Science Teacher Educator Change: A Case Study Report

Kathleen R. Foley
THE FLORIDA STATE UNIVERSITY
COLLEGE OF EDUCATION

SCIENCE TEACHER EDUCATOR CHANGE: A CASE STUDY REPORT

BY

KATHLEEN R. FOLEY

A Dissertation submitted to the Department of Middle and Secondary Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Degree Awarded:
Spring Semester, 2004
The members of the Committee approve the dissertation of Kathleen R. Foley defended on February 25, 2004.

Nancy Davis
Professor Directing Dissertation

Judith L. Irvin
Outside Committee Member

Penny J. Gilmer
Committee Member

Owen Gaede
Committee Member

Approved:

David F. Foulk, Chairperson, Middle and Secondary Education

The Office of Graduate Studies has verified and approved the above named committee members
ACKNOWLEDGMENTS

Putting this study together into a dissertation is a long and arduous task. I would like to thank my dissertation committee, Nancy T. Davis, Penny J. Gilmore, Judith “Judy” Irvin, and Owen Gaede for their continuous support and encouragement. In particular, I want to recognize, Michael L. McLaughlin, who continued to give me the prodding and encouragement to go forward. With his steadfast guidance and humor, I was able to achieve my academic goals. Of course, there is Nancy Gilliom ... for remaining dedicated to me throughout this process and for her love, support, encouragement, and friendship. In addition, Dr. B whose dedication to the science teaching community, her commitment to learning and students, and her belief in her endeavors makes me strive to improve as a science teacher. She has been my mentor, and I am proud to be a part of her community of learners. I will forever be grateful to these people and many more who were involved with my journey.
# TABLE OF CONTENTS

LIST OF TABLES............................................................................................................ vii  
LIST OF FIGURES ........................................................................................................... ix  
ABSTRACT........................................................................................................................ x  

CHAPTER 1  
SCIENCE TEACHER EDUCATOR CHANGE: A CASE STUDY REPORT ................. 1  
  Introduction......................................................................................................................... 1  
  Purpose of this Study .......................................................................................................... 3  
    Definition of Terms  
  Statement of Research Questions........................................................................................ 5  
  Methods, Procedures and Approach to Study..................................................................... 6  
  Analysis and Interpretation................................................................................................. 7  
  Limitations to the Study...................................................................................................... 7  
  Significance of the Study.................................................................................................... 8  
    Order of Presentation  

CHAPTER 2  
LITERATURE REVIEW ................................................................................................. 10  
  Introduction....................................................................................................................... 10  
  Science Education Reform................................................................................................ 10  
    Inquiry Science Teaching and Reform  
    Teacher Preparation  
    History of Teacher and Teacher Educator Change  
  Teacher Educator Change................................................................................................. 18  
    The Role of Uncertainty in Change  
  Role of Beliefs .................................................................................................................. 20  
  Reflection.......................................................................................................................... 21  
  Research Methodology ..................................................................................................... 25  
    Qualitative Research  
  Summary of Literature Review......................................................................................... 27  

CHAPTER 3  
METHODOLOGY and METHODS ................................................................................ 29  
  Introduction......................................................................................................................... 29  
  Pilot Study-Focus of the Investigation................................................................................ 30
LIST OF TABLES

Table 3-1. Data Collection/Analysis................................................................. 34
Table 3-2. Guiding Questions for Follow-up Interviews................................. 36
Table 3-3. Criteria for Judging the Adequacy of Fourth Generation Evaluation ...... 37
Table 3-4. PDDPMSR Model Categories.......................................................... 39
Table 4-1. Data Source Coding Summary.......................................................... 46
Table 4-4. Reflection and Relationship Building Theme in Science Education Methods-Summary of main points using the PDDPMSR Model........................................ 59
Table 4-5. Inquiry Theme in Science Education Methods-summary of main points using the PDDPMSR Model............................................................................................... 66
Table 4-6. Science Teaching Theme-summary of main points using the PDDPMSR Model ....................................................................................................................... 71
Table 5-2. How was Dr. B’s secondary science methods course different from other teaching methods classes?................................................................. 81
Table 5-3. What aspect of Dr. B’s course did you find most helpful, least helpful?....... 81
Table 5-4. What influence, if any, did this science methods class have on how you think about teaching? ................................................................. 85
Table 5-5. How has reflection (reflecting on your teaching practices) affected your teaching? ................................................................................................................... 87
Table 5-6. What personal beliefs do you hold that might influence the way that you teach? .......................................................................................................................... 88
Table 5-7. From your perspective, how does an inquiry-based approach to teaching science differ from other approaches? ................................................................. 90
Table 5-8. Can you describe a lesson that you have taught that incorporates the aspects of inquiry you learned about in the science methods course? ................................................................. 92

Table 5-9. How often do you teach using inquiry-based methods? ........................................ 93

Table 5-10. What student impacts, if any, have you observed when using inquiry-based approach to teaching science? ............................................................................................. 95
LIST OF FIGURES

Figure 3-1. PDDPMSR Model (Loucks-Horsley, Hewson, Love and Stiles, 1998) - the figure is a graphic representation of the influence that reflection can have on strategies, knowledge and beliefs, critical issues, context, goal setting, planning, and doing. ........................................................................................................................ 33

Figure 4-1. Data Collection and Analysis........................................................................ 48
ABSTRACT

This study, *Science Teacher Educator Change: A Case Study Report* continues an investigation on teacher change that began as a pilot study that focused on the role of beliefs, reflection and inquiry as a teaching methodology. The importance of research in this area of teacher educator change is reflected in the continued calls for education reform in teacher change, improving student learning and test scores, and ensuring the United States educational system continues to foster the development of leading scientists and mathematicians who continue to learn and grow. The pilot study describes and analyzes changes and the implications of these changes in a university professor actively implementing an inquiry-based curriculum in a secondary science methods course.

To provide a more comprehensive description on the impact of teacher educator change and inquiry-based teaching, a follow-up study is conducted with individuals who were students in the secondary science methods course. The students, who are now teachers, shared their perspectives on inquiry-based teaching and on the impact of the secondary science methods course their teaching. The role of beliefs and reflection are also investigated with the former students.

Reported results support using inquiry-based teaching methods, exploring individual belief systems and frameworks during teacher preparation and placing additional emphasis on the role of reflection in teacher preparation. The need for teachers’ in-service professional development opportunities and pre-service teacher education to move from a primary focus on curricula for bringing about improvements to science teaching to a focus on the actual teacher and the practice of teaching are also reported as key conclusions. Support is cited for using an inquiry-based approach to teaching science which emphasizes learning how to learn, that begins with the exploration of a particular phenomenon and that delays the teachings of terms and principles until they are needed. The complexity and difficulties of enacting an inquiry-based approach to teaching science, which is called for by the National Science Education Standards, in light of the increasing acceptance of standardized tests as a measure of student learning and teacher and school effectiveness are also discussed.
CHAPTER 1
SCIENCE TEACHER EDUCATOR CHANGE: A CASE STUDY REPORT

Introduction

As an elementary school student during the late 1950s, I vividly remember my parents’ fear of the Russians defeating America in the race to the moon. We practiced safety drills, simulated going to fall-out shelters and practiced spelling words that included many science and space terms. The Aberdeen Proving Ground (APG), an Army base where the testing for military weapons and chemical warfare took place, located in Aberdeen, Maryland was only twelve miles from my home.

Aberdeen Proving Ground employs engineers and scientists, many of whom lived in my small community and were friends of my parents. As small children, we were fascinated by adult conversations that included descriptions of scientific analysis and the importance of the scientific work at APG. As children, we played as though we were astronauts, engineers, and scientists building models and pretending to complete scientific experiments in our garages and basements. My strong interest in science was well established early in my life.

When I began teaching middle school in the late 1980s, I encountered teaching practices that were familiar to me from my formal schooling in the 1960s. Many methods of teaching that were practiced during the 1960s continued to be used in classrooms in the 1980s. In my view, little had changed. For many teachers, textbooks, seatwork, and lectures were the primary means of delivering content. There appeared to be little reflection or discussion within the teaching community, of which I was part, concerning real student progress or improving teaching practices. Integrating research, theory, “best practices”, or new curriculum into personal teaching practices was not apparent. These observations, my increasing dissatisfaction with traditional teaching practices, and the apparent apathy towards creative and innovative teaching methods led me to experiment with some non-traditional ways of teaching science. It seemed to be the case that the more that I experimented with new methods of teaching the more the students appeared to engage and learn.

I wanted to continue to develop innovative ways to reach students and desired to enhance my own teaching skills. Thus, in the spring of 1993, I applied for and was granted admission to Florida State University (FSU) for enrollment in a special program entitled Science FEAT (For Early Adolescence Teachers). Florida State University, located in Tallahassee Florida, received from the National Science Foundation a collaborative grant allowing middle school science teachers to focus on enhancing their practices while pursuing a graduate degree in Science Education. I was excited about the
opportunity to start earning an advanced degree and felt this program might be the stimulus that I needed to build my interest in a teaching career. My participation in the Science FEAT Program was such a positive experience that I was able to cultivate and sustain a passionate interest in the subject of teacher education and teacher change.

