflecting, learning, changing” (p. 241). This parallels with Gilmer’s (1999) definition of contextual learning in science as “learning in the context of doing, thinking, speaking, and experiencing science” (p. 13). Placing pre-service science and/or mathematics teachers into a contextual science research setting and following them into their classroom is the heart of this study. This doctoral study not only allowed me to pursue my goals for the study and to answer my research questions, but it also has proven to be a very educationally enriching, a personally rewarding, and a professionally challenging experience for me as a new researcher and science educator.

All participants in my study contributed towards the enhancement of science and mathematics education. Throughout the entire research, each participant, including myself as the researcher, assumed the role of learner. I found the collaborative and sharing process in the hermeneutic vein to be a very powerful experience. In this chapter entitled, Findings, I focus on Lessons Learned, as there were many over the course of a five-year study. I answer my research questions, which were of personal and professional interest to me. I also discuss the implications and recommendations for the future. In the final sections, I discuss how I learned about myself as a researcher, teacher, a learner, and a participant in life. I divide my Lessons Learned into five categories: Answers to my Research Questions, Implications and Recommendations for Pre-service Teacher Education in Science and Mathematics, Researcher Bias and This Study, Personal Reflections, and Seeking a PhD: Lessons Learned in Life.
Answers to My Research Questions

I begin the section by reiterating my original research questions for this study. These questions are:

1. What are the beliefs towards the culture of science and the culture of science in the classroom of a novice science and a novice mathematics teacher after completing a constructivist-based, contextual science research course?

2. What are the classroom practices of these novice teachers after completing a constructivist-based, contextual science research course with respect to:
   a. implementing constructivist-based, contextual science methodology in their own classrooms?
   b. forming collaborations with scientists and the science community?
   c. integrating science and mathematics in the classroom?
   d. implementing inquiry-based, hands-on science activities?

3. After completing a constructivist-based, contextual science research course, what are the influences on the novice teachers’ constructions of (a) science content knowledge and/or (b) pedagogical content knowledge?

Beliefs About the Culture of Science

Peterman (1993) offers this definition of beliefs, “beliefs are defined as an individual’s ‘mental constructions of experience—often condensed and integrated into schemata or concepts’ (Sigel 1985, [p.] 351) that are held to be true and may guide personal action” (p. 229). Given this definition, the beliefs that the two novice teachers held with regards to the culture of science were long held beliefs dating back to their own schooling experiences. This was also true of their beliefs about the culture of science in the classroom.

Both participants, Rob and Cathy, began this study with somewhat naive beliefs about the culture of science. Cathy believed that most people perceive science to be boring. She also admits to having stereotypical perceptions of the scientists. While Cathy believed science and scientists to be boring, she did enjoy science. Science intimidated Rob, and he did not plan to teach science for that reason. He believed that science courses were difficult; thus, he preferred mathematics to science. After the completion the contextual science research course, both novice teachers experienced a positive change in beliefs towards the culture of science.
Cathy enjoyed working with the scientists and realized that they were not the stereotypical scientists that she had imagined. She did experience some tedium in her work with cloning sea grasses, but believed that the science that she experienced was fun and rewarding. Her study with sea grasses was the initial phase of a local pilot project, which is now in a major environmental undertaking in her community. She is extremely proud to have been involved with its inception, as this was real-life and meaningful for her. Both of these aspects of science have emerged as significant goals for Cathy in her teaching. Science no longer intimidates Rob. While he still prefers teaching mathematics, he has an increased interest in doing integrated lessons that demonstrate the connections between mathematics and science. He feels much more comfortable with science content and with conducting laboratory experiments.

The collaborations with the science researchers helped to alleviate some of these misconceptions about scientists and science for Rob and Cathy. Their own immersion into science, with the opportunity to be scientists, gave them confidence and helped them to see for themselves that science was not boring, just tedious at times. They were also able to experience real-life and meaningful science, which have played an important part in the outcomes of this study. Rob and Cathy were able to see the connections between mathematics and science through their research experiences. This was very critical for Rob, who favors mathematics and who needed to be involved with science research in which the use of mathematics played a large role.

Beliefs About the Culture of the Science Classroom

Rob and Cathy believe that the traditional culture of science in the classroom places too much emphasis on the use of textbooks and lecture. They both see the culture of science in the classroom as boring, not hands-on enough, and too much emphasis on the textbook. After the contextual science research, Rob and Cathy both agreed that their own classrooms would include more hands-on science activities and would use much less textbook-driven lessons. This, however, did not emerge in the teaching practices of either teacher. I observed both Cathy and Rob using the textbook on numerous occasions. Cathy did, however, adapt a new strategy for teaching with the textbook using students’ stories of real-life examples of scientific concepts during group reading of the textbook. These stories helped to bring to life the concepts from the book, and made the reading more enjoyable for the students. I did, however, observe several hands-on activities, which will be discussed later.
Therefore, the beliefs about the culture of science in the classroom for both participants have evolved from being a textbook-oriented classroom, that is hard to learn, boring, and not fun, to a classroom full of hands-on activities that are fun, real-life, and certainly not boring. I believe that Rob and Cathy still believe that their perception of the textbook and lecture-oriented culture of the science classroom still permeates through most of the nation’s schools. I think that these two teachers, with more time, may resolve these issues to ensure that their own classrooms are more innovative than the typical ones.

Classroom Practices of Novice Teachers After Completing a Contextual Science Research Course

When faced with putting their beliefs into practice, the fear of job security looms over their actions. Peterman (1993) asserts that a constructivist-based environment that includes the teacher as learner and involves the teacher in praxis, such as this contextual science research course, empowers teachers through their own sense making or constructions. This, at least, was the intent of the study. My own immersion into a constructivist-based, contextual science research course (Hahn, 1999) greatly empowered me to change my beliefs and my practices through my own constructions of gained knowledge. My change of practices, however, was well into my teaching career. I had grown bored of teaching. My students’ grades were poor. While I had established myself as a strong teacher, I knew that my teaching was not as effective as I wanted it to be, nor was I doing as many hands-on/minds-on activities as I once had done. I was resorting back to the security of the textbook, work sheets, and tests! My whole experience with biochemistry (Hahn, 1999) and the work in which I was involved helped to change my beliefs and, subsequently, my practices.

The novice teachers, on the other hand, have not been teaching long enough to need a change as I did. However, I do believe that early exposure through a constructivist-based, contextual science research course can afford the novice teacher with a strong base for their classroom teaching. When faced with difficulty, Rob and Cathy will be able to draw from their contextual science research in the laboratory and field as past experiences and build upon these at a later time.

In their study, Klepper and Barufaldi (1998) found that the induction years for novice teachers are stressful due to barriers such as emphasis on standardized testing, classroom management, “documentation of everything” (p. 9), short class periods, inclusion, time
management, and trying to cover all of the content. Some of these barriers could be affecting
Rob and Cathy’s ability to put into practice some of what they believe about teaching science.

**Constructivist-Based, Contextual Learning**

The tenets behind my research strive to instill in the teachers the importance of a
constructivist-based classroom in which one’s ideas and constructs will be open for discussion,
without fear of failure or ridicule. The types of real-life connections often used in a contextual-
based learning environment are of critical importance when working with young adolescents
(Irvin, 1992). Within their own classrooms, teachers should ask the question, “Am I trying to

teach certain content in terms of factual information using memorization as my method of
inSTRUCTION?” A teacher who has participated in a contextual learning situation acknowledges,
first-hand, that true understanding and retention of content comes from immersion in that
content, or context.

The question is, can we create a classroom environment rich in contextual, experiential
activities that include the specific standards that we are told to teach? Yes, it is possible. It will
not be easy, but a start is to provide teachers with such experiences themselves. We need to place
pre-service teachers in contextual learning courses during their pre-service careers so that they
may begin to realize that they can gain content through experience.

On several occasions, Rob described the concept of prior knowledge. I believe that Rob is
familiar with the concept of constructivism, and has plans to incorporate more than he is willing
to commit at this point. Classroom management issues still inhibit Rob from taking away too
much structure from his classroom. I believe that the comfort zone he finds with more lecture-
driven teaching and use of the textbook is difficult to change, due to discipline problems that
arise when he offers his students more hands-on opportunities, which often require movement
about the classroom and more student interaction.

In my own experiences with science research and my ability to begin to implement
strategies that would complement my newfound knowledge and contacts, I was not a novice
teacher. I was a tenured teacher with several years of experiences. The situation for the two
novice teachers in my study was much different. While both novice teachers declared an
aversion to the overuse of textbooks, as well as lecture, in reality, both of them still relied heavily
on the textbook. While there was some hands-on instruction taking place in their classrooms, I
am sure that not all hands-on science can count as contextual and/or constructivist-based.
Forming Collaborations with Scientists and the Science Community

Cathy expressed that she was strongly supportive of inviting scientists into her classroom and collaborating on community projects. Unfortunately, neither of these objectives materialized during her first two years of teaching. She did, however, use some of the materials given to her by the Department of Environmental Protection, the agency where she did her first summer’s contextual research. Rob, as a teacher of mathematics, was not as vocal about forming such science partnerships. I believe that Rob has not yet realized that scientists as guest speakers and/or involvement with community science-related projects can be an excellent way to integrate mathematics. He did realize many mathematics and science connections throughout the course, however. He even collaborated in a thematic unit on hurricanes with a science teacher. However, the connection that he can access the science community to help assist his students with mathematics has yet to occur to Rob.

The research process immersed the learner in the culture and language of science (Lemke, 1995), without forcing them to memorize useless information. The teacher as learner could reflect upon his/her experiences, compare them to traditional textbook learning experiences, and understand that this was a far richer step to learning. The teacher can apply this to his/her own classroom, where s/he can implement more contextual learning opportunities.

Integrating Science and Mathematics in the Classroom

Rob especially was able to integrate several lessons using science and mathematics. This was one of his original goals for participating in the contextual science research course. Whether or not his participation directly influenced his ability to integrate these lessons is unclear. He did make a statement to that effect, however:

As a direct result of my science research experience, I try to encourage the students in the importance of math in their science and try to get them to understand how to do formulas so they won’t have problems in science (Interview, May 28, 2003).

There were a total of 72 out of 317 passages in the text of Rob’s interviews related to science and mathematics connections, which tell me that there is evidence of influence on his integrating science and mathematics lessons in his classroom practices. There was also evidence of science and mathematics connections in Rob’s chapter. He actually discussed the two activities that I was able to observe with the lemonade and the hurricane houses. Cathy, too, discussed integrating mathematics into her science teaching on several occasions. She paralleled
her own use of mathematics in her research experience with having her own students do some of the mathematics involved with the mold study.

The influence of the contextual science research course on assisting the participants with making connections between mathematics and science, and on integrating mathematics and science through classroom activities, has emerged as a significant finding in this study, especially for Rob. Rob was able to make these connections for himself and for his students on many occasions. For himself, he had always shied away from science courses because he believed science to be hard and difficult. He knew that mathematics, which he enjoys, was used in science, but not to the extent that he experienced through his contextual science research. This connection helped Rob to see how important mathematics is to science and vice versa. As a result, he implemented several lessons that integrated mathematics and science, which helped students to see the importance of mathematics and science in real-life.

Implementing Inquiry-Based, Hands-On Science Activities

During Rob’s first year, I observed several activities that incorporated inquiry with hands-on activities. However, as previously mentioned, I did not observe these types of activities during the second year. This could be explained by Rob’s concern with discipline and student management teaching at the second school. Hands-on instruction, especially inquiry-based instruction, does involve student interactions and movement. Rob’s comfort level did not support this type of instruction at this school. He wanted to include this type of instruction, but other factors, or contradictions, prevented this from occurring.

Cathy’s teaching practices were the opposite of Rob’s during the second year. She incorporated more inquiry-based, hands-on instruction during her second year. Her comfort level obviously increased as she became more familiar with her surroundings and her students. While she did implement more inquiry-based, hands-on activities, there were very few. I only observed one during the ten observations that I conducted. She did, however, integrate some of the essential features of classroom inquiry found in Table 6-2 (NRC, 2000) into her lectures through the stories in which she engaged her students during classroom discussions.

Gaining Science Content Knowledge

On numerous occasions, Cathy mentioned that she learned more science in her contextual science research course than she did during all of her college science courses. “Learning by doing” (Gilmer, 1997, p. 1) is a common theme in much of the literature on scientific work.
experience for practicing teachers. In this study, the pre-service teachers were able to learn more by being in the context of science, thus gaining science content knowledge. They not only gained the science content, but they also have been able to retain the content years after their initial experience. I discovered this phenomenon through subsequent interviews with each participant.

Rob is also very proud of the fact that he gained a great deal of science content from his contextual science research experience. For Rob, the foray into science research was to gain science content, as he had a true desire to learn science and to learn ways to merge science and mathematics into his classroom.

**Gaining Pedagogical Content Knowledge**

I included the practicing science teachers in the CO-LEARNERS program in order to help the pre-service teacher develop lesson plans and teaching strategies and to help the novice teachers with how to decide what can or cannot be done within the constraints of the classroom. In other words, the practicing teacher brought the culture of the science classroom to the pre-service teacher while the scientists brought the culture of science to the pre-service teachers. Then the three participants together developed ideas and pedagogy as to how to merge the two cultures into the novice teacher’s classroom for the benefit of the students. I anticipated that this pedagogical content assistance would be invaluable to the novice teachers.

Both Rob and Cathy believe that science teachers place too much emphasis on the textbook and not enough time engaging students in hands-on activities. I observed several situations in which both Rob and Cathy continued to rely on the textbook. However, I also observed two very powerful lessons with Rob in which he nicely illustrated the mathematics and science connections. Rob states in his chapter:

> Do my students have fun in class learning just from books? Every once in a while, teachers need to step back into the role of student to remind themselves that learning needs to be fun. Learning also needs to be hands-on and pertinent to students’ everyday lives. The CO-LEARNERS Program provided me with this experience.

I believe that Rob is beginning to make the connections necessary to develop lesson plans that include more contextual learning in his pedagogy.

Cathy, too, implemented several lessons, such as the mold study which was close to being constructivist-based, as well as contextual. Students devised their own mold terrariums without much information other than the prior knowledge that they had previously learned from the textbook. Then they observed the terrariums over a period of several weeks, formulating
hypotheses, collecting data, and making some conclusions based on their observations and data. Although this was the only such lesson that I observed, it was a good example. The previously discussed constraints could have limited the amount of lessons that Cathy conducted using this method. However, she does demonstrate that she has the PCK to develop such lessons. Cathy, too, used mathematics in her research and was able to see how this could be incorporated in her own classroom. Although to a lesser extent than Rob, Cathy did incorporate some real-life mathematical applications with regards to her science teaching.

*Using the Cultural-Historical Activity Theory Model to Explain the Findings of the Study*

As the researcher of this study, which evolved from the original Pilot Study project that I helped to design, implement, and ultimately evaluate, I was disappointed that the teachers were not as fully engaged in implementing the types of teaching practices that they implied that they would. Understanding the mechanics of how contradictions play a pivotal role in the cultural-historical activity theory model (Figure 10-1) helped me to understand that *over time* these contradictions could be replaced with more coherences, thus allowing the teachers to go to the desired outcomes. As with many things, time will tell. At least the seed has been planted, and I strongly believe the influence of their experiences will ignite as they begin to see more clearly that some of the teaching practices that they have been using in order to teach standardized testing information and facts have not been successful.

There are definite *contradictions*, including curriculum mandates, emphasis on standardized testing, classroom management issues, and limited resources, which all add to up the demands faced by the novice teacher (Klepper & Barufaldi, 1998; Dawson, 2002). Any or all of these issues create contradictions, which might occur as the subjects (the novice teachers) strive to go to their outcomes (teaching beliefs put into actions). There are *coherences*, as well. These *coherences* do allow for the subjects (the novice teachers) to move toward the objects (*contextual experiences and collaborations*), and, at least, partially to go to their desired outcomes (teaching beliefs put into practice, or *praxis*). These *contradictions* and *coherences* do help to illustrate the degrees of *influences*, ranging from *no influence* to *minimal influence* to *positive influence*, of the contextual research course on the novice teachers in certain areas. There were no negative influences. Figure 10-1 shows the cultural-historical activity theory model,
while Table 10-1 explains how my study fits within the model, which I find to be an organized way to analyze a text document, particularly one used in constructivist-based research.

**Application of Cultural-Historical Activity Theory: An Example**

To illustrate how I used cultural-historical activity theory, I offer the following as an example from my study. Rob hoped to move towards becoming a more “hands-on teacher” (*outcome*) at the onset of the pilot study. Rob (*subject*) was given the opportunity to participate in the contextual science research course (*object*) and collaborate (*object*) with practicing science teachers and science researchers (*communities*). Initially, Rob accomplished this in his first year of teaching as he felt comfortable in his teaching situation (*schema*) in a new school with updated facilities (*tools*). He collaborated with a science teacher (*division of labor*) willing to collaborate with him on lessons that integrate science and mathematics (*outcome*). While there were *contradictions* of mandated curriculum and pressures of standardized testing, there were more *coherences* (cooperative students, state of the art facilities, and collaborating science teacher) that allowed Rob to move to his outcome. However, during his second year of teaching, he experienced more contradictions (discipline problems, outdated facilities, lack of peer collaboration, and all of the constraints associated with being a novice teacher). He was not successful in moving to his outcomes.

![Figure 10-1. Cultural-historical activity theory model diagram](image-url)
Table 10-1
Application of Cultural-Historical Activity Theory on the Influence of a Pre-service Contextual Science Research Experiences on Novice Teachers Beliefs and Practices

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Objects</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-service/novice science and mathematics teachers</td>
<td>Contextual/experiential science research experiences</td>
<td>Novice teachers learn science content and gain comfort within the culture of science by learning through collaborations with the science researchers</td>
</tr>
<tr>
<td></td>
<td>Field studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collaborations with practicing science teachers</td>
<td>Novice teachers gain PCK in science with the practicing science teachers</td>
</tr>
<tr>
<td></td>
<td>Journal of learning experiences</td>
<td>Novice teachers gain access to the science community for his/her classroom</td>
</tr>
<tr>
<td></td>
<td>Professional development activities (Published writings and presentations)</td>
<td></td>
</tr>
</tbody>
</table>

**Primary movement**

<table>
<thead>
<tr>
<th>Coherences and/or contradictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tools</td>
</tr>
<tr>
<td>Science research facilities</td>
</tr>
<tr>
<td>Science laboratory equipment and materials</td>
</tr>
<tr>
<td>Science laboratory equipment and materials</td>
</tr>
<tr>
<td>Technology</td>
</tr>
<tr>
<td>Funding for materials to replicate studies in the classroom</td>
</tr>
<tr>
<td>Science classroom facilities</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Communities**

<table>
<thead>
<tr>
<th>Division of labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science community/scientists</td>
</tr>
<tr>
<td>Education community/practicing teachers</td>
</tr>
<tr>
<td>University teacher education community: pre-service science research course availability</td>
</tr>
<tr>
<td>Science education professors and graduate assistants</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

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Construction of Knowledge in Cultural-Historical Activity Theory

Cultural-historical activity theory sees construction of knowledge more broadly than the current research texts, such as used in a typical pre-service teacher course. In this type of contextual research course, the students construct their learning “more as voices and utterances in ongoing dialogues within and between the collective activity systems under investigation” (Engeström & Miettinen, 1999, p. 10). Learning is not always a linear process, moving from Point A to Point B. Rather, there are multiple-points and layers weaving in and out as though forming an intricate web, some providing contradictions and others providing coherences to achieve a specified outcome. Learning is not isolated.

In my study, the actual dialog and collaborations among the scientists, the practicing science teachers, and the pre-service teachers constitute this type of constructive learning within the cultural-historical activity theory. The notion of immersing pre-service mathematics and science teachers within an actual research experience working alongside scientists and practicing mathematics and/or science teachers within the scientific community is an excellent example of the cultural-historical activity theory in practice.

In Summary

To help summarize my findings using the cultural-historical activity theory diagram (Figure 10-1), I organized Table 10-2 to help explain how contradictions and coherences affect the degree of influence that this science research experience have on the novice teacher participants.

Table 10-2
Contradictions and Coherences: The Influences of a Pre-Service Contextual Science Research Course on Novice Science and Mathematics Teachers

<table>
<thead>
<tr>
<th>Beliefs about the Culture of Science and the Culture of Science in the Classroom</th>
<th>QSR Node(s)</th>
<th>Contradictions</th>
<th>Coherences</th>
<th>Degree of Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>As pre-service teachers, the participants admit to having negative pre-conceived perceptions of scientists and science.</td>
<td>Through collaborations with scientists and the science community, novice teachers can feel more connected to science.</td>
<td>Positive influence, immersion into the constructivist-based, contextual science research course influenced the novice teachers’ beliefs in a positive manner.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Table 10-2—Continued.**

<table>
<thead>
<tr>
<th>Research Question 1—Continued.</th>
<th>QSR Node(s)</th>
<th>Contradictions</th>
<th>Coherences</th>
<th>Degree of Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Collaborations with Scientists and Practicing Science Teachers</td>
<td>These perceptions often lead to a “dislike” of science, and the perception that “science is hard” or “boring.”</td>
<td>With positive role models and good teaching practices, “science is fun” can prevail.</td>
<td>They no longer saw science as boring and/or hard. Cathy no longer believed that scientists were “nerdy” or boring.</td>
</tr>
<tr>
<td></td>
<td>Science Research (Perceptions of science and the scientist)</td>
<td>Participants acknowledge that the traditional science classroom do not model the culture of science</td>
<td>Novice teachers, too, can begin to “think like a scientist,” which will help with their comfort level with science, which may transfer to the students.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>There are ways to “model” the culture of science in the science classroom through effective teaching practices.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Through the collaboration with the practicing teacher, as well as the scientists, the novice teacher will better understand how to merge the two cultures in the classroom.</td>
<td></td>
</tr>
</tbody>
</table>

Research Question 2: What are the classroom practices of these novice after completing a constructivist-based, contextual science research course with respect to (a) implementing constructivist-based, contextual science methodology in their own classrooms; (b) forming collaborations with scientists and the science community; (c) integrating science and mathematics in the classroom; and (d) implementing inquiry-based, hands-on science activities?