Throughout my masters program I was encouraged to reflect on my own teaching practices by those professors who demonstrated the type of teaching and learning strategies that, seemed to me, effective for science teaching. These professors readily shared personal reflections on their own university level teaching practices with the Science FEAT Program participants and in a very short time I began to recognize that self-reflection was an important component in a model for effective teaching. Regular exposure to self-reflective practitioners, including secondary education practitioners and my college professors continued to pique my interest in the role of reflection and in the area of educational change. The pedagogical beliefs of these individuals, what these educators did to change their teaching practices, and how they continued the analyses of their practices were all of strong interest to me.

While working toward my masters degree, I was encouraged to reflect on my own teaching practices. I closely watched the many professors in the Science FEAT Program who demonstrated the type of teaching and learning strategies that, it seemed to me, were highly effective for teaching science. These professors readily shared personal reflections on their own university-level teaching practices with the Science FEAT Program participants. In a very short time I began to recognize that self-reflection was an important component in a model for effective teaching. Regular exposure to self-reflective practitioners, including secondary education practitioners and my college professors, continued to pique my interest in the role of reflection in the area of educational change. The pedagogical beliefs of these individuals, what these educators did to change their teaching practices, and how they continued the analyses of their practices were all of strong interest to me.

As I referenced earlier, the reader may remember the historically significant 1957 event when the Soviet Union launched Sputnik, the first satellite to orbit the Earth. Unified in their fear Americans rose to the challenge that suddenly seemed real; losing the space race and falling behind the Russians in the pursuit of military power. The goal to reach the moon before the Russians became paramount. America focused its educational efforts on producing scientists and engineers through improved science and mathematics programs (National Committee on Excellence, 1983). After many years of issuing clarion calls for educational reform and establishing explicit expectations related to the study of science, The National Science Education Standards (NSES [NRC], 1996) addressed what students should know and be able to do related to science. A major emphasis in these standards (NSES) was the call to expand the inquiry-based approach in teaching science. This inquiry-based approach had gained much attention and significance after the launch of Sputnik and the publishing of A Nation at Risk: The

---

1 The term, “self-reflection” in this study, refers to an educators’ ability to look within and evaluate the effectiveness of their practice, learning, and their students. Reflection is a necessary part of rational thinking! It is what sets rational thinking apart from mythic (authoritarian, received knowing) thinking (Belenky, Clincky, Goldberger, Tarule, 1986).
*Imperative for Educational Reform*, (National Committee on Excellence, 1983). The continued integration of scientific inquiry in curriculum products, in science classrooms, and in science teaching and learning, along with the growing research based on inquiry-based science teaching, added credence to the belief that inquiry-based science improves both science teaching and students’ learning (NRC, 1999).

Today researchers and practitioners alike recognize the need for improvement in science and mathematics education for all students. The media, government, parents, reformers, legislators, teachers, students, principals of schools, and members of business communities continue to plea for improvements in the area of science education (Matthews, 1994). Politicians, most notably President Bush (DOE, 2001), state that educational improvement is their top priority. In Florida, Governor Jeb Bush continues the call for educational reform and more stringent accountability. Efforts to improve science education are addressed by many reform initiatives proposing changes in curriculum, teacher preparation, assessments, and methodology (Bybee, 1997; NRC, 1996; Shulman, 1986; Spiegel, 1997).

While these calls for change have been made since Sputnik and much political rhetoric has been produced about the necessity for change in schools, the reality I observed in my first years of teaching was that very little was changing. The question remained: Where is change most effective? Is it possible to originate change with current, experienced teachers, or is it better to have change originate in teacher education programs? In this Case Study Report, I shed light on these questions through the processes of science teacher education and how it influences teacher practices.

**Purpose of this Study**

The purpose of this study, *Science Teacher Educator Change: A Case Study Report*, is to continue an investigation on teacher change that began as a pilot study. This pilot study is designed to describe and analyze changes and the implications of these changes in a university professor actively implementing a new curriculum described as inquiry for a secondary-science methods course. In the course of conducting the observations for this pilot study, it became apparent that extending the investigation beyond the primary participant would provide a more comprehensive description on the impact of teacher educator change and inquiry-based teaching.

Detailed observations and discussions of the change process in a university professor using self-reflection and an inquiry-based approach for teaching science methods course and the subsequent interviews with this professor and with the college students who participated in this methods class serve as primary data elements for this study. Areas of additional focus include the collaboration among learners, the selection of classroom assessments, the community of learners, the nature of the inquiry-based approach, changes in the participants’ framework resulting from discussions of observations and the perceived effectiveness and impact of this teaching approach by the college students. In seeking what Geertz (as cited in Eisner, 1991) calls “thick descriptions” my aim is to go beyond observation and build shared meanings from the
observed classroom events and their influence on the professor and students. The professor’s pedagogical beliefs that likely form the platform for a change in teaching practice and the role of self-reflection are also analyzed.

In summary this study focuses on the following:

- Philosophical and professional perspectives of the observed professor.
- Pedagogical changes (what changed or what was observed as changed) during the pilot study.
- The process of change (how changes came about in the observed teaching practice).
- What changes occur in the professor as the researcher shares her observations and interpretations in follow-up discussions.
- The reasons for the changes (why or the interpretation of the change) in the university professor.
- The role of beliefs and self-reflection in changes made by this professor.
- Observations and interpretations related to the college students’ perceived impact of the professor and the methods class on their teaching practice.
- Perceived changes in perspectives in transitioning from this methods class to actual teaching.

Methods for data collection include observations recorded as field notes, videotape recordings of classes, audio-tape recordings of structured discussions between the professor and me, college student journal-writing examples, recorded notes from student interviews, and other related artifacts from the science methods course.

**Definition of Terms**

The meanings of many terms commonly used in education can be interpreted in different ways. To ensure clarity for the reader the following definitions are provided below:

*Change* as used in this study refers to the process of self-reflection on aspects of one’s teaching practice and relating these reflections to a change in current state. Change may involve analysis and action to introduce aspects of new teaching practices. An example of change may be looking at how assessment is being used in one’s practice, and whether this practice matches the current standards of reform, and then trying to introduce alternative assessment methods into one’s practice. It is important to note that interpreting the process of change in this study is dependent on observed actions as well as more covert change to include changes in frameworks and beliefs. Cognitive theorists like Ellis (1998) reminds us that change in frameworks and beliefs or covert change precedes overt or behavioral change.

*Teacher Educator* refers to College of Education professors who work with teachers and pre-service teachers in Science Education.
**College Students** are the students in the College of Education secondary science methods course.

**Teacher (K-12)** refers to classroom teachers in elementary through high school classes.

**Student** refers to students in elementary through high school classes.

**Inquiry** is a term defined by the National Science Education Standards (NRC, 1996) and refers to the “diverse ways in which scientists study the natural world and propose explanations based on 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). For the purposes of this study, the term inquiry-based curriculum in science teaching is associated with the processes of science: observation, inference, and experimentation combined with scientific knowledge and critical thinking skills. This definition reflects the essence of how this researcher and the participating university professor perceive science teaching.

**Classroom teacher** is any classroom teacher that does not include the college students or the university professors mentioned above.

### Statement of Research Questions

Research questions provide a guiding framework in this study and can be categorized as dependent on descriptive data or dependent on interpretive data. Although descriptive data and interpretive data are better conceptualized as ends of a continuum, guiding questions that rely more on descriptive data are best addressed through observable data whereas those questions that are best addressed through careful analyses of language and the building of shared meaning are reliant on interpretation by the researcher and the participants.

The guiding research questions on which this study will focus are:

1. What pedagogical assumptions and beliefs are related to the teaching of secondary science methods courses (Interpretive)?

2. What changes in teaching approaches to the secondary science methods course are desired (Interpretive) and what changes occurred (Descriptive)? (in college students and professor)

3. What is the nature and process of change as observed by this researcher (Descriptive)?

4. What impacts occurred for the university professor and her college students related to changing the teaching practices in the secondary science methods course (Interpretive)?

5. What is the role of self-reflection and beliefs in using inquiry-based approach to teaching science methods (Interpretive)?

6. What perceptions do the college students have related to the influence of the professor on their classroom practices or on their work life (Interpretive)?
7. What changes in perspectives occurred as college students transitioned from this methods class into actual teaching (Interpretive)?

Methods, Procedures and Approach to Study

The research methods outlined here describe a process for interviewing and surveying college students and to continue explorative discourses with the university professor who participated in a pilot study when this university professor was engaged implementing changes necessary to better align a secondary science methods course with the tenets of necessary reform measures.

My intent in this study is to tell a story of a teacher educator, the nature of change, the role of her beliefs in change, the impact of self-reflection, the perceived value of an inquiry-based teaching approach and the perceived impact of this approach on her college students. Ultimately, my hope is that this story contributes in some small way to the improvement of education and the preparation of future scientists. In ways similar to Philip Jackson, Sarah Lawrence Lightfoot, Theodore Sizer, and Alan Peshkin this study relies on naturalistic inquiry (as cited in Lincoln & Guba, 1985) and on multiple sources of data. Direct observation of the teacher educator and the participants conducted in the pilot study are supplemented by follow-up interviews and observations, in-depth discourse between the participants and me, and shared negotiation for building joint meaning from this study. As Eisner (1991) states, observing, listening and seeking understanding to hear what the teacher educator and the college students learn as this investigation unfolds is critical. The voice of the teacher educator is key to understanding change and what implications the change may have for professional development. To capture this voice, studies describing teacher educator change in implementing new curricula have been done more recently with qualitative research. Qualitative research or qualitative inquiry can provide a double advantage of learning about this teacher educator and her college students in ways that are useful for understanding other teacher educators and college students and for learning about this teacher educator and her college students in ways that are useful to them (Eisner, 1991). One of the criteria for judging the quality of this research will be the participant’s learning as well as my own.