<table>
<thead>
<tr>
<th>QSR Node(s)</th>
<th>Contradictions</th>
<th>Coherences</th>
<th>Degree of Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborations (with Practicing Teachers) Science Research (Contextual learning, mathematics and science connections) Teaching Practices (Contextual learning, experiential learning, hands-on science, meaningful science, real life science, and teaching inquiry in science) Collaborations (with researchers of science)</td>
<td>Beliefs are often not put into practice due to the job difficulties of the novice teacher “We teach as we were taught,” therefore negative reinforcement of less effective teaching methods, such as those that are textbook dominated and lecture-driven are counterproductive to good teaching practices. The inclusion of a practicing science teacher is vital, but expense of summer pay for the teachers can limit this aspect.</td>
<td>Teachers’ deeply held beliefs might be put “into action” and they will experience <em>praxis</em> “We teach as we were taught” therefore, positive modeling of good teaching practices such as contextual learning, experiential learning, meaningful science, real life science, and inquiry-based, hands-on activities, are excellent practices for novice teachers to model, “transfer” into his/her classroom. The inclusion of a practicing teacher can be funded through grants or staff development funding.</td>
<td>a) Minimal degree of influence, both teachers have begun to implement constructivist-based, contextual science research into their classrooms. I anticipated more, based on what the teachers said they would do. However, they are making progress, and I anticipate more constructivist-based pedagogy and contextual learning as the teachers gain more experience and comfort in their classrooms. b) No observed influence, neither of the teachers formed collaborations with the scientists nor the science community.</td>
</tr>
</tbody>
</table>
Table 10-2—Continued.

<table>
<thead>
<tr>
<th>Research Question 2—Continued.</th>
<th>Contradictions</th>
<th>Coherences</th>
<th>Degree of Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSR Node(s)</td>
<td>Accessibility to the science researcher can be difficult due to their busy schedules</td>
<td>Immersion into an actual science research project enables the pre-service teacher to experience science and mathematics connections, making it easier to transfer this into the classroom.</td>
<td>This was greatly disappointing, as I had anticipated that the teachers would do this. This may occur with time as the teachers gain more flexibility with their teaching time and comfort in their role as a teacher.</td>
</tr>
<tr>
<td>Science and Mathematics Connections</td>
<td>A collaborative effort does require planning and sometimes a financial commitment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Due to time constraints, curriculum mandates, and standardized testing, the addition of guest speaker, field studies, and/or other collaborative efforts are often difficult to schedule.</td>
<td></td>
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<tr>
<td></td>
<td>Some schools (as in Cathy’s situation) have more rigid scheduling</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Field trips to the science community facilities might prove to be financially difficult.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Question 3: After completing a constructivist-based, contextual science research course, what are the influences on the novice teachers’ constructions of (a) science content knowledge and/or (b) pedagogical content knowledge?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QSR Node(s)</td>
<td>Contradictions</td>
<td>Coherences</td>
<td>Degree of Influence</td>
</tr>
<tr>
<td>Science Research Collaborations with Practicing Teachers Teaching Practices (Constructivist-based, contextual learning methods, as well as hands-on, meaningful, and real-life)</td>
<td>Some science content might be difficult for a pre-service teacher who lacks prior knowledge. Standardized testing often dictates the curriculum and the pressure of the tests forces teachers, especially novice teachers who fear losing their jobs, to depend on teaching facts from the textbook and information that will be included on the standardized test, or “teaching to the test.”</td>
<td>An immersion into science, and contextual learning increases the opportunity for gaining and retaining science content. Teachers who participate in such learning experiences are more likely to develop empathy for their own students. As the novice teachers begin to realize how much more they learned through the contextual learning experience</td>
<td>a) Positive influence, both teachers gained science content knowledge as evidenced by their writings and interviews. b) Some degree of influence, while both teachers expressed that they would limit the use of textbooks and lecture, there was still a great deal of dependency on their use. There was some inclusion of hands-on, real-life, and meaningful science.</td>
</tr>
</tbody>
</table>
Table 10-2—Continued.

<table>
<thead>
<tr>
<th>QSR Node(s)</th>
<th>Contradictions</th>
<th>Coherences</th>
<th>Degree of Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice teachers may have difficulty introducing non-traditional pedagogy in his/her classroom the first or second year of teaching</td>
<td>as opposed to textbooks and lecture, they will experience more empathy with their own students, helping to catalyze their pedagogy.</td>
<td></td>
<td>Cathy modified how she used the textbook. Rob integrated several inquiry-based, hands-on lessons during his first year, but I observed none during his second year of teaching.</td>
</tr>
<tr>
<td>Student discipline problems might make the implementation of a “less structured” teaching strategy more difficult for a novice teacher to control.</td>
<td></td>
<td>As novice teachers begin to feel more comfortable in his/her classroom, they may find implementing different teaching strategies less difficult.</td>
<td></td>
</tr>
<tr>
<td>Classroom size and, therefore, classroom management might create tension when attempting to use teaching practices that allow for less rigidity and structure.</td>
<td></td>
<td>As the novice teachers begin to realize how much more content that they learned through his/her immersion into contextual science research, this powerful learning experience could create empathy that increases the likelihood that the novice teacher may transform his/her own pedagogy. However, this may take time to emerge into practice in the classrooms of these teachers.</td>
<td></td>
</tr>
<tr>
<td>The “fear” of not gaining tenure often keeps novice teachers from trying new, innovative teaching practices.</td>
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</table>

**Authenticity Criteria Addressed**

There are five authenticity criteria, which are my quality criteria: fairness, ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity. I address each of them in this section.

**Fairness**

In Guba and Lincoln (1989), “fairness refers to the extent to which different constructions and their underlying value structures are solicited and honored within the evaluation process” (pp. 245–246). I did pay attention to and included the voices of Cathy and Rob and all other stakeholders (including the practicing teachers, the scientists, and my doctoral committee members). Throughout the five years, I shared my constructions with Cathy and Rob and obtained their feedback on whether they thought I understood them, giving them a chance to correct my constructions. At the conclusion of writing this doctoral dissertation, I met with Cathy
and Rob individually, after having given them the chapters that each wanted to read, and they had no further comments and agreed with my analysis.

**Ontological Authenticity**

As **ontological authenticity** refers to the extent to which we improve the individual’s or group’s constructions, the use of reflective writings, journals, observation notes, and interview responses helped each participant in the writing of his/her SERVE chapter. This was a group effort among all of the CO-LEARNER participants to help establish educative authenticity by producing a body of work helpful to those in the education community who seek to establish similar programs.

SERC@SERVE published the monograph, *Experiential Learning for Pre-Service Teachers: Applications to Secondary Classrooms* (Gilmer et al., 2002) in May of 2002. I include these chapters, written by the pre-service teachers participating in this study, on the influence of their research experiences on their own learning. SERC@SERVE disseminated the monograph widely to university faculty who teach pre-service teachers in their methods courses. In this study, what the participants learned might influence how teacher preparation program coordinators decide how to offer science content to pre-service science teachers.


> The idea for this project began at the Southeastern Association for the Education of Teachers in Science (SAETS) meeting held in 8-9 October 2000, at Auburn University. While attending a session on inquiry-based learning I heard papers by Hahn and Gilmer (2000) and Melear (2000). On the drive home my advisor, Dr. Lucy, and I had a very stimulating conversation about how Dr. Melear’s work could lead to a dissertation project for me. (p. 2)

Wilson’s (2002) work involves pre-service and in-service teachers in an immersion experience in astronomy at Georgia State University. He also presented at the International Conference for the Association for the Education of Teachers in Science (Brown et al., 2003).

**Educative Authenticity**

“Educative authenticity represents the extent to which individual respondent’s understanding of and appreciation for the constructions of others outside their stakeholding group are enhanced” (Guba & Lincoln, 1989, p. 248). Through interactions with other participants and other stakeholders, the novice teachers gained valuable information and insight.
into science and science teaching. From collaborations with the science researcher, the participants learned science content and the complexities of the culture of science. Through collaborations with the practicing teacher, the novice teachers gained insight into how to bring science into the classroom.

Cathy presented her paper at several FCETP conferences during the duration of this study, building upon her professional development. Rob was unable to participate due to work commitments. Through their participation in the doctoral research, they are fully aware of the time and dedication invested in such a pursuit. Cathy has expressed an interest in pursuing a Master’s degree, perhaps through Florida State University’s on-line graduate program. Her involvement with this project established a strong foundation for her to conduct educational research in her own graduate program.

**Catalytic Authenticity**

Did the immersion into the contextual science experience serve as a catalyst for teacher change? There is evidence that the contextual research experience positively enhanced the teachers’ beliefs about the culture of science and the image of the scientist. The teachers developed a better understanding of how to merge the culture of science in the classroom more closely with the culture of science. While this finding relates more closely to the teachers’ beliefs, the following criteria, *tactical authenticity*, relates more to the actual practices of the novice teachers.

**Tactical Authenticity**

_Tactical authenticity_ refers to the empowerment of the participants to act upon what they believe. In other words, are the novice teachers _empowered_ to put their beliefs into practice, or experience _praxis_, as discussed in Chapter 2? There is some subtle evidence of _tactical authenticity_ as the two novice teachers implemented some inquiry-based, hands-lessons, employing a constructivist-based, contextual science methodology. However, they did not implement this type of teaching practice on a consistent basis. Additionally, there was no evident to indicate that the two novice teachers were able to establish collaborations with the science researchers as they indicated that they would like to do.

The demands of the novice teacher (Dawson, 2002) and the influences related to the _induction years_ (Klepper & Barufaldi, 1998) of the novice teacher are counterproductive to the development of empowerment, leading to the teachers’ ability to fully experience _praxis_.

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Implications and Recommendations for Pre-service Teacher Education in Science and Mathematics

While this study has noteworthy implications for the education of pre-service science and/or mathematics teachers, there is need for improvement with respect to the novice teachers’ ability to transfer more of their experiences into the classroom. In this section, I offer the implications of the study, as well as recommendations for improvement for developing and/or implementing future programs of this nature.

**Implications for Teacher Education Programs**

While findings from research on practicing teachers, as well as my own personal experiences in contextual research, find supporting evidence on the potential for science and/or mathematics teachers to transfer their experiences from science research to their classrooms, the pre-service teachers as novice teachers, in my study, had limited success. I assert that as novice teachers, they were not at a point in their teaching careers where they could fully commit themselves to implementing teaching practices, due to job security issues and comfort level as a novice teacher (Klepper & Barufaldi, 1998; Dawson, 2002).

Based on the overall positive experiences of the pre-service teachers, the practicing teachers, and the researchers, the case for including scientific research in the form of contextual learning courses for pre-service teachers gains strength. Scientific research would be both beneficial to the pre-service teacher and his/her future students, as there is evidence of a shift away from the more positivist thinking towards a more constructivist-based thinking among these pre-service teachers.

While the pre-service teachers in this study enjoyed only limited success in transferring their experiences in the science laboratory to their actual classroom practices, due to concerns with classroom management and job security, the implications for incorporating a similar contextual science research course in the teacher preparation programs of pre-service teachers are significant. Based on this study, I find that a pre-service teacher immersion into the culture of science does influence several aspects of the novice science and mathematics teachers’ beliefs and practice. In summary, I offer the following implications for the education of pre-service teachers. A contextual science research course taken during pre-service education can influence teachers’ beliefs and/or classroom practice by providing novice science and mathematics teachers with:
1. the opportunity to learn science content knowledge within the context of science;
2. the experiences necessary to develop positive beliefs towards the culture of science and the culture of science in the classroom;
3. the opportunity to develop lesson plans prior to teaching in the classroom with the assistance from their practicing teacher mentors;
4. the confidence to enter the classroom better equipped to model their own classrooms as close to the culture of science as possible;
5. the foundation to form collaborations with scientists, such as guest speaker visits, field trips, and science fair assistance;
6. the capacity to generate more empathy towards their students. Having seen how much they have enjoyed this type of experience themselves, the teachers transfer these types of experiences to their classroom for their own students (although to a minimal degree in this study);
7. the personal experiences necessary to develop a better understanding of constructivist-based, contextual science experimentation;
8. the experiences needed to include opportunities to integrate science and mathematics in the classroom;
9. the opportunity to develop a better understanding of scientific inquiry and, thus, implement more inquiry-based, hands-on science activities; and
10. the experiences need to develop PCK in science teaching based on their own learning experiences and to begin to transfer these to their own classrooms.

Based on their strong beliefs, some changes in practice, and gradual steps towards praxis, I predict that they may begin to pull more pieces of their experiences into their practices as their comfort level with the teaching increases and as they gain more control of their classroom management situation. In the case of Cathy, finding a comfort zone to try something innovative that challenges the tradition within a parochial school may provide more opportunity for change. For Rob, better classroom management, gaining tenure, and less pressure from standardized testing may enable him to introduce more science and mathematics integrated hands-on lessons.

While the answers to my questions did not yield as many positive influences as I anticipated, there were no negative influences associated with the participants’ participation in the course and the participants were enthusiastic about the experience, in general. While this is
encouraging, I do have recommendations to improve the ability of novice teachers to transfer more of their experiences into their classrooms.

Recommendations

There are many individuals involved with this type of study who could be instrumental in this process of change towards helping the novice teacher bring more of their experiences into the classroom. I divided my recommendations based upon the role of each collaborator, as collaborations help form the foundation of this study and each participant made a commitment to help mentor the pre-service teacher towards the role of an excellent novice, science and/or mathematics teacher. These individuals include the collaborating research scientists, the practicing teachers, the university instructor or coordinator of the course or program, and the principal or other administrator of the novice teacher’s school.

The Research Scientist

The participation of the research scientist is especially important for several reasons:

1. The participating scientist can introduce the teacher to the culture of science, the process of science, and the tools of science;
2. The participating scientist can reflect upon his/her own schooling and what specific activities made an influence on his/her career decision to pursue science;
3. The participating scientist can offer what specific skills students need to pursue science as a career;
4. The participating scientist can assist the teacher with the development of laboratory activities which are representative of real world science and are applicable for the classroom;
5. The participating scientist serves as a facilitator to help teachers better acquire science content; and
6. The participating scientist can help the science teacher to better understand the culture, language, and nature of science in the classroom through the shared interactions of science teaching.

The research scientist serves to bring the culture of science to the pre-service teacher, as well as the practicing teacher. Expanding the role of the scientist could provide more opportunities for the novice teachers to form collaborations with the science community.
My recommendation to ensure collaborations with the scientists with the novice teachers is for the collaboration to extend throughout the novice teacher’s first year of teaching. This was initially in the plan for CO-LEARNERS, however, due to changes in job assignments of some of the researchers and the lack of follow-up, we did not do this. Therefore, maintaining contact with the science researcher is imperative for the novice teacher to form collaborations. Selecting a science researcher who is willing to maintaining a professional relationship with the novice teacher is a key element to success.

*The Practicing Science Teacher*

The participation of the practicing science teacher brings the realities of the science classroom to the pre-service teacher by bringing the culture of the science classroom as it currently exists. The practicing teacher informs the pre-service, soon to be novice teacher, as to what can or cannot be done in the classroom, what needs to be done, and how it can be done.

As discussed previously in Chapter 2, Fosnot (1993) stresses the involvement of both pre-service and practicing teachers in prolonged fieldwork. While Fosnot’s study deals primarily with classroom pedagogical issues, in general, my study focuses on science content knowledge and pedagogy. However, Fosnot’s suggestion of continuing the mentorship through the first year of teaching is critical. In the mentoring component of her study, Fosnot (1996) places novice teachers under the mentorship of faculty members. She asserts that without the faculty members working with them during the first year, many would have “floundered as they struggled with all the overwhelming issues of classroom management, curriculum, administration’s demands, and parental demands that burden the first year teacher” (p. 215). Fosnot further suggests that the mentor be a teacher who bases his/her practices on constructivism and not necessarily employed at the same school as the novice teacher. This practice would help to ensure that the novice teacher introduce innovative ideas that are not limited to the current practices within in the school.

I think that if Cathy and Rob had maintained a professional mentorship relationship with their collaborating pre-service science teacher, they would have felt more at ease with the collaboration. This is problematic, as some school districts require that mentoring teachers have special in-service training and/or coursework to become a mentor. When selecting a practicing teacher for the science research, careful attention should be paid to insuring that he/she is qualified to be a mentor. The school district could offer in-service points to the practicing
teacher, and/or the university could offer a tuition waiver towards graduate credit. There are creative ways to resolve this issue.

In her study of mentoring novice teachers, Dawson (2002) asserts that teachers in science and mathematics have needs that go beyond better classroom management skills, better understanding of the workings of the school, and better communication with parents. Teachers in science and mathematics also need help with understanding science content, obtaining and preparing laboratory materials, and guiding students to understand difficult subject matter. Dawson also discusses the importance of mentors during the first year of teaching. Such collaborations often continue beyond the teacher’s pre-service experiences and extend as the novice teacher enters his/her classroom. These collaborations can occur on a more dynamic level if the teacher maintains contact with the mentor(s), or on a cerebral level as the pre-service teacher retains what was learned during the mentorship.

Another possibility to explore is forming mentoring relationships with National Board Certified Teachers. In many states, the state departments of education provide a salary to National Board Certified teachers to mentor novice teachers.

**The University Instructor or Course Coordinator**

If the school district requires mentors to have specific training, the instructor and/or coordinator of the contextual science research course could arrange this for the mentoring teacher through the university, based upon their interest and willingness to work in the collaboration. The mentoring teacher may or may not have to be in the same school as the novice teacher. The mentoring teacher could follow the novice teacher through his/her first year of teaching, perhaps receiving course credit or in-service points. This mentoring could be done at the school, if possible. If not, use of E-mails would work to allow the novice teacher the opportunity to ask questions, discuss concerns, and find someone to provide needed encouragement during these difficult induction years of teaching (Klepper & Barufaldi, 1998).

Another factor to consider is that both Rob and Cathy first participated the summer before their junior year of study. Cathy also participated in CO-LEARNERS during the summer before her senior year. Because he worked full time, Rob was not able to participate the second summer. Following their summer research, both participants enrolled in other teacher education courses that they needed to complete. Rob and Cathy also completed a teaching internship before they actually graduated and began teaching. While I was able to coordinate their practicum
experience with their collaborating pre-service teachers, I could not place them with that same
teacher for their internship. The university had specific requirements about this matter, and
placed both teachers in internships with other teachers. A full-time professor would have more
flexibility in designing the course and arranging the follow-up internship of the pre-service
teacher. Completing an internship with the collaborating pre-service teacher would be provide
additional support, as the teams would continue to build a strong professional relationship. This
would all have to be carefully considered through the university placement office.

Another recommendation would be to have the pre-service teacher enroll in the
contextual science research course, the summer preceding the teacher’s internship or graduation.
The option may be difficult as most students graduate during the spring.

*School Administration of the Novice Teacher*

Support from the school principal or other administrator is necessary. Prior to
employment, the novice teacher could inform the principal that s/he may be implementing some
innovative teaching practices, and ask for support. The university coordinator may serve as an
additional source of support for the novice teacher as s/he implements some of the innovative
teaching practices gained through their immersion experiences.

*The Novice Teacher*

The responsibility of the novice teacher is to commit to make the effort to put his/her
beliefs into practice. Providing feedback during course is an excellent start. Cathy’s suggestion
to keep a journal was a very critical and important to the study. The reflections from the
participants, such as in their journals, are necessary to make sure that the research is real, and to
ensure that there is more than one researcher involved who knows what is occurring. These
suggestions are also a good forum for future suggestions for improvement.

*Final Comment*

Fear of keeping one’s job is very real. I would strongly advice against forcing a novice
teacher to implement a teaching practice or activity that he/she felt would be looked upon
negatively by the school administration. The school situation must be looked at carefully before
making decisions.

Encouragement from all collaborators should provide the support and coherences for the
novice teacher to move beyond their beliefs and to practice science teaching the way that they
have experienced it. Contradictions related to the pressures of being a novice teacher (Dawson,
2002), the fear of job security, and concerns with standardized testing may be alleviated, as well. Classroom management, outdated facilities, and lack of funding for extracurricular activities could also be resolved with proper guidance from an experienced teacher and supportive administration.

**Researcher Bias and This Study**

As I previously discussed, there was researcher bias in my study. Because an immersion experience while I was a practicing teacher greatly influenced my own teaching, I had assumed at the start that the novice teachers would quickly embrace this feeling of empowerment, similar to what I had experienced through my own praxis. I soon began to realize that my situation was greatly different from my study subjects. I had been teaching for 10 years and was enrolled in graduate studies when I became involved with course work, which involved authentic science research and contextual learning in science.

The main difference between the novice teachers and myself was that I had built a comfort zone within my own classroom. I had tenure, I knew what my students needed to know when they completed my course, I knew the content that I was required to teach, and I was not overwhelmed with trying to teach. The successes of the many other SWEPT programs across the county for practicing teachers could be attribute to the same types of experience that I had experienced. Seasoned teachers often need a *boost*, or a re-awakening of their teaching soul. This type of immersion experience can provide the needed catalyst.