Science education studies, using qualitative research are written to show change over time (Bogdan & Biklen, 1998; Erickson, 1994; Lee & Yager, 1986). The emphasis is on rather long written descriptions of events and analyses of the issues as they emerge. As Miles and Huberman (1994) state, these words give a study the quality of undeniability. Describing human relationships and events in a complex social context such as a university or public school setting in a way that captures meaning and proves convincing is at best difficult. Using words organized into incidents and stories that have a concrete, vivid, meaningful flavor prove far more convincing to a reader, another researcher, a policymaker, or a practitioner than pages of summarized numbers. Thus, my use of a story type format may create vicarious experiences for the reader.
Analysis and Interpretation

Effectively analyzing, translating, describing and interpreting the process of change, and recounting the happenings in a classroom often require using models or constructs from the social sciences (Erickson, 1991; Janesick, 2000). This study uses the Professional Development Design Process for Mathematics and Science Education Reform (PDDPMSR) Model (Loucks-Horsley, Hewson, Love, and Stiles, 1998) for analysis, interpretations and perspectives on necessary reform. This model provides a framework for diagnosing change from many perspectives including context, self-reflection and beliefs. Chapter 3 provides an in depth review of this model. The PDDPMSR Model, used as a guiding framework in developing curriculum, assists teachers in recognizing the benefits for their students in analyzing, translating and interpreting the process and impact of change. Additionally, the PDDPMSR Model serves as a guiding framework for these teacher educators attempting to restructure their courses, by providing a roadmap for creating change (Loucks-Horsley, et al., 1998). Knowledge, beliefs, teacher motivation, student reactions, pre-planning, and the time allowed for changing approaches are all factors that result in different documented observations from very similar studies.

Limitations to the Study

Eisner (1991) reminds us that what we are able to represent through inquiry depends on two factors. First is the form of the representation we use to convey meaning and understanding. Text, even the richest of text, creates a different experience from one that is created with a picture. Second, what we attend to, what we observe, the categories we utilize, and the theories we use to guide our work are strongly influenced and maybe driven by our own conceptual frameworks which are shaped and developed by personal experience.

The value of these personal experiences and their relationship to theory can be a powerful method for conducting social science research (Clandinin & Connelly, 1994). In referring to the “self as an instrument” Peshkin (1986) reports that research interpretations are often the positive explorations of the author’s own subjectivity. Each person’s history, experiences and frameworks will indeed affect how we interpret what we see (Eisner, 1991). In describing observations related to the nature of change and the type and process of change directly observed, my interpretations and observations are framed by my own experiences and reflections of those experiences as a science teacher. I use methodical and acceptable methods of observations, detailed discussion, thick descriptions, personal reflection, and interpretive and expressive language to yield a compelling and persuasive story to inform the existing body of educational research in teacher preparation, teacher educator change, and professional development related to teaching science.
This study assumes significant similarities between teacher educator change and teacher change because the roles and responsibilities do not significantly differ. Although the classroom between a teacher and teacher-educator may vary along several dimensions, the issues of pedagogy, pedagogical content knowledge, modeling, and reflection are assumed to be similar for classroom teachers and teacher educators. This study will focus on one classroom, one teacher educator and several college students from that one classroom and thus it must be left to the reader to determine to what extent the interpretation that will be shared here transfers to or informs educational procedures in other classrooms.

Educational reform, educational change, improved teaching practices and science teacher education change are important and relevant constructs in public education today (NRC, 1996). Teacher educators, including science teacher educators are being asked to step forward and respond to the reform notions in educational policy mandates (Bybee, 1997; NRC, 1996; Shulman, 1986; Spiegel, 1997). How best to step forward, to obtain necessary support from teachers and other stakeholders to ensure expanded and accelerated development of scientists and to break the heavily guarded frameworks and paradigms rooted in didactic approaches to teaching will require research and inquiry in many areas of education. This study will serve as one informative step forward through examining and sharing the process of changing pedagogy, the investigation of beliefs, the impact of inquiry-based methods classes, and the utilization of reflective science teaching practices.

Significance of the Study

Teacher preparation, improving student learning and test scores, and ensuring the U.S. educational system continues to foster the development of leading scientists and mathematicians who continue to learn and grow are significant and perhaps daunting challenges. John Glenn, acting as the National Commission on Excellence Chairman, states “the future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically” (NRC, 1999, p. 4). Glenn, on behalf of the Commission, states that mathematics and science are critical in supplying the “core forms of knowledge that the next generation of innovators, producers, and workers in every country will need if they are to solve the unforeseen problems and dream the dreams that will define America’s future” (NRC, 1999, p. 6).

University coursework, including teacher-preparation coursework, has traditionally used a didactic approach; often, it is only through periodic laboratory experiences that any hands-on activity takes place (National Committee on Excellence, 1983). In contrast, an inquiry-based approach emphasizes learning how to learn: it begins with the exploration of a particular phenomenon and delays the teachings of terms and principles until they are needed.
Responsibility and accountability for effectively negotiating and meeting these challenges are often viewed to be within the purview of classroom teachers, university professors, and the designers of teacher-preparation programs (NRC, 1999).

Thus, change, the process, nature and value of change observed and reported; the associated pedagogical beliefs regarding change; and the implications of change for professional development, are important topics for future educators, future science teacher educators, and colleges of education. Additionally, the relevance and applicability of this study to professional development and teacher preparation throughout Florida where teachers are struggling with accountability, reform, change, and how best to create necessary change, are both strong and timely.

Because pedagogical beliefs play an important, if not critical role, in defining behavior and organizing knowledge and information (Nespor, 1987), it is vital to examine them. Investigating and documenting changes and perceived impacts resulting from the implementation of an inquiry-based approach and focused self-reflection can help determine how to educate teachers. My craft of writing a compelling and persuasive story that may inspire others to action that ultimately brings about effective change and improved student learning.

Much has been written in the educational literature citing the importance of content and methods courses in teacher preparation programs. However, conducting follow-up studies to ascertain the impact of methods classes on the actions, behavior or teaching style of the novice teacher has been relatively infrequent. This study is focused on change, beliefs, reflection, inquiry, and the impact of these on the participants and represents a somewhat unique contribution to existing knowledge.

Order of Presentation

In Chapter 1, I present an overview of the study and outline the purpose of the study and the significance of the research about teacher education change as it relates to science teacher educators. Chapter 1 also outlines the research questions investigated in this study and an overview of the methods and procedures that I used.

Chapter 2 provides a review of the research related to science education reform, inquiry-based teaching, history of teacher and teacher educator change, teacher preparation, beliefs and uncertainty, reflection, and presents an overview of the research methods used in this study. Chapter 2 concludes with a summary of the literature. Chapter 3 details the methodology, methods, procedures, and design for this study. Chapter 4 reports observations, interpretations and the meanings I develop with the study’s participants during the pilot study. The follow-up to this pilot study described in Chapter 5 provides an understanding of the impacts related to educational change on the students, now classroom teachers who participated in Dr. B’s course on the educational change and science methods. Chapter 6 discusses the conclusions and implications from both studies. Suggestions for future research related to teacher educator change is reported in Chapter 6.
CHAPTER 2
LITERATURE REVIEW

Introduction

This chapter outlines and discusses the review of literature related to science education reform, inquiry-based teaching, history of teacher and teacher educator change, teacher preparation, beliefs and the uncertainty of change, and reflection. It concludes with an overview of the research methods used in this study.

In its organization, this review of the literature begins with discussions of the reformation process in science education including a discussion of an inquiry-based teaching approach and teacher preparation as it relates to reform, with particular emphasis on science teacher preparation. The next section begins with a review of the literature regarding the history of teacher and teacher educator change to include the role of uncertainty in change. This section is followed by a review of the role of beliefs and a review of self-reflection. The remaining section of this chapter presents a review of the literature supporting the selected research methods, including the case study approach to qualitative research used and a discussion of the questions guiding the research.

Science Education Reform

The evolution of science teaching like the history of teacher education is replete with change, both evolutionary and revolutionary. Paradigmatic change related to science teaching is found in early research references that focused on developing a teacher-proof curriculum. In 1958, Jerrold Zacharias, Jerome Bruner, and Francis Friedman, all prominent academicians, discussed science education that focused particularly on physical science and physics (Bruner, 1983). Their discussion eventually led to a plan to prepare a science curriculum that was *teacher-proof* and that could be used with science students across the country. These individuals, members of the Society of Atomic Scientists, were involved in proposing to the Massachusetts Institute of Technology, (MIT) a way to improve the methodology of teaching physics:
We make ninety films of twenty minutes duration complete with textbooks, problem books, question cards, and answer cards. Success or failure depends to a large extent on having the entire apparatus of the experiment really right. Like a high fidelity phonograph one must have besides the machine a good piece by a composer played by an artist. The room must be good, not too noisy, and the people have to want to listen, but that all depends on the piece. (p. 179)

Zacharias’ intent in making the films described above was to design a teacher-proof curriculum, ensuring that both teachers and students could see physics taught by real physicists. Zacharias believed, along with other reformers of the time, that the gap between the knowledge of university scholars’ and the classroom curriculum needed to be narrowed. This view that the teacher must be bypassed to ensure effective learning was laden with powerful implications for teachers and would long have tremendous implications in the American classroom (Bruner, 1983).