For the novice teacher, there is less need for a re-energizing, but rather the need for a catalyst for change. I believe, however, that participating in a pre-service contextual research course can provide knowledge for the novice teacher to build upon as he/she begins to pass the novice stage of teaching. I believe that the science content gained, the access to scientists and the science community, and the transfer of experience with constructivist-based contextual science will eventually surface in his/her classroom to a much greater degree than what I see with the novice teachers in my study. In their *cases*, the influences while not as dramatic as in my own experiences, were there and I believe may continue to emerge as the teachers begin to gain more confidence and begin to feel more empowered to act as they begin to see the direction that science education must evolve.

Fosnot (1989) defines an empowered teacher as “a reflective decision maker who finds joy in learning and in investigating the teaching/learning process—one who views learning as
construction and teaching as a facilitating process to enhance and enrich development” (p. xi). The participants in my study expressed similar feelings throughout the study.

Personal Reflections

When students study science themes, such as Rob’s thematic unit on hurricanes, and solve problems that relate to their own lives, they are more likely to relate to and retain this learning because they see the relevance of science. I found this to be true in my own classroom. Like Cathy, I think that in order for students to appreciate and enjoy learning science they must feel connected to science. I incorporate as much real-life science as possible and financially feasible. To support extra-curricular activities, I made grant writing a part of my teaching routine.

Some of the best examples of students learning for understanding have come from research projects in which I actively engage my students. These projects include sand dune restoration at a local beach, building and installing bat houses, cleaning up beaches, and tracking sea turtle nesting grounds. Planning and implementing such projects was very difficult and costly due to bus transportation, but the results were worth the effort. Most teachers have not yet realized the power of this type of teaching, unless they have experienced it themselves.

The Pilot study described in Chapter 4 allowed for the teaching and learning of science to include interactions with a science researcher that were rich in experiential activities that had an impact on the students’ community. Some of the research that the pre-service teachers experienced included testing the effects of fluoride added to drinking water, the propagation and planting of sea grasses for use in environmental mitigation, testing for water pollutants in areas with heavy marine/boating traffic, and other water quality studies. These are examples of real-life science.

My own scientific research with algal toxins at the EPA proved fascinating to my students (Hahn, 1999). Living on the Gulf coast of Florida, my students could see the relevance of algal toxins. They had often heard the term the “red tide” and were mostly familiar with that type of algae. While the science textbook did not mention algal toxins, the students were still very intrigued by the damage that these toxins could do to living things. As a result, I designed and implemented a similar study for my students. This, too, could happen for Cathy and Rob as they evolve into more established teachers and begin to realize that they have more freedom in the classroom than they currently believe.
Having pre-service teachers form collaborations with science researchers can serve to bring more real-world applications and community awareness into the classroom in several ways. One way is through the eyes of the pre-service teacher and his/her classroom activities. Another way is through the experiences of the science researcher, who may serve as a guest speaker or a science fair mentor or may plan a field trip for the students to his/her research facility.

Seeking the PhD: Lessons Learned in Life

Another finding that emerged from this study is the realization that my participation in the doctoral program and my study of the pre-service teachers had many parallels. By this statement, I mean that much like the novice teachers, who believed that they learned so much more through immersion into the culture of science, I too learned so much more when I was on campus through my immersion into the culture of a graduate student in science education. My isolation as a distance learner was very difficult at times, which stalled my learning process. I had to rely mostly on the readings of others. The university offered some electronic discourse and campus meetings, which were of great benefit. Only when I was on campus did I experience the true culture of science education and graduate student life.

I agreed to participate in the distance doctoral cohort to earn a Ph.D. from my Alma Mater University, as this was a great opportunity. I was intrigued because I would be able to do some of my studies on campus, but remain at home with my family. This, however, proved to be one of the more difficult challenges I have ever faced. Nonetheless, I have successfully persevered through constant ups and downs, and survived many moments in which I felt like giving up the dream of receiving my Ph.D. I hope that my young son will see his mother as someone who does not give up and who endures through adverse situations. I hope that this will inspire him to do the same when faced with difficult obstacles.

I am enormously appreciative of the opportunity to be a participant in the distance learning doctoral cohort, and I am eternally grateful to my committee and my major professor for working so diligently to help guide me through my learning. Technology is a wonderful educational tool and should be used a supplemental way to carry on discourse. One caveat, however, is that there is no permanent replacement for human interaction with particular regards to collaborations with peers, professors, and graduate studies personnel. Distance students should spend as much time as possible immersed in the context of a collaborative graduate
environment with fellow graduate students. The isolation is often counterproductive to creativity and progress. Reading the work of Malone (1998) helped me to better understand my situation. Malone (1998) discusses combating the isolation of distance learners, arranging face-to-face contact, preparing the distance learner to conduct research, and keeping the distance student informed. I regained my confidence after understanding that others shared my difficulties, and that I was not alone.

If a graduate student can financially afford to be a full-time student living on or near campus and has the flexibility to be away from family or to bring his/her family to the university, then I would recommend doing so. If there are no alternatives, other than being a distance learner, then I would wholeheartedly recommend trying it for a few semesters, especially if this was the only way he/she could earn a much desired and/or needed graduate degree. Depending upon the circumstances of the individual, it could work out without difficulty. Each case would be different. Cathy has expressed an interest in pursuing her Master’s degree in Science Education through a distance-learning program of studies. I am encouraging her to do so, while her son is still an infant. As he grows, so will she, both intellectually and professionally. She can serve as a role model for him.

The immersion into a scholarly atmosphere, much like the pre-service science teachers immersed in a science laboratory facility, is so much more empowering than learning from the work of others. Each time I returned to campus, I felt invigorated, ready to embrace the next step of my journey. Then I would return home to face the challenges of being a mother and wife, and my educational goals would be cast aside until a better day and time. My priorities are, and always will be to my family. Because of this, I took the time to complete this journey in order to enjoy both my family and my love of life-long learning. Given that, I believe that I succeeded in my original goals with this study and so much more.
MEMORANDUM

TO: Heidi Hodges, Assistant to Betty Southard, Chair, Human Subjects Committee

FROM: Penny J. Gilmer, Professor and Lori Hahn, graduate student

RE: “CO-LEARNERS—Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science”

DATE: 12 April 1999 (Last Revision and Request April, 2003)

We are submitting a request for use of human subjects in research project entitled, “CO-LEARNERS—Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science.” Attached is a copy of the Human Consent Form with questions to the human subjects.

If you require further information, please contact either Penny Gilmer at 644-4026, e-mail at <gilmer@sb.fsu.edu> or Lori Hahn at (850) 438-7609 in Pensacola, e-mail at <HAHN_L@popmail.firn.edu>.

Please let us know once this is approved.

Human Subject in Research Form

The Federal Government and University policy requires that the use of human subjects in research be monitored by the Institutional Review Board (IRK). The following information must be provided when humans are used in research studies, whether internally funded, extramurally funded, or unfunded. Research in which humans are used may not be performed in the absence of IRK approval.

PLEASE COMPLETE AND SUBMIT PAGES 1 AND 2 plus YOUR ANSWERS TO THE QUESTIONS (on page 3) IN TYPEWRITTEN FORM TO: HEIDI HODGES (644-8633), Mail Code 2811, or OFFICE OF RESEARCH, INNOVATION PARK, 109 MORGAN BUILDING, TALLAHASSEE, FL 32306-2811; e-mail: hhodges@res.fsu.edu

Researcher: Lori Livingston Hahn, Florida State University

Project Title: “CO-LEARNERS—Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science”

Project Period: June 1, 1999 - May 31, 2000 (Request for extension through May 2003)
**Position in University** (faculty, etc.) If student, please indicate FSU Advisor:
Lori Hahn, doctoral student, Department of Curriculum and Instruction
Advisor is Dr. Penny J. Gilmer, Department of Chemistry

**Department:** Curriculum and Instruction

**Telephone:** Lori Hahn (850) 438-7609 Penny Gilmer (850) 644-4026

**E-Mail Address** (where you can be reached in case of a problem with your application):
Lori Hahn: HAHN_L@popmail.firn.edu Penny Gilmer: gilmer@sb.fsu.edu

**Mailing Address** (where your approval will be mailed):
Department of Chemistry, Florida State University, Tallahassee, FL 32306-4390

**Project is** (please check one): X dissertation ___teaching ____thesis X other

**Project is** _____unfunded X funded (if funded, please complete the following):

Funding Agency (actual/potential):
1. National Science Foundation

Contract/Grant No. (if applicable) ___1312-796-41____________

FOR EVALUATION OF YOUR PROJECT, PLEASE CHECK THE FOLLOWING WHICH APPLY:
Mentally or Physically Challenged Subjects:
Subjects studied at FSU:
Minor Subject (under 18 years old):
Subjects studied at non-FSU location (s): XX
Prisoners, Parolees, or Incarcerated Subjects:
Students as Subjects: XX
Filming, Video, or Audio Recording of Subjects: XX
Employees as Subjects: XX
Questionnaires or Survey (s) to be administered: XX
Pregnant Subjects:
Review of Data Banks, Archives, or Medical Records: XX
Fetal, placental or surgical pathology tissue (s):
Subjects’ major language is not English:
Subjects to be paid: XX
Involves Deception (if yes, fully describe at Question No. 7)

This document is available in alternative format upon request be calling (850) 644-8633 Human Subjects Application (rev. 8/96)
**Survey Techniques:** Check applicable category if the only involvement of human subjects will be in one or more of the following categories:

- [X] Research on normal educational practices in commonly accepted educational settings
- [X] Research involving survey or interview procedures (if checked, please see below)

If research involves use of survey or interview procedures to be performed, indicate:

1. Responses will be recorded in such a manner that human subjects cannot be identified, by persons other than the researcher, either directly or through identifiers linked to the subjects.
   - [X] yes  [ ] no

2. The subject’s responses, if they became known outside the research, would reasonably place the subject at risk of criminal or civil liability or be damaging to the subject’s financial standing or employability.
   - [ ] yes  [X] no

3. The research deals with sensitive aspects of the subject’s own behavior, such as illegal conduct, drug abuse, sexual behavior, or use of alcohol.
   - [ ] yes  [X] no

4. Does Research Involve Greater Than Minimal Risk to Human Subjects?
   - [ ] yes  [X] no

(If yes, explain in full at Question No. 2)

“Minimal Risk” means that the risks of harm anticipated in the proposed research are not greater, considering probability and magnitude, than those ordinarily encountered in daily life, or during the performance of routine physical or psychological examinations or tests.