The catalyst for and promulgation of a teacher-proof curriculum came primarily from forces outside the classroom. During the time 1950s and 1960s, many educators, researchers and government sanctioned committees looked for methods to improve science and mathematics curricula and consequently, the beginnings of curriculum reform emerged (Bruner, 1983; Lortie, 1975). The tremendous psychological impact that the Russian launch of Sputnik had in America resulted in a national mandate for educational reform. Shortly after the launch of Sputnik and with tremendous resolve, teachers, parents, educational experts, and government officials at the state and national level initiated an in-depth review of schools and of science related curriculum in hopes of determining why the Russians reached this milestone ahead of the U.S. (Elsbree, 1939; Lortie, 1975). As a result of Sputnik, a more rigorous mathematics and science curriculum was demanded by education experts and others, with the intent to produce more qualified workers and maintain the competitive stand of the United States.

Additionally, in the late 1950s, American academics, scientists, and professional associations, with physicists at the forefront, underscored the argument for the reform of U.S. science education. There was a rampant dissatisfaction with the accelerating creep of non-academic classes into U. S. schools. Jerome Bruner, after the furor brought about by the launch of Sputnik (1960), called for establishing inquiry, a different approach to teaching, as an important concept in science teaching. This approach, initially proposed by Bruner during a conference presentation, was later published and translated into 13 different languages. It became an international best seller (Matthews, 1994) and is frequently referenced to today in the literature, under the title The Process of Education (Bruner, 1960).

Reform measures and an enormous amount of legislation began to emerge following the launch of Sputnik. Using a grant from the National Science Foundation (NSF) Jerrold Zacharias established the Physical Science Study Committee (PSSC) which produced the PSSC Physics text that eventually would be used by students across the U.S. and throughout the world. Jerome Bruner (1983) credited Jerrold Zacharias, a physicist at MIT in 1956, as doing more than anyone else to convert the launch of the Sputnik into subsequent critical curriculum reform. Perhaps the largest piece of legislation affecting reform was the National Defense Education Act, which allocated
many dollars for science education from 1958 through 1975 (Matthews, 1994). This Act provided for increased funding for science education and was instrumental in softening the debate that began in the 1940s, long before Sputnik, accusing American schools of not being sufficiently rigorous.

In addition to the previously mentioned PSSC produced by MIT’s Physical Science Study Committee, the National Science Foundation (NSF) supported many other efforts in science education reform in the late 1950s and early 1960s and developed new curricula, including Chemical Bond Approach (CBA), Biological Science Curriculum Study (BSCS), Chemical Education Materials (CHEMS), Earth Science Curriculum Project (ESCP), Introductory Physical Science (IPS), Project Physics and many more project and curricular reform initiatives.

Despite this plethora of curricula reforms, concerns arose that most of the major NSF-funded curricula reforms, with only two exceptions, failed to address the practical and technological applications of science. These two exceptions, The Harvard Project Physics course and the yellow version of the Biological Science Curriculum Study (BSCS) High-School Biology course that integrated case studies into teaching, and were noted as effective in increasing student understanding (Matthews, 1994). Piel (1981) in searching for the underlying reason that science instruction became largely theoretical and left little evidence of technological thought processes found that it was the role that non-teacher scientists played in the shaping of science curricula. Science teacher educators, having played a more minor role in these reform measures, voiced concern that many of these newer approaches lacked the reflective aspects of learning needed to increase student understanding (Rutherford & Ahlgren, 1989).

In response to these concerns, United States curricular reforms of the 1960s broadened the focus beyond specifying content or establishing topics to be taught to include curricula that emphasized the development of scientific thinking and the use of scientific methodology by students. Jerome Bruner, a Harvard cognitive psychologist whose earlier work had inspired others to develop teacher proof curricula, and Joseph Schwab, a University of Chicago educationalist involved in the BSCS project, now became key figures in advocating the use of inquiry or discovery learning - that is a teaching approach that emphasizes student questions, active student involvement and hands-on activities. Although scientists were to still have a role in developing content, teachers were seen as critical to developing and using discovery-based learning.

**Inquiry Science Teaching and Reform**

This section of the literature review presents a discussion on the inquiry-based method for science teaching. At least two definitions of inquiry emerge from a review of existing literature. The conceptual definition refers to inquiry as a teaching and learning methodology; the second view describes inquiry as “what scientists do.” Illustrating these two different views the authors of *The National Science Education Standards* (NRC, 1996) offer the following:

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. (p. 23)

In calling for science teaching reform, *The National Science Education Standards* (NRC, 1996, 2000) advocates that students be scientifically literate and that all students and teachers strive to be lifelong learners. Efficient strategies for acquiring, transforming, organizing, storing, and using information in problem solving (Bruner, 1960; Foley, 1999; Gilmer & Alli, 1997; Roth, 1996; Roth, McGinn & Bowen, 1998; Schank, Fano, Bell & Jona, 1994; Spiegel, 1997) are stressed as critical for students to learn. In addressing the requirements of what students should know and be able to do concerning science, *The National Science Education Standards* (1996, 2000) establish inquiry-based teaching approach as integral to science learning. This approach focuses on: interrelated processes of science such as observation and inference, questioning, constructing explanations, testing explanations against existing science knowledge via experimentation, communicating of findings and exercising critical thinking by looking at alternative possibilities (Barnes & Foley, 1999); it became a central organizing theme in state and national standards. Laws (1991) and Mazur (1997), as cited in *The National Science Education Standards* (1996) find that to enhance students’ conceptual understanding, teacher pedagogies must implement scientific inquiry in the science classroom and that practices in prospective teachers’ undergraduate programs should model the research found in cognitive psychology and sociology (NRC, 1996; Lagemann, 1987).

Inquiry-teaching methodology for science teaching and learning in many ways eventually came to be viewed as a panacea for the issues, challenges, and questions that were triggered from the launch of Sputnik and the publishing of *A Nation at Risk: The Imperative for Educational Reform* (National Committee on Excellence, 1983). Yet, long after Sputnik, science reform measures continued through the 1960s, 1970s, 1980s, and the 1990s. Evaluation is an inherent component in many of these reform measures. Students’ test scores are used to evaluate teachers, schools are graded, and knowledge is measured by standardized tests in hopes that changes in the educational system will improve society as a whole (Bruner, 1983). Still today, clarion calls continue to be made for better teaching, more learning, more scientists and mathematicians, better scores on standardized tests, changes in teaching curricula, better teacher preparation, more accurate assessment, and improved curriculum methodology (Bybee, 1997; NRC, 1996; Shulman, 1986; Spiegel, 1997).

These calls are perhaps best exemplified in the State of Florida, with the *No Child Left Behind Program*, written by U.S. President George W. Bush and supported by current Governor Jeb Bush. This program calls for more assessments, more accountability, smaller classrooms, and better results. These calls for reform, evaluation and accountability, have been long heard and continue to be heard in the arena of teacher preparation.
Teacher Preparation

A brief overview of concepts and constructs associated with teacher preparation programs is provided here to assist the reader in building additional context for understanding how teacher preparation programs ultimately affect the way in which one teaches. The important role that teacher preparation programs have in addressing reform measures, in understanding teacher change, in investigating inquiry-based teaching, and its effectiveness cannot be overstated (McEwan & Bull, 1991).

In writing on teacher preparation, Shulman (1986) distinguishes between three areas of content knowledge—subject matter content knowledge, curricular content knowledge, and pedagogical content knowledge. He views pedagogical content knowledge as both an area of specialization specific to teachers in general and as a bridge between the traditional areas of subject matter and pedagogy. Shulman (1986) describes pedagogical content knowledge as being “the particular form of content knowledge that embodies the aspects of content most germane to its teachability” (p. 219). Similarly, Tobin, Tippins, and Gallard (1994) in describing an intrinsic connection between content knowledge and the methods and strategies of teaching conclude that it is critical for teacher educators and classroom teachers to understand both pedagogical content knowledge and subject-matter knowledge.

Teacher preparation programs have traditionally focused on content, what the teacher is to teach, and methods courses, teaching teachers how to teach the subject matter content. The National Science Education Standards (1996) and Inquiry and The National Science Education Standards: A Guide for Teaching and Learning (2000) in addressing this traditional approach of science teacher preparation, expressed concern that undergraduate courses communicate science as a body of facts and standards for memorization, rather than as a way that would help future teachers understand their natural world (NRC, 1996, 2000). In-service programs and teacher preparation courses often emphasize technical skills over decision-making, theory, and reasoning skills that are necessary for life-long learning. To balance this technical emphasis and accomplish reform, The National Science Education Standards (1996) strongly urges that teacher preparation programs include experiences that engage current and future teachers in active learning that builds on their existing knowledge, understanding and ability (NRC, 1996). It further urges that professional development and pre-service programs to model good science teaching as described in these standards. The standards call for teachers of science to have a strong, broad base of scientific knowledge for developing an understanding of scientific inquiry, its central role in science, and how to use the skills and processes of inquiry (NRC, 1996). The standards for the professional development for teaching of science cite that it is virtually impossible to expect the changes set forth in reform measures to be regarded and implemented when teacher preparation and professional development programs do not include these changes (NRC, 1996). Similarly, studies (NRC, 1996, 2000; Kielborn & Gilmer, 1999; Spiegel, 1997) confirm that when teachers participate in science courses where they have the opportunity to become immersed in a culture of scientific research, they develop a deeper understanding of scientific knowledge and of the manner and context in which this...
understanding takes place. When teachers are provided with these types of opportunities they are more likely to teach their own students in a similar manner (NRC, 1996).

The importance of teacher preparation and development as these elements relate to educational reform in science has been highlighted by a model proposed by Loucks-Horsley et al. (1998). This model, The Professional Development Design Process for Mathematics and Science Education Reform (PDDPMSR) recognizes the importance of considering the professional development of teachers from a content perspective. The PDDPMSR Model draws on concepts that Richardson (1997) suggests are powerful means for science teachers to make changes in their courses to reflect the elements called for in measures of educational reform. These concepts, as defined by Richardson, support a constructivist view – namely, that individuals create, establish and construct their own new understandings, based on the interactions between what they already know and believe and new phenomena or ideas with which they come in contact (Loucks-Horsley et al.; Richardson, 1997).

In focusing on science and mathematics teacher education the PDDPMSR Model addresses the enhanced goals proposed by The National Science Education Standards in 1996 which suggest a need to focus science teaching more on deep understanding, inquiry, and problem solving rather than on the acquisition of facts. Additionally the PDDPMSR Model focuses on the application of knowledge, collaboration among learners, and improved assessment procedures that measure the progress of individuals in reaching new learning goals while also measuring the effectiveness of the teaching and the school. Loucks-Horsley et al. (1998) present the PDDPMSR Model as a framework for designing professional teacher education development. This framework recognizes the roles that decision making and self-reflection play in designing and implementing teacher education programs. Thus, this PDDPMSR Model can also serve as a diagnostic instrument in analyzing these and other critical factors necessary for educational reform. The PDDPMSR Model has four central categories: 1) context; 2) critical issues; 3) knowledge and beliefs; and 4) strategies. According to Loucks-Horsley et al. (1998), the category of context inform the design and implementation of teacher education programs primarily through situative and normative factors about where, when, and what is occurring in teacher education program development. For example, if a program is implemented at a university in the state of Florida, it will have contextual needs, such as the policies of the institutions and available resources, compared to a program implemented at a specific university, such as Cambridge University.

The critical issues category refers to common challenges and aspects of teacher education development programs across the nation. Critical issues include “equity and diversity, professional culture, leadership, capacity building for sustainability, public support, effective use of standards and frameworks, time for professional development and evaluation and assessment” (Loucks-Horsley et al., 1998, p. 21).

The other two important inputs into the PDDPMSR Model are knowledge and beliefs and strategies. Loucks-Horsley et al. distinguish between knowledge and beliefs in several ways. Knowledge is something sure, solid, dependable, and certain, although not static because teachers may regularly acquire more knowledge. Beliefs on the other hand are described as what we think we know: they are defined as the knowledge that
teachers call their own, that which they have had time to reflect upon and fully integrate into their personal knowledge base. In expanding on the knowledge and beliefs category Loucks-Horsley et al. identify five distinct but related critical knowledge bases for informing professional developers: 1) learners and learning; 2) teachers and learning; 3) the nature of science and mathematics; 4) the principles of effective professional development; and 5) change and the change process.

Finally, the strategies category refers to the approach to teaching and the activities associated with such approach. I reference this model, which will serve as a framework for crafting a persuasive story in the study, again in this chapter’s methodology overview.

Summarizing this section on teacher preparation may best be done by the words of two educational researchers. McNutty (2002) reminds us that it seems virtually impossible to exaggerate or overstate the importance of teacher preparation and its effect on student achievement. Similarly, Linda Darling-Hammond (2001) reports that the effects of well prepared teachers on student achievement can be stronger than the influences of student background factors such as poverty, language background, and minority status.

**History of Teacher and Teacher Educator Change**

A major focus of this study relates to teacher change, the nature of change and teacher educator change. Thus I provided constructs, concepts and theories related to teacher education change in the sections that follow. I begin with a brief view of the history of teacher educator change.

It was common for religious leaders to influence what was taught in early United States of America classrooms as teachers were frequently told what to teach (Lortie, 1975). Teacher effectiveness, during these times, was judged by what students could recite from memory when community leaders quizzed the class. Unlike today, teachers in early pioneer schools were predominately male, they were expected to hold high moral standards and they often relied on using physical force to control their students (Lortie, 1975). Change, however, would come quickly in many areas. As compulsory education became a way of life and as teachers were asked to motivate their students (Lortie, 1975) the use of physical force, diminished.

As life in the United States became more urbanized and schools spread more rapidly, teachers were expected to maintain their professionalism through a variety of leadership and learning strategies. As discipline came to mean something different from physical control, teachers had to develop new ways to motivate and inspire their students (Lortie, 1975). The notion of teacher certification, currently mandated in every state, began in the middle of the nineteenth century. Spiegel (1997) comments on this era, noting that, “the perceived need for teacher education changed as the organizational and sociological structure of schools changed” (p. 11).

By the time of the Great Depression 1929-1937, changes in teacher education were advancing steadily as evidenced by the fact that 32 states now required that teachers have more than a high-school preparation. During this time, many colleges established teacher-education chairs and departments and by 1928, all but five states
had created teachers’ colleges also called “Normal” schools. Teacher preparation programs were designed too to meet the needs of those already teaching, and many state governments contributed significantly to the teacher preparation process by offering low-cost, non-elitist training institutions where teachers enhanced their skills. Training became a means for teachers to advance, and key issues such as tenure, certification, and pay were managed by a central administration (Lortie, 1975).

As alluded to earlier, public discussion and emotion-filled discourse calling for educational reform has a long history. One of the earliest examples came in December 1957 with the publication of the National Education Association Bulletin titled “Ten Criticisms of Public Education” (Levin, 1998). In the years since that publication appeared numerous other authors and groups have hurled accusations that public education is to blame for the nation’s educational problems. Thus; teacher education or teacher preparation has often been the focus of attention for those who want to implement overall improvement measures (Berliner & Biddle, 1995; NRC, 2000; Hargreaves, 1994; Lee & Yager, 1986; Pinar, Reynolds, Slattery, & Taubman, 1995). In short, we have witnessed several decades in which teacher educators have been called upon to change themselves, and to change their curriculum, in reaction both to internally generated initiatives and as a reaction to external mandates (Hargreaves, 1994).

Externally mandated calls for changes and reform often are coupled with the issue of accountability. As more emphasis is placed on accountability, individual teachers focus their efforts on improving test scores, and this focus in turn leads to curricular changes (Pinar et al., 1995). The new standards of accountability are themselves continuously emerging and changing, and so the teachers’ focus on standardized tests increases even further. Test taking practice for these standardized tests in many subject areas is common-place in many subject areas. Thus it seems reasonable to conclude that this laser like attention on test performance and the increased pressures to meet ever-changing standards can inhibit a teacher’s creativity (Berliner & Biddle, 1995). The pressures to produce better test scores present a serious dilemma for teachers who also want to incorporate the changes called for by the reform movement and maintain a sense of integrity about their practice (Hargreaves, 1994; Intrator, 2002; Lee & Yager, 1986; Palmer, 2000, Richardson & Anders, 1994). Additionally, science teachers are perplexed because many of the new education policy mandates require that they rethink their past practices and make adjustments that may run counter to their pedagogical beliefs (Bruner, 1960; Hillocks, 1999; Richardson & Anders, 1994; Schön, 1983; Spiegel, 1997; Tobin, Butler-Kahle, & Fraser, 1990) and, may conflict with what is noted as “best practice” by the National Science Foundation. The enhanced focus on standardized tests accompanied with the increased pressure on teachers to demonstrate student growth via these tests, and their own desires to implement the tenets of reform measures leave teachers caught in the middle: they do not have the sense that they can create an environment of discovery.

---

2 The term integrity means the ability to remain congruent with one’s pedagogy within the complex educational setting where teachers find themselves teaching.
Reflecting on the learners, making adjustments in the standards or mandates coming from the district or state office, and attempting to implement different teaching and learning strategies are what Fullan, (1991) and Richardson and Anders, (1994) describe as the process of change. The process often can be lengthy and complex, as it involves context, culture, and content.

**Teacher Educator Change**

Definitions of change vary significantly, according to who is doing the defining, for what purpose and in what type of industry or profession. For example, Hargreaves (1994)—who investigates the changes that classroom teachers experience in a postmodern rapidly changing world and how these changes affect teachers’ classrooms—concludes that change is “complex, social and has multiple meanings” (p. xiii). Jackson (1992) describes change which emphasizes the word development and refers to “the way individual teachers develop in the process of their careers” (p. 63). Hargreaves and Fullan, (1992) discuss teacher change as they derive from changes in age, finances, location, and time in the system.