I HAVE READ THE FLORIDA STATE LETTER OF ASSURANCE FOR THE PROTECTION OF HUMAN SUBJECTS IN RESEARCH AND AGREE TO ABIDE BY IT. I ALSO AGREE TO REPORT ANY SIGNIFICANT AND RELEVANT CHANGES IN PROCEDURES AND INSTRUMENTS AS THEY RELATE TO SUBJECTS TO THE CHAIR, HUMAN SUBJECTS COMMITTEE, OFFICE OF RESEARCH.

RESEARCHER (signature)   (Date) 12 April 1999

_______________________________ ____________________

RESEARCHER (signature)   (Date) 12 April 1999

_______________________________ ____________________

Human Subjects Application (rev. 8/96)
Questions
FOR RESEARCH INVOLVING HUMAN SUBJECTS

USE ADDITIONAL SHEETS FOR ANSWERING THE FOLLOWING QUESTIONS
PLEASE SUBMIT YOUR ANSWERS IN TYPEWRITTEN FORM

1. GIVE A COMPLETE DESCRIPTION OF YOUR RESEARCH PROCEDURES AS THEY RELATE TO THE USE OF HUMAN SUBJECTS.

This project will be developed as part of a National Science Foundation Collaborative for Excellence in Teacher Preparation grant. Three practicing teachers, three prospective teachers, and three science researchers will form three teams of “CO-LEARNERS”. As participants in these teams, each learner will assume the role of teacher, learner, and researcher. Teachers, practicing and prospective, will spend time in a science research facility to conduct research and become acquainted with the language and culture of science. The science researcher will collaborate with the practicing and prospective teachers to develop lesson plans and activities for the classroom. The science researcher will also be immersed in the culture of classroom science, as he/she will “teach” science to the students on several occasions throughout the school year. The interrelationship and collaboration among the teams will result in shared learning experience.

The research methods used in this study will be one of an interpretative research design in which each participant will be interviewed at various points of their collaboration. They will be asked for their permission to tape record the interviews. After transcribing the interview, participants will be giving the transcripts for correction and reflection. The hermeneutic dialectic circle will be utilized as a means to share reflections with all the members of the study. Due to the nature of the emergent design, new questions may arise during the research project. This will be instrumental in helping to establish this program as an on-going project in this community. The goals of this research are to provide practicing and prospective middle school teachers opportunities to participate in science research, to form collaborations among science researchers and science teachers, and to determine if this type of experience can impact teachers’ beliefs about the teaching and learning of science, and ultimately their teaching practices.

2. HAVE THE RISKS INVOLVED BEEN MINIMIZED AND ARE THEY REASONABLE IN RELATION TO ANTICIPATED BENEFITS OF THE RESEARCH, IF ANY, TO THE SUBJECTS AND THE IMPORTANCE OF THE KNOWLEDGE THAT MAY REASONABLY BE EXPECTED TO RESULT?

The risks have been minimized. In fact, the subjects will learn from the results of the research. Science researchers will not expect teachers to conduct research that is deemed unsafe or beyond the teachers scope of experience and background.

3. WHAT PROVISIONS HAVE BEEN MADE TO INSURE THAT APPROPRIATE FACILITIES AND PROFESSIONAL ATTENTION NECESSARY FOR THE HEALTH AND SAFETY OF THE SUBJECTS ARE AVAILABLE AND WILL BE UTILIZED?
Teachers participating in scientific research at various sites will be educated on safety procedures in accordance with that facility.

4. DESCRIBE PROCEDURES TO BE USED TO OBTAIN INFORMED CONSENT. (See attached sample and tips on Informed Consent attached to this application.) Attach a copy of the informed consent you will use when submitting this application. ALSO, PLEASE ANSWER THE FOLLOWING:

A) WHO WILL BE OBTAINING INFORMED CONSENT?

Lori Hahn, doctoral student, will interview teachers and researchers wishing to participate, and provide them with details of the study.

B) WHEN WILL THE SUBJECTS BE ASKED TO PARTICIPATE AND SIGN THE CONSENT FORM?

Subjects will be asked to participate as soon as the Human Subjects Application is approved. All individuals will be given a consent form and asked to sign it.

C) IN USING CHILDREN, HOW WILL THEIR ASSENT BE OBTAINED?

There will be no children directly involved in this study. However, students of participating teachers may be videotaped as part of the study. These students will have in their files, a signed parental consent form. The Escambia County School District requires that all students who are to be videotaped for any purpose have a parental consent form on file in the school office.

5. DESCRIBE HOW POTENTIAL SUBJECTS FOR THE RESEARCH PROJECT WILL BE RECRUITED?

Several potential subjects have already been selected because they have expressed a verbal interest in the project. All of the practicing teacher subjects teach in middle schools in Escambia County, Florida. Several science researchers have also expressed an interest through personal communication by Lori Hahn. The Teacher Education Advisor at the University of West Florida will recruit prospective science teachers.

6. WILL CONFIDENTIALITY OF ALL SUBJECTS BE MAINTAINED? HOW WILL THIS BE ACCOMPLISHED? PLEASE ALSO SPECIFY WHAT WILL BE DONE WITH ALL AUDIO AND/OR VISUAL RECORDINGS, IF APPLICABLE, PICTURES AND PERSONAL DOCUMENTATION OF SUBJECTS BOTH DURING AND AFTER COMPLETION OF THE RESEARCH.

Confidentiality will be maintained on all audiotapes and videotapes, which will be kept by Dr. Penny J. Gilmer in her locked office for a period of five years and then destroyed.
7. IS THE RESEARCH AREA CONTROVERSIAL AND IS THERE A POSSIBILITY YOUR PROJECT WILL GENERATE PUBLIC CONCERN? IS SO, PLEASE EXPLAIN.

The research is not controversial.

8. DESCRIBE THE PROCEDURE TO BE USED FOR SUBJECT DEBRIEFING AT THE END OF THE PROJECT. IF YOU DO NOT INTEND TO PROVIDE DEBRIEFING, PLEASE EXPLAIN. Office for Protection from Research Risks

There will be several meetings in which all participants will interact to discuss the evolution of the project, providing feedback. Individual teachers and their researchers will also meet several times over the year. The use of e-mail will be used for input, concerns, and suggestions.
Interview Questions (for Practicing and Prospective Teachers) for CO-LEARNERS: Pre-Participation

1. Do you have any experience working in a science laboratory?
2. Why would you be interested in working in a science research facility?
3. Describe what you believe to be the “culture of science.”
4. Describe how this differs from the culture of the science classroom.
5. How do you and/or your students perceive scientists and the study of science?

Interview Questions (Practicing and Prospective Teachers) for CO-LEARNERS: Post-Participation

1. Describe your experience working in a science laboratory?
2. Did working in a science research facility meet your expectations?
3. Describe what you believe to be the “culture of science.”
4. Describe how this differs from the culture of the science classroom.
5. Do you believe that your experience will influence how you and/or your students perceive scientists and the study of science?
6. How do you think that your science research experience has impacted you as a person, as a teacher? In what ways?
7. What will you or have you already done differently with your students as a direct result of your science research experience?
8. Has anything happened to you or your students as a direct result of your science research experience?
9. What are your thoughts on how to arrange the collaboration of a scientist, a lead teacher, and a university student who is pursuing science teaching? Is it worthwhile? Should it be a part of teacher preparation programs? Why or why not?
10. Do you believe that collaborations between teachers, both practicing and prospective, and researchers of science are worthwhile for students? (i.e., what products, ideas, revelations, insights, etc., were resultant of this collaboration?)

Interview Questions (for Researchers of Science) for CO-LEARNERS
Pre-Participation and Post-Participation

1. What experiences do you have with education and/or the science classroom? (Have you ever been in a secondary science classroom since your own schooling?)

2. What, if any experiences, did you have in your own schooling that ignited your interest in science?

3. What types of things do you believe that science teachers should be doing in the classroom to promote learning of science and positive attitudes towards science and scientists?

4. What types of activities do you believe that science teachers could do in the classroom to create an interest in science?

5. How would you describe the “culture of science”?

6. How would you describe the “culture of the science classroom”?

7. Do you believe that your involvement with the science classroom made an impact on the students in the classroom (i.e., interest level, attitudes towards you as a scientist, etc.)?

8. Was “teaching science” difficult for you?

9. What parallels do you see between “teaching science” and “doing science”?

10. Do you believe that collaborations between teachers, both practicing and prospective, and researchers of science are worthwhile for students? (i.e., what products, ideas, revelations, insights, etc., were resultant of this collaboration?)
INFORMED CONSENT FORM
Date _______________________

I freely and voluntarily and without any element of force or coercion, consent to be a participant in the research project entitled, CO-LEARNERS-Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science”, within a National Science Foundation grant titled, Florida Collaborative for Excellence in Teacher Preparation. Mrs. Lori Hahn, a graduate student at Florida State University, and Dr. Penny J. Gilmer, a Professor of Chemistry at Florida State University, is conducting the study. I understand the purpose of the research is to better understand practices, communication, and learning while immersed in scientific research. I understand that if I participate in the project I may be asked questions about my scientific research experience, as well as general information about my background knowledge and myself. The information learned about the project may be used in a dissertation written by Lori Hahn.

I understand I will be asked to participate in several interviews conducted by Lori Hahn. The total time commitment for an interview is about 30 - 45 minutes. I will be asked permission to allow audiotaping of this interview. I may refuse to participate, or request that the interview be stopped for any reason, and may also ask to have the interview materials discarded afterwards, if I wish. The design of the study will be open-ended or emergent, so the ideas will emerge during the inquiry as Ms. Hahn incorporates a qualitative research method, in which the stakeholders’ (which includes myself) inputs (i.e., claims, concerns, and issues) are of vital importance and relevance.

I understand that I will be videotaped on several occasions, during my own scientific research and in my classroom while conducting scientific investigations with my students. I may refuse to be videotaped, and may also ask to have the videotape discarded afterwards, if I wish. I will make sure that all of my students who will appear in the videotape have signed consent forms on file in the school office. The Escambia County School District requires all students, who are to be videotaped for any reason, to have a signed parental consent form on file in the school office.

I understand that my participation in this project is totally voluntary, and I may stop participation at any time. I understand that I may choose to change or omit any background information about me or quotes made by me.

The audiotapes and videotapes will be stored in Dr. Gilmer’s locked office for five years and destroyed by 2007.

I understand there are benefits for participating in this research project. My own awareness about how I view science and scientists, and how I teach science may be enhanced for the benefit of my students and myself. Also, I will provide other teachers and researchers with valuable insight of the first-hand experiences (including the joys and struggles) of conducting their own scientific research. This knowledge can assist others in sparking an interest in becoming involved in their own scientific research experience to improve teaching and learning.

I understand that I may contact Lori Hahn, 3256 Bayou Lane, Pensacola, FL 32503 at (850) 438-7609 or by e-mail at HAHN_L@popmail.firm.edu or Dr. Penny J. Gilmer, Department of
I understand that this consent may be withdrawn at any time without prejudice, penalty, or loss of benefits to which I am otherwise entitled. I have been given the right to ask and have answered any inquiry concerning the study. Questions, if any, have been answered to my satisfaction. In the future, I understand I may contact either Ms. Lori L. Hahn or Dr. Penny J. Gilmer for answers to questions about this research or my rights. I have read and understand this consent form.