Although literature related to teacher change and teacher educator change frequently uses the two terms interchangeably, pedagogical content knowledge, reflection, and ability to change are sometimes found to be slightly different in teachers and in teacher educators (Hillocks, 1999). Additionally, personal experience with, and personal meanings and understandings of change, may be very different among individual teacher educators: these factors tend to be influenced by whether the change was voluntarily (internally) generated or imposed (externally generated) (Fullan, 1991; Hargreaves, 1994; Hargreaves & Hopkins, 1991; Schön, 1983, 1987, 1991; Schwab, 1961). For us teacher educators’ change may come about either because it is imposed on us (by natural events or deliberate reform) or because we voluntarily participate in or even initiate change when we find dissatisfaction, inconsistency, or intolerability in our current situation. In either case, the meaning of change will rarely be clear at the outset, and ambivalence will pervade the transition (Fullan, 1991). It does seem clear that effective and lasting change is a complex process that is driven by and dependent on the confluence of both internal and external change (Hillocks, 1999; Richardson & Anders, 1994).

Reflecting on, embracing, leading and making change are often difficult and likely involve significant consternation. Many, if not all of us, have dreamed of or relished the thought about a bus ride, train ride, boat ride or plane ride where we might have time to do nothing but sit back and think about work, issues, relationships, or situations. Thinking back or reflecting is often viewed as a luxury for the few; however, it seems plausible that real or lasting change depends heavily on the role of this type of reflection. Reflecting on one’s practices mentally and comparing our practices with those practices found in current literature or methodologies may create a new vision of possibility or a burning desire to do something new. Evaluating the positives, negatives and the neutrals of the past behaviors, personal or professional, can be a powerful
catalyst for the genesis of change.

For teacher educators, making change, whether it be in response to internal initiatives or external mandates, strongly depends on reflecting and thinking about one’s practice (Hargreaves & Fullan, 1992). Reflecting on aspects of one’s teaching practice and how one’s practice relates to current “best practices” may involve analysis, action, integration of selected aspects of current “best practices” and the discarding of long held beliefs and paradigms. Reflection is recognized as an important precursor to change, yet teachers who take time to reflect, ask questions and check for clarity are often viewed as opponents to change (Hargreaves & Fullan, 1992). Hargreaves (1994) states “that change can be misconstrued, such as when a person is resisting making a change due to the amount of time given to implement the change, and this is viewed as resistance to the idea” (p. 5). Similarly, Morimoto, Gregory, and Butler (1973) suggest:

When change is advocated or demanded by another person we feel threatened, defensive, and perhaps rushed. We are then without the freedom and the time to understand and to affirm the new learning as something desirable, and as something of our choosing. Pressure to change, without an opportunity for exploration and choice, seldom results in experiences of joy and excitement in learning. (p. 200)

Expanding on reflection and incorporating the role of beliefs in reflection, Richardson and Anders (1994) report, “if teachers have a vision that includes an understanding of their knowledge and beliefs, their reflections on their practice will have more meaning” (p. 203).

In addition to reflection the role of beliefs seems critical in understanding the nature and process of change. Changes in teacher beliefs over time and the discovery of effective practices are attributed to teacher change. Loucks-Horsley et al. (1998) claim that for change to occur teachers have to “listen to the content of professional learning and the listening must come from both inside and outside the learner and from both research and practice” (p. xix). Knowledge and beliefs influence whether a teacher views a particular classroom practice as either contributing to or detracting from achieving educational goals.

The Role of Uncertainty in Change

During any change process there are periods of times when teacher educators may be uncertain about what change is taking place and what the ultimate benefits are. Frequently, administrators view these periods of uncertainty as resistance and the people involved in resisting the change as troublemakers: they thereby compound the difficulty of incorporating or socializing any type of change (Hargreaves & Fullan, 1992). Suggesting that “the resistance may be to the new rather than to the change process” (p. 5), Hargreaves and Fullan (1992) advocate a period of adjustment that allows the uncertainty to become familiar.
As Fullan (1991) points out:

It is possible, indeed necessary, to combine ambitious change and quality. I have maintained that it is what people develop in their minds and actions that count. People do not learn or accomplish complex changes by being told or shown what to do. Deeper meaning and solid change must be born over time. With particular changes, especially complex ones, one must struggle through ambivalence before one is sure that the new vision is workable and right (or unworkable and wrong). Good change is hard work; on the other hand, engaging in a bad change or avoiding changes may be even harder on us. (p. 73)

It seems universal that feelings of uncertainty are inherent in any significant change process. Therefore, it is critical for teacher educators to adequately reflect on their practice for deeper meanings and beliefs (Fullan, 1991).

### Role of Beliefs

In a study about teacher educator change, where frameworks, perceptions, and the construction of meanings are important concepts, understanding the role of beliefs and the influence the beliefs have on change is a critical area for investigation.

As the tenets of cognitive theory have come to play a larger role in psychological theory, educational theory, and research, the concept or construct of beliefs has received increasing attention (Siegel, 1985). Although it is not the intention of this study to embark on a detailed philosophical analysis of beliefs as a construct, a brief presentation on the differing notions of beliefs may aid in providing an additional theoretical framework for the reader.

Siegel (1985) defines beliefs as “mental constructions of experience often condensed and integrated into schemata or concepts” (p. 351). Fishbein and Ajzen (1975) refer to beliefs as the “information a person has linking an object to some attribute or expectancy” (p. 12). Expanding on their notion of beliefs to provide a more complete picture of what may be a causal chain relating to beliefs, Fishbein and Ajzen, (1975) portray beliefs as the receiver of information which lead to the formation of attitudes, which in turn influence intentions that are the basis for decisions that ultimately lead to action.

Abelson (1979) describes another definition of beliefs as people as manipulating knowledge for a particular purpose. Dewey (1933) notes the importance of belief by stating “it covers all the matters of which we have no sure knowledge and yet which we are sufficiently confident of to act upon and also the matters that we now accept as certainly true, as knowledge, but which nevertheless may be questioned in the future” (p. 6). Spradley (1972) echoes Dewey in citing that belief systems are important because they “enable the individual to identify those aspects of the environment, which are significant for adaptation, provide direction for instrumental activity, and permit the anticipation of future events” (p. 235).
If beliefs are a foundation for action, beliefs of teachers may prove an important basis for their professional practice (Dewey, 1938). Thus, the study of teacher beliefs including teacher educator beliefs becomes important in analyzing and understanding teaching practices. Teachers’ beliefs about the importance of the content taught, their beliefs regarding appropriate instructional strategies and their sense of self-efficacy have all been found to influence instruction (Hargreaves & Fullan, 1992; Loucks-Horsley, et al. 1998; Shulman, 1991).

Nespor (1987) in a study titled “The Role of Beliefs in the Practice of Teaching” presents a review of a field-based research project on teacher thinking. The “Teacher Beliefs Study” follows eight teachers for one semester. First, the study reports that beliefs serve as a means of defining teacher tasks and goals. The teachers’ beliefs about what a classroom should be like influenced what actually happens in the classroom. Secondly, noting the impact of teacher beliefs on course content, Nespor (1987) reports that the values placed on course content and beliefs often influence how teachers taught the content.

Other research indicates that both K-12 teachers and undergraduate science faculty members are unlikely to reform their science teaching practices to align with new standards without careful consideration of their beliefs and values, intellectual analysis of their work, exploration of alternative methodology and serious time investments (NRC, 1996). NSES (NRC, 1996) appearing to confirm the importance of change in teacher preparation programs, states “Changing the pedagogical practices of higher education is a necessary condition for changing pedagogical practices in schools” (p. 238).

Reflection

A learning theory known as constructivism states that the process of learning involves the construction of links between what is known and the new information presented (Richardson, 1997). Learning, in this constructivist view, is described as a complex process in which learners construct their own meaning through actively engaging in new ways of being or applying new meanings to their situation (Dewey, 1938; Richardson, 1997). Reflection is viewed as providing the lens through which learners can monitor these meanings, their ideas, and their thought processes, can compare and contrast theirs with the ideas and processes of others and can provide reasons why they accept one point of view over another (Dewey, 1938; Richardson, 1997).

Reflection is an important process often associated with change (Dewey, 1938). However, before moving into a deeper discussion on reflection, a more thorough review of constructivism may be helpful. To describe what knowledge is and where it comes from, constructivism is viewed as an epistemology (von Glaserfeld, 1993; Lorsbach & Tobin, 1992; Tobin, Tippins & Gallard, 1994). Shulman (1991) refers to two basic kinds of epistemological belief systems: objectivist and constructivist. Teachers may believe that the knowledge (information subject to change) is out there to be
comprehended and internalized (objectivist), or that it only becomes knowledge (beliefs or personal knowledge) when the buzzing, blooming confusion out there is constructed actively into knowledge by the learner (constructivist). Developing the concept of constructivism, Schifter and Simon (1992) suggest that negotiation of shared meaning within social integration often provides a source of cognitive dissonance or that a perturbation is necessary to allow individual students to restructure their concepts and develop a link from knowledge to beliefs.

To experienced classroom teachers, constructivism is an epistemology, a theory of knowing how one knows what one knows (von Glaserfeld, 1993). Several authors writing on constructivism suggest “learning is defined as the construction of knowledge by individuals as sensory data are given meaning in terms of prior knowledge” (Tobin, Briscoe, & Holman, 1990, p. 410) and that constructivism is described as a “meaning-making theory” (Richardson, 1997). Others have described constructivism as a descriptive theory of learning (the way people learn or develop) as opposed to a prescriptive theory of learning (the way people should learn) (Hillocks, 1999; Richardson, 1997). Many constructivists, in viewing the importance of prior knowledge, consider students not as blank slates but as individuals who have a strong base of knowledge that they have constructed or developed from their own experiences (Tobin et al., 1994).

Offering another view of constructivism, Richardson (1997) describes two forms of social constructivism: situated cognition and sociocultural. The situated cognition form of constructivism suggests that a person in transaction with the environment constructs knowledge and this learning leads to individual change.

The sociocultural form of constructivism considers the development of the individual, which in turn depends on the individual’s social interactions. It is within this social interaction that cultural meanings are shared within a group, and then internalized by the individual into beliefs (Richardson, 1997; Richardson & Hamilton, 1994). In this view, formal knowledge, as understood in signs and symbols, enters the learning situation as tools within the social interaction. Thus formal knowledge may affect development or learning through activity engaged in by the learner.

Further ideas related to constructivism come from Spiegel (1997) who analyzes learning from three perspectives: cognitive, organizational, and symbolic interaction. Spiegel’s research and subsequent observations are taken from a study of middle school science teachers participating in a program called Science FEAT (Science for Early Adolescent Teachers). Spiegel explains that the teacher’s mind (knowledge, perceptions) and mental processes (thinking, planning) are the main considerations for decisions and constructions. Spiegel’s cognitive and organizational perspectives correlate to Richardson’s (1997) notion of situated cognition.

Spiegel demonstrates with his model that the cognitive perspective of learning focuses on pedagogical knowledge, knowledge of subject matter, and pedagogical content knowledge.

The organizational aspects, according to Spiegel, include those issues related to time, policies and regulations, resources, constraints (perceived and actual), and other pragmatic points.
In Spiegel’s model, symbolic interaction recognizes and emphasizes the interpretive process in establishing the sociocultural context and explains the growth of teachers as individuals through human interaction. Symbolic interaction sees meaning as arising in the process of interaction between people. The assumption is that human experience is mediated by interpretation (Blumer, 1969) and that people create the meaning of an interaction from the ways in which other individuals act toward the aspect of the interaction and toward each other. Therefore, the opportunities for exploration, inquiry, and discussion in classrooms depict many possible landscapes for interpretation (Dewey, 1938; von Glasersfeld, 1993).

A recent writer makes the connection between constructivism and reflection in the paragraph “From constructivism to constructivism value added” (Taylor, 1998, p. 1119). Taylor states that college students (future teachers) need to be empowered to change so that they can draw from their lives as they build their own understandings and reconstruct what can be described as new knowledge. They should be encouraged to draw upon their experience to build their own understandings and meaning, sharing their experiences to construct a totally new landscape of learning. Educators should encourage college students to build these opportunities constructions into their future classrooms.

Reflection, as noted above is hugely important and its importance in the change process, Hillocks (1999) and Schön (1987) argue that one form of internally driven change is self-reflection and that without self-reflection, changes made by classroom teachers are relatively small. For example, classroom teachers may make a small change in an assignment such as adding a collaborative group activity or a hands-on inquiry activity. This is referred to as change in the knowledge of how to do something.

Hargreaves (1994) emphasizes that “teachers must have the opportunities for reflection so that they can understand the complex, social meanings in the ever changing world for their learners” (p. 10). All teachers need time for reflection so that they can set goals, plan, do, and then reflect again to develop strategies and identify critical issues within their teaching practice (Darling-Hammond, 2001). Hillocks (1999) in a study of classroom reading teachers and community college faculty, concludes that teacher educators had more time for self-reflection. In The National Science Education Standards, another writer argued that prospective teachers need the time to become active researchers where they study their practice through participation in research projects, clinical studies, and internships (Hashweh, 1987; NRC, 1996). More specifically, teachers should have the opportunities for collegial structured reflection where they plan and actively participate in professional teaching and scientific networks (NRC, 1996).

Another example of the literature highlighting the importance of reflection occurs in the work of Schön (1983) who posits that teacher educators must have something upon which to reflect and that there must be some discussion with other educators. Expanding on what Schön posits, Richardson and Anders (1994) report “that reflection must have a clear sense of purpose” and that “this purpose should be grounded in the aim to foster the acquisition of enlightenment ...” (p. 203). They wrote that through social mediation, the meaning is formed which is neither a simple nor a quick process, yet remains one way for the learner to gain new knowledge.
Schön (1983) describes an example of reflection as knowing in action as a result of observing that teachers are able to change their practice during the course of a class session. When interviewed later, teachers are not able to describe the sequence of events that had taken place related to this change in practice (Schön, 1983; Tobin, Briscoe, & Holman, 1990). Schön (1983) describes knowing in action as a particular sense that educators have that is similar to a baseball player’s knowledge of when and how to throw a particular pitch. This sense cannot be expressed in words but only made known through an action, judgment or discussion (Schön, 1983). There appears to be an instinctive common sense way of knowing about the process, whether it is baseball or teaching. This particular type of reflection, knowing in action, has varied descriptions. For example, Schön (1983) says that it is “knowing more than we can say” (p. 51) that there is certain intuitiveness to reflective instruction, and that this intuitiveness enables teacher educators to change their practice spontaneously by reflecting on action while in action. Schön (1983) references Chester Barnard and states that “these processes may occur so rapidly that the brain cannot analyze them” (p. 50).

Hillocks (1999) also describes teaching as having an intuitive quality to it, stating that later there may be an inability to describe the steps taken over a course of events that actually worked well. Hillocks does not suggest that teaching is haphazard and illogical but rather, that understanding what teachers know requires analyzing what they do and say. Often, through reflection, a teacher will not be able to recall why he or she changed his or her practice in a certain way. This is what Bruner (1983) refers to as the conception of the mind. Conceptions of mind are acted out on the baseball field, in the moves on a chessboard, in the strategies on a football field, in a science laboratory, and in a science classroom. Bruner’s (1983) conceptions of mind about physics is, “You do not think about physics, you think physics. Physics is not just a description of the world; it is the way you get to the description” (p. 183).

Another concept, which bears similarity to knowing in action, is tacit knowing. Tacit knowing refers to the skill of knowing in action that many teacher educators demonstrate (Richardson, 1997; Spiegel, 1997) and is often referred to as teaching sense (Spiegel, 1997). In expanding on tacit knowing, Schön (1983) reminds us that “Psycholinguists have noted we speak in conformity with rules of phonology and syntax which most of us cannot describe” (p. 53) and that “Alfred Schultz has analyzed the tacit, everyday know-how that we bring to social interactions such as rituals of greetings, ending a meeting or standing in a crowded elevator” (p. 53). The knowledge base for tacit knowing is acquired through feelings of which teachers are initially aware but which become internalized over time. For example, when someone recognizes a face among a thousand faces, that person may not be able to describe how he or she knew the face but only that he or she recognizes it. Teachers may know that they know, yet cannot describe how they know it.

In classrooms, tacit knowing prompts teachers to change a lesson in response to cues from students, to new activities, or to schedule changes. As a teacher circulates in the classroom during a laboratory experience, he or she gathers information related to performance by checking the students’ understandings. If the responses or cues that the teacher receives from the students are not what the teacher wanted, the teacher may make several adjustments spontaneously.
Schön (1983) describes reflection as *reflecting-in-action* – that is the ability to think about doing something while doing it; the ability of teachers to change their practice while they are in the midst of teaching (Fullan, 1991; Hargreaves, 1994; Schön, 1983, 1987). In clarifying *reflecting-in-action* Schön (1983) uses the analogy of a baseball pitcher and his or her ability to find the groove; this is often described as a pitcher’s ability to feel the ball leave his or her hand and knowing that he or she has pitched a perfect slider. During the course of batters, pitchers can feel that a change in pitches is needed and they are able to make those changes by reflecting on their pitching, the batters, and making the adjustments according to this feeling. This same concept applies to teachers in that teachers seem to have an innate or tacit way of knowing when and how to change what is happening in a class. Other constructs related to reflection, worthy of note and reported in Elliot Eisner’s (1991) book, *The Enlightened Eye* are tacit knowing, reflecting in action, and knowing in action. These three constructs or concepts relate to ways of reflecting, thinking, changing, adjusting, and learning about teaching, students and being.

**Research Methodology**

Methodologically, this study, in part, is theoretically framed by the tenets of constructivism. Therefore, unlike research conducted and grounded in a positivist approach, this study offers no claims or conclusions along the lines of “this is the way things really are” (Guba & Lincoln, 1989, p. 12). In the positivist paradigm, also described as the scientific paradigm, research is typically oriented at determining the truth in an objective, independent, value and bias free way, one in which the inquirer can stand separate from any findings, conclusions or assertions (Guba & Lincoln, 1989). That is not the approach being taken here.

The constructivist paradigm or set of beliefs asserts, instead that there are multiple realities that are constructed and devised by individuals attempting to make sense of their experiences. These constructions of reality are not viewed as independent discoveries governed by natural laws; they are viewed, rather, as views of reality developed through shared interaction, ungoverned by natural laws and dependent on and influenced by the experiences and prior knowledge of the constructor(s) (Guba & Lincoln, 1989).

This present study, framed from a constructivist view, employs a hermeneutic methodology, whereby researcher-developed constructions are shared with the participants, these constructions are critiqued and revised by the participants, and opportunities for the emergence of new paradigms are thereby created. A better understanding of the research questions will emerge from shared construction of meaning between the professor, the college students and me. I anticipate that the utilization of a hermeneutic approach in this study ultimately lends to a better understanding of the phenomena investigated here (Guba & Lincoln, 1989). In asserting the value of a constructivist view, Guba and Lincoln (1989) relate the construction of these shared meaning to “the phenomenon of interaction; that is outcomes are shaped
during the course of inquiry by the interaction of the investigator and the object of inquiry” (p. 99).