______________________________
(Printed name)

______________________________
(Signature)

______________________________
(Date)
APPENDIX B: HUMAN SUBJECTS APPROVAL

OFFICE OF THE VICE PRESIDENT FOR RESEARCH
Tallahassee, Florida 32306-2811
(850) 644-5260 • FAX (850) 644-4392

APPROVAL MEMORANDUM
from the Human Subjects Committee

Date: April 29, 1999
From: David Quadagno, Chair
To: Lori Hahn
 MC: 4390
Dept: Chemistry
Re: Use of Human subjects in Research
 Project entitled: "CO-LEARNERS-Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science"

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and two members of the Human Subjects Committee. Your project is determined to be exempt per 45 CFR § 46.101(b)2 and has been approved by an accelerated review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by April 29, 2000 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is M1339.

cc: P. Gilmer
APPLICATION NO. 98.167
APPROVAL MEMORANDUM
from the Human Subjects Committee

Date: April 29, 1999
From: David Quadagno, Chair
To: Lori Hahn
Dept: Chemistry
Re: Use of Human subjects in Research
Project entitled: "CO-LEARNERS-Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science"

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and two members of the Human Subjects Committee. Your project is determined to be exempt per 45 CFR § 46.101(b)2 and has been approved by an accelerated review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by April 29, 2000 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is M1339.

cc: P. Gilmer
APPLICATION NO. 99.167
INFORMED CONSENT FORM

Date ______________

I freely and voluntarily and without any element of force or coercion, consent to be a participant in the research project entitled, CO-LEARNERS-Collaborative Opportunities: Learning Experiences And Research Uniting Educators and Researchers of Science,” within a National Science Foundation grant titled, Florida Collaborative for Excellence in Teacher Preparation.

The study is being conducted by Mrs. Lori Hahn, graduate student at Florida State University and Dr. Penny J. Gilmer, Professor of Chemistry at Florida State University. I understand the purpose of the research is to better understand practices, communication, and learning while immersed in scientific research. I understand that if I participate in the project I may be asked questions about my scientific research experience, as well as general information about my background knowledge and myself. The information learned about the project may be used in a dissertation by Lori Hahn.

I understand I will be asked to participate in several interviews conducted by Lori Hahn. The total time commitment for an interview is about 30 - 45 minutes. I will be asked permission to allow audiotaping of this interview. I may refuse to participate, or request that the interview be stopped for any reason, and may also ask to have the interview materials discarded afterwards, if I wish. The design of the study will be open-ended or emergent, so the ideas will emerge during the inquiry as Ms. Hahn incorporates a qualitative research method, in which the stakeholders’ (which includes myself) inputs (i.e., claims, concerns, and issues) are of vital importance and relevance.

I understand that I will be videotaped on several occasions, during my own scientific research and in my classroom while conducting scientific investigations with my students. I may refuse to be videotaped, and may also ask to have the videotape discarded afterwards, if I wish. I will make sure that all of my students who will appear in the videotape have signed consent forms on file in the school office. The Escambia County School District requires all students, who are to be videotaped for any reason, to have a signed parental consent form on file in the school office.

I understand that my participation in this project is totally voluntary, and I may stop participation at any time. I understand that I may choose to change or omit any background information about me or quotes made by me.
The audiotapes and videotapes will be stored in Dr. Gilmer's locked office for five years and destroyed on June 1, 2004.

I understand there are benefits for participating in this research project. My own awareness about how I view science and scientists, and how I teach science may be enhanced for the benefit of my students and myself. Also, I will provide other teachers and researchers with valuable insight of the first-hand experiences (including the joys and struggles) of conducting their own scientific research. This knowledge can assist others in sparking an interest in becoming involved in their own scientific research experience to improve teaching and learning.

I understand that I may contact Lori Hahn, 3256 Bayou Lane, Pensacola, FL 32503 at (850) 438-7609 or by e-mail at HAHN.L@popmail.fln.edu or Dr. Penny J. Gilmer, Department of Chemistry, Florida State University, Tallahassee, FL 32306-4390 at (850) 644-4026 or by FAX at (850) 644-8281 or by e-mail at gilmer@sb.fsu.edu, for answers to questions about the research.

I understand that this consent may be withdrawn at any time without prejudice, penalty, or loss of benefits to which I am otherwise entitled. I have been given the right to ask and have answered any inquiry concerning the study. Questions, if any, have been answered to my satisfaction. In the future, I understand I may contact either Ms. Lori L. Hahn or Dr. Penny J. Gilmer for answers to questions about this research or my rights. I have read and understand this consent form.

(Printed name) (Signature)

(Date)
# APPENDIX C: EVALUATION MATRIX FOR PILOT STUDY

## CO-LEARNERS Evaluation Plan Matrix

<table>
<thead>
<tr>
<th>The Influence of Science Research Experiences on Pre-service Middle School Science Teachers</th>
<th>Indicators</th>
<th>Data to be Collected</th>
<th>Time-line for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Outcomes: Influence on Content Knowledge gained from science research experience</td>
<td>Students responses concerning research and the content knowledge</td>
<td>Students’ interviews</td>
<td>Pilot Study data 1999/2000.</td>
</tr>
<tr>
<td></td>
<td>Students ability to discuss the science research via a research paper, as well as in group or individual discussions</td>
<td>E-mail discussions</td>
<td>Full Study Fall of 2000 and Spring of 2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research papers</td>
<td>Follow up observations and interviews with pre-service teachers to continue through 2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Journal entries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group and individual discussions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interviews with science researchers</td>
<td></td>
</tr>
<tr>
<td>Change in Outcomes: Influence on the Pre-Service Teachers’ Teaching and Learning of Science/Transfer of Experience (Constructivist Pedagogy and Contextual Learning Experiences)</td>
<td>Students responses concerning theoretical framework, the teaching and learning of science, the nature of science versus classroom science, and the culture of science versus the culture of classroom science</td>
<td>Interviews with both pre-service and practicing science teachers</td>
<td>Pilot Study data 1999/2000.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E-mail discussions</td>
<td>Full Study Fall of 2000 and Spring of 2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lesson plans</td>
<td>Follow up observations and interviews with pre-service teachers to continue through 2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Journal entries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group and individual discussions</td>
<td></td>
</tr>
<tr>
<td>Changes in Collaboration: Influence on how pre-service teachers form collaborations with research scientists and the science community</td>
<td>Students’ responses concerning working with the science researcher(s)</td>
<td>Interviews with participants and observations of interaction with science researchers</td>
<td>Pilot Study data 1999/2000.</td>
</tr>
<tr>
<td></td>
<td>Plans and ideas for classroom activities that emerge from the science research experience</td>
<td>E-mail discussions</td>
<td>Full Study Fall of 2000 and Spring of 2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research papers</td>
<td>Follow up observations and interviews with pre-service teachers to continue through 2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lesson Plans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Journal entries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group and individual discussions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interviews with science researchers</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D: SYLLABUS FOR EXPERIENTIAL SCIENCE AND MATHEMATICS COURSE

EDM 4990 Experiential Science/Math in Middle School
Summer 2000: Term C June 22-August 4
Instructor: Lori L. Hahn
857-6337, Building 85/194
Office hours: Tuesday and Thursday 9:00-2:00
E-mail: lhanh@uwf.edu
Professors of Record: Dr. David Stout and Dr. Carol Briscoe

Course Outline:
This course is an experiential science course designed to provide the pre-service middle school science and/or math teacher with a contextual learning opportunity in a scientific research setting. Unlike a laboratory course, this is an authentic research experience done in conjunction with a research currently being conducted at the University of West Florida’s Center for Environmental Diagnostics and Bioremediation (CEDB) and the Institute for Coastal and Estuarine Research (ICER), or the Florida Department of Environmental Protection (FDEP). The pre-service teacher will work alongside researchers at their assigned research facility, as well as a practicing science and/or math teacher. The researcher will assist the pre-service with the science content and research, while the practicing teacher will assist the pre-service teacher with the classroom applications of such an experience. This community of learners will collaborate on a learning experience designed to bring science to middle school students.

This course can be used as a substitute for ZOO 4254 Marine Invertebrate Zoology, ZOO 4304 Marine Vertebrate Zoology, or MAE 4990 Applied Mathematics for the 21st Century.

Goals:
To better prepare the pre-service teacher/education student to meet selected indicators in each of the following Accomplished Practices mandated by the State of Florida: #1, #2, #3, #4, #8, #9, #10, #11, #12 (www.firm.edu/doc/bin00026/acco-prc.htm.)

To better prepare the pre-service teacher/education student to use appropriate Sunshine State Standards in teaching middle level science and/or math with respect to lesson plan development. (www.firm.edu/doc/curric/prek12/frame2.htm.)

To better prepare the pre-service teacher/education student to meet the National Science Education Standards (National Research Council). (www.nap.edu/books/0309053269)

To help prepare the pre-service teacher/education student to pass items related to science content and science teaching on the Florida Department of Education Professional Examination.

Objectives:
The pre-service teacher/education student will be able to better use the language of science. This will be evidenced through the completion of a scientific paper based on the actual research completed at the research site, as well as the discourse between the learning community.

The pre-service teacher/education student will be able to better understand the Nature of Science through their interactions with the research scientists and the research that they will be undertaking. They will realize that answers are not always easy to find in science, and that the “Scientific Method” is often elusive.

The pre-service teacher/education student will become immersed in the culture of science through their interactions with the researchers within a scientific environment.

The pre-service teacher/education student will be placed in a contextual learning experience, which will enable them to become familiar with this type of constructivist-based pedagogy. This may inspire and impact their own teaching methodology.

The pre-service teacher/education student will be able to develop new contacts and access to the scientific community for their future classrooms through their interactions with the research scientists and other members of the scientific community.

The pre-service teacher/education student will be able to “Bring science in to the classroom” more effectively through their discussions with the practicing teacher on the nature and needs of the middle school student, what to anticipate in the middle school classroom, such as limited resources, and ideas for incorporating “real” science in to the classroom, with regards to grant writing, finding community support, and creative planning.

The pre-service teacher/education student will become a part of a community of learning, as they become “co-learners”, in order to best bring science to their future students within their classrooms.

The pre-service teacher/education student will be able to write a lesson plan using the Sunshine State Standards.

The pre-service teacher/education student will be able to think like a scientists, use the language of science, and therefore be able to better relate science their students.

The pre-service teacher/education student will be able to reflect on their experiences through the writing in their journal, and begin to realize ways that “science” can be brought to their students in ways other than lecture and textbooks.

The pre-service teacher/education student will be able to discuss their research using the content they have gained through their experience.

The pre-service teacher/education student will have an opportunity to attend a professional meeting at which they will present their paper, as well as an opportunity to have their paper published in a SERVE document.
**Course Requirements:**
The student will:

Satisfactorily complete all research assignments given to him/her by the researchers at the assigned research site.

Complete a one-page lesson plan, which could be used in a middle school science and/or math course. The lesson plan objectives should satisfy at least two of Sunshine State Standards in Science for Middle School. The lesson plan should be somewhat based on the research project. Complete a journal of his/her work in the lab, and include any reflections on teaching and learning science. This does not have to be kept daily, but on a regular basis. Complete a five-page research paper, based on the research he/she has completed. This paper should include at least 5 references. Because the paper might be published, the paper should be done according to APA.

All research should be completed by August 4th, the last day of the semester. All required papers will be due no later than August 6th, as grades are due by August the 8th.

**Grades will be assigned as follows:**

4 Completed assignments = A
3 Completed assignments = B
2 Completed assignments = C
1 Completed assignment = D

“Completed” is defined as average to above average work as would be expected of Upper Division Education Majors.
APPENDIX E: CATHY’S PERMISSION TO REPRINT

Department of Chemistry and Biochemistry
The Florida State University
Tallahassee, Florida 32306-4390 FAX: 850-644-8281 http://www.chem.fsu.edu

LORI L. HAHN

3256 Bayou Lane
Pensacola, FL 32503
(850) 438-7609

February 26, 2004

Ms. Christy Morgan

Dear Ms. Morgan,

I am completing a dissertation at Florida State University entitled “Interpretive Case Studies on the Influence of a Pre-service Contextual Science Research Course on Novice Science and Mathematics Teachers.” I would like your permission to reprint in my dissertation your chapter from the SERVE monograph, “Experiential Learning for Pre-Service Science and Mathematics Teachers: Applications to Secondary Teaching” called:

“No! Your Typical Textbook and Lecture-based Class Anymore.”

The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages. These rights will in no way restrict publication of the material in any other form by you or by others authorized by you. This authorization is extended to University Microfilms International, Ann Arbor, Michigan, for the purpose of reproducing and distributing copies of this dissertation. Your signing of this letter will also confirm that SERVE owns the copyright to the above-describe material.

If these arrangements meet with your approval, please sign this letter where indicated below and return it to me in the enclosed return envelope. Thank you very much for your support and encouragement.

Sincerely,

[Signature]

Lori L. Hahn

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

[Signature]

Ms. Christy Morgan

Date: 5/30/04
APPENDIX F: ROB’S PERMISSION TO REPRINT

LORI L. HAHN

3256 Bayou Lane
Pensacola, FL 32503
(850) 438-7609

February 26, 2004

Mr. Ron Wark

Dear Mr. Wark:

I am completing a dissertation at Florida State University entitled “Interpretive Case Studies on the Influence of a Pre-service Contextual Science Research Course on Novice Science and Mathematics Teachers.” I would like your permission to reprint in my dissertation your chapter from the SERVE monograph, “Experiential Learning for Pre-Service Science and Mathematics Teachers: Applications to Secondary Teaching” called:

“Science From a Different Perspective: Through the Eyes of a Mathematics Teacher.”

The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages. These rights will in no way restrict publication of the material in any other form by you or by others authorized by you. This authorization is extended to University Microfilms International, Ann Arbor, Michigan, for the purpose of reproducing and distributing copies of this dissertation. Your signing of this letter will also confirm that SERVE owns the copyright to the above-describe material.

If these arrangements meet with you approval, please sign this letter where indicated below and return it to me in the enclosed return envelope. Thank you very much for your support and encouragement.

Sincerely,

Lori L. Hahn

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

Mr. Ron Wark

Date: 5-31-04
APPENDIX G: SERC@SERVE’S PERMISSION TO REPRINT

March 12, 2004

Dr. Francena Cummings
Southeast Eisenhower Regional
Consortium for Mathematics and Science
Education @ SERVE
1203 Governor’s Square Blvd., Suite 400
Tallahassee, FL 32301

Dear Dr. Cummings,

I am completing a dissertation at Florida State University entitled “Interpretive Case Studies on the Influence of a Pre-service Contextual Science Research Course on Novice Science and Mathematics Teachers.” I would like your permission to reprint in my dissertation two chapters written by two of my former students from the following monograph with which I was involved as co-editor:

“Experiential Learning for Pre-Service Science and Mathematics Teachers: Applications to Secondary Teaching”

The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages. These rights will in no way restrict publication of the material in any other form by you or by others authorized by you. This authorization is extended to University Microfilms International, Ann Arbor, Michigan, for the purpose of reproducing and distributing copies of this dissertation. Your signing of this letter will also confirm that SERVE owns the copyright to the above-describe material.

If these arrangements meet with your approval, please sign this letter where indicated below and return it to me in the enclosed return envelope. Thank you very much for your support and encouragement.

Sincerely,

Lori L. Hahn

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

Dr. Francena Cummings

Date: 5/20/04
APPENDIX H: NATIONAL ACADEMIES PRESS’ PERMISSION TO REPRINT

THE NATIONAL ACADEMIES PRESS

Marketing Department
Rights & Permissions

May 26, 2004

Lori Hahn
Florida State University

Dear Lori Hahn:

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THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

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APPENDIX I: TIMELINE FOR DOCTORAL PROGRAM FOR LORI HAHN

Fall 1995 Entered Ph.D. program

Fall 1995 Submitted Qualifying Exam (with MS in Science Education)

Spring 1997 Presented at NARST, Oak Brook, IL

Spring 1998 Presented at NARST, San Diego, CA

April 28, 1999 Signed Program of Study submitted

April 1999 Passed Preliminary Exam

Chapter published in SERVE monograph

Spring 1999 Submitted Human Subjects Committee Form to Florida State University for Approval

Human Subjects Form Approved (April 28, 1999)

Planned Pilot Study at the University of West Florida (Arranged for course approval through UWF, talked to students, found research scientists willing to work with pre-service teachers and practicing teachers, met with science supervisor of Escambia County schools to recommend practicing teachers)

Worked with Dr. Penny Gilmer on for Pilot Study at Florida State site

Worked on the development of the CO-LEARNERS project for both FSU and UWF

Presented at FCETP, Tallahassee, FL
<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer 1999</td>
<td>Conducted Pilot Study at the University of West Florida</td>
</tr>
<tr>
<td></td>
<td>Conducted interviews with students and researchers at both Florida State University and the University of West Florida</td>
</tr>
<tr>
<td></td>
<td>Began literature search on science research experiences for teachers</td>
</tr>
<tr>
<td>Fall 1999</td>
<td>Prepared a summative and formative evaluation of the CO-LEARNERS Pilot Study for the NSF FCETP Collaborative</td>
</tr>
<tr>
<td></td>
<td>Observed participants during practicum work</td>
</tr>
<tr>
<td>Spring 2000</td>
<td>Continued the Pilot Study as a research base to form questions and make appropriate methodological changes</td>
</tr>
<tr>
<td></td>
<td>Selected participants for second summer of the Pilot Study</td>
</tr>
<tr>
<td></td>
<td>Made presentation at NARST, New Orleans</td>
</tr>
<tr>
<td>Summer 2000</td>
<td>Conducted follow-up study based on Pilot Study findings</td>
</tr>
<tr>
<td></td>
<td>Worked on the second summer of the Pilot Study</td>
</tr>
<tr>
<td>Fall 2000</td>
<td>Complete transcribing of interviews</td>
</tr>
<tr>
<td></td>
<td>Reviewed data collection and prepare matrix checklist</td>
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<tr>
<td></td>
<td>Continued to analyze data</td>
</tr>
<tr>
<td></td>
<td>Presented at SAETS, Auburn, AL</td>
</tr>
<tr>
<td>Spring 2001</td>
<td>Selected to be Co-Editor of SERVE monograph</td>
</tr>
<tr>
<td></td>
<td>Worked with teacher participants on SERVE chapter</td>
</tr>
<tr>
<td></td>
<td>Made some observations</td>
</tr>
<tr>
<td></td>
<td>Continued literature search on science research experiences for teachers</td>
</tr>
</tbody>
</table>
Presented at AETS, Costa Mesa, CA

Presented at FCETP, Orlando, FL

Spring 2002
Prepared Prospectus for Doctoral Dissertation using the Pilot Study to develop questions and methodology

May 2, 2002
Prospectus Successfully Defended
Made revisions on prospectus as needed
Obtained committee signatures
Completed all necessary paperwork and forms

Summer 2002
Arranged for all classroom research and follow ups
Continued writing of dissertation
Continued literature search on science research experiences for teachers

Fall 2002
Completed all classroom research, interviews, and other follow-ups
Scheduled Appointment with Graduate Studies

Spring 2003
Completed observations and interviews
Obtained QSR NVivo for analysis

Summer 2003
Began writing of dissertation

Fall 2003
Continued analysis and writing
Met with Dr. Gilmer on a weekly basis in Tallahassee

Spring 2004
Set dissertation defense date for Spring semester 2004
Applied for extension defense and graduation for Summer of 2004

Summer 2004

Defend dissertation on July 2, 2004

Successfully defended dissertation on July 2, 2004

Made changes suggested by committee members and completed necessary paperwork

Graduated on August 7, 2004
REFERENCES


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BIOGRAPHICAL SKETCH

Lori Livingston Hahn received a B.S. degree in Science Education in 1982 and an M.S. in Science Education in 1995 from Florida State University. She has taught science at the middle school level and science and science methods at the university level. Currently, she is on leave to complete her doctoral studies in Science Education also from Florida State University. She plans to return to teaching when her studies are complete.

She has presented several papers at national science teaching conferences, such as the Association for the Education of Teachers of Science (AETS), National Association for Research in Science Teaching (NARST), Southeastern Association for the Education of Teachers of Science (SAETS), and the National Science Teachers Association (NSTA). She published a chapter in a SERVE monograph, entitled Meaningful Science: Teachers Doing Inquiry + Teaching Science. She served as co-editor of another SERVE monograph entitled, Experiential Learning for Pre-service Science and Mathematics Teachers: Applications in Secondary Classrooms. Lori worked as a graduate assistant with an NSF funded grant entitled, the Florida Collaborative for Excellence in Teacher Preparation. She co-developed and implemented a pilot project, CO-LEARNERS, with her major professor, Dr. Penny Gilmer.

She was an Apple Crossroads Grant recipient, a Shell Teaching Award finalist, a NEWMAST Award teacher, a Presidential Award for Excellence in Science Teaching nominee, and received the Award of Promise for Outstanding New Science Teacher awarded by the Florida Association of Science Teachers (FAST) during her early teaching career.

Her motto to live and to learn by is a quote from Mahatma Gandhi, “Live as if you will die tomorrow, learn as if you will live forever.” She interprets this to mean: Live your life to the fullest surrounded by family and loved ones. In addition, take some time to be a lifelong learner, as this fuels your personal growth spiritually, physically, and mentally, and will ultimately benefit those you love.