In keeping with what Guba and Lincoln (1989) describe as credibility and fittingness, the post-pilot interviews and associated artifacts are offered to further clarify and expound on what I observed during the pilot observations. The importance of this research is evident when one considers the mandated educational reforms, the emphasis placed on science and mathematics, the increasing need to enhance teacher preparation programs and the need to use the learning from our science majors to continue the competitive stance this country now enjoys.

Qualitative Research

A central aim in this study is to describe and analyze changes and the implications of these changes in a university professor actively implementing a new curriculum for a secondary science methods course. The richness of these descriptions will, in large part, depend on to what degree the reader is able to participate vicariously in the events that transpire in this investigation. Just as “a painter takes the sun and makes it into a yellow spot and an artist takes a yellow spot and makes it into a sun” (P. Picasso in Eisner, 1991, p. 9). I use the art of language and negotiated meaning to give the reader an authentic view of the events of this study. Therefore, this study follows the tenets and features of a methodology that is best described as qualitative inquiry or qualitative research. This study is described as interpretive research—namely research whereby “inquirers try to account for what they have given account of” (Eisner, p. 35). Interpretive research also is concerned with meaning: Why did someone do something? What was their framework? How have experiences impacted the meaning attached to events?

Qualitative research, interpretive research, documents in detail, reports of the conduct of everyday events and meanings: these studies of reality most frequently describe phenomena in words rather than in numbers. They attempt to capture meaning through language and are often used to understand social phenomena (Erickson, 1998; Janesick, 2000; Wiersma, 1995). This language-based rather than quantitative-based research format is particularly appropriate for investigating the subjects at hand. Erickson (1998, p. 1155) states that qualitative research is especially appropriate when the desired intent is:

- To understand detailed information about implementation.
- To identify the nuances of subjective understanding that motivates various participants in a setting.
- To identify and understand the nature of change over time.

Eisner (1991) uses the term qualitative inquiry to research and describe the complex processes of teaching. Qualitative inquiry, used in an educational arena, tries to understand what teachers and students do in the settings in which they work. Observing, describing and detailing the stories of teachers in their classrooms to such a degree that the reader can vicariously experience the classroom is an accepted process
for conducting educational research (Clandinin & Connelly, 1992, 1994; Cuban, 1992; Hargreaves, 1994). The value of qualitative research in the field of education is firmly grounded in its use in earlier works of anthropology and sociological studies (Bogdan & Biklen, 1998; Miles & Huberman, 1994). Of course, qualitative research is not limited to the set of theories and concepts found in the fields of anthropology and sociology (Eisner, 1991). In many ways, schools and educational systems are viewed as a culture much like those that Margaret Mead describes. As teacher educators, we need not only the perspectives of theory, but also the perspectives of political science with its explanation of power, and sociology, with its perspectives on issues such as gender, status and understood social norms (Eisner, 1991). Qualitative research is typically non-manipulative and can be what Lincoln and Guba describe as naturalistic (Eisner, 1991).

To add to the level of confidence the reader can have in my observations, interpretations and conclusions, I have drawn from a multitude of perspectives. Although an interview protocol (see Appendix C) serves as an instrument to bring focus to a discussion, the primary instrument in this study is me. It is my role to observe, cogently interpret and to construct a coherent persuasive case to the reader, as described in detail earlier, one lens, perspective, or model used to craft a persuasive case is the PDDPMSR framework for teacher development proposed by Loucks-Horsley, et al., (1998) (see Figure 3-1).

### Summary of Literature Review

Reflection appears to be critical if teacher educators are to change their beliefs and practices. Reflection takes many forms; knowing in action, reflecting in action, and tacit knowing (Fullan, 1991; Hargreaves, 1994; Schön, 1983, 1987; Spiegel, 1997). These forms of reflection describe ways in which teachers create, develop, and move their practices forward. Although change is continuous and many times randomized, Senge (1990) identifies six principles of change that may have relevance for teacher educators:

- Change is a process that takes time and persistence.
- As individuals progress through a change process, their needs for support and assistance change.
- Change efforts are effective when the change to be made is clearly defined, when support and assistance are available, and when leaders and policies support change.
- Most systems resist change.
- Organizations that are continuously improving have ongoing mechanisms for setting goals, taking actions, assessing the results of their actions, and making adjustments.
- Change is complex because it requires people to communicate with one another about complex topics in organizations that are, for the most part, large and structured.
Many of these principles are found in the aforementioned research studies. The teacher educator change process describes a cycle of reflection, self-reflection, and advancing practices forward through communication with self, colleagues, and interactions with the larger organization (Senge, 1990).

The preceding review of related literature describes the ever-changing landscape of teaching and learning theories. Earlier ideas and methodologies rooted in the belief that students are passive recipients of dispensed knowledge are contrasted with constructivist theories of learning and teaching. The promulgation of a teacher proof curriculum as described by Bruner (1960) did little to silence the call for educational reform. Clarion calls for legislative reform measures have been heard for several decades and advocates for widespread implementations of inquiry-based approaches to teaching science have had limited successes. Change is not easy and does not come readily. In sharing many perspectives on the nature and process of educational change and the critical role of beliefs and self-reflection in expanding the inquiry-based approach to teaching science, I offer insight into my own framework.

The literature reviewed in conjunction with this investigation is replete with studies that fall towards the quantitative end of the quantitative/qualitative research methodology continuum. Quantitative research perhaps primarily reliant on numbers and statistical tools to communicate and still viewed as the dominant research methodology has made room for more personal ways of conducting educational inquiry.

Our American system of education is complicated by a confluence of factors too numerous to describe fully. Complicated systems cannot be characterized by a single set of related concepts or by well developed theory. Building an understanding of our schools, colleges, and universities and of all who claim membership in them or who are affected by them requires a rainbow of perspectives.

Educational reform, improved science teaching resulting in more scientists and an increasingly scientifically literate citizenry depends on our ability to develop and socialize more effective pedagogical practices. The degree of openness and acceptance in learning a variety of research methods and practices will ultimately determine the success in this endeavor. Long held theories, assumptions, teacher educator preparation practices, and teacher practices if no longer practical, regardless of which methodology was used to establish these, must make way for new and improved educational practices that appropriately reflect the voices of the teaching community.

Theories of learning, reviewed above, like constructivism, must continue to be tested. The role of beliefs and self-reflection in the teacher change process and teacher educational change process purported to be critical, remain viable areas for investigation. The continued conveyance of research through qualitative inquiry which reflect the experiences of real teachers, teacher educators, and college students deep enough that impact future teachers and teacher educators is not without merit.

The next chapter describes the precise methodology, processes and procedures used in this study.
CHAPTER 3
METHODOLOGY and METHODS

Introduction

The research methods outlined here describe a process for continuing an investigation on teacher change that begin as a pilot study of a university professor intending to implement changes necessary to better align a secondary science methods course with the tenants of promoted reform measures. In the course of conducting this pilot study, designed to describe and analyze changes and the implications of these changes, it became apparent that extending the investigation beyond the primary participant provides a more robust description of the impacts of teacher educator change and inquiry-based teaching on college students once the pre-service teachers entered the teaching practice. Additionally, the role of beliefs and self-reflection in the change process is explored in this follow up study.

Although my intent is to craft and convey a story of the entire classroom situation studied in this investigation, selected observations and discussions pertaining to the change process in the participating university professor and subsequent discourse during interviews with the students (see Appendix C) who participate in this methods class serve as primary areas of emphasis. Sarah Lawrence Lightfoot’s work (as cited in Eisner, 1991) refers to this type of reduction in reported observations of all that is experienced as a portrait.

The importance of research in this area of change, reform and inquiry-based teaching is highlighted in The National Science Education Standards that call for providing teachers with the knowledge and abilities necessary to improve science literacy among all their students (NRC, 1996). In conjunction with the pilot study described here in this chapter, a review of the details of the design for gathering and reporting information from the interviews, observations, and structured discussions of and with the university professor and the college students is provided. This chapter concludes with a discussion of issues and constructs related to trustworthiness, credibility, transferability, dependability, and confirmability of intended and expected outcomes in the qualitative research arena.

Before turning to the essence of this chapter a review of the guiding research questions as posed earlier may be helpful to the reader. As reviewed earlier the purpose of this study is to describe, analyze, document, construct joint meanings, and ultimately paint a vivid portrait of a story that focuses on the following areas:

- Philosophical and professional perspectives of the observed professo
• Pedagogical changes (what changed or what was observed as changed) during the pilot study.
• Change processes (how changes came about in the observed teaching practice).
• Changes in the professor as the researcher shares her observations and interpretations in follow-up discussions.
• Perceived reasons for the changes (why or the interpretation of the change) in a university professor implementing inquiry-based approach into a secondary science methods course.
• Role of beliefs and self-reflection in changes made by this professor,
• Observations and interpretations related to the college students perceived impact of the professor and the methods class on their teaching practices, and
• Perceived changes in college students’ perspectives in transitioning from this methods class to actual teaching.

Pilot Study—Focus of the Investigation

The participant in this pilot study and a major participant in this follow-up study is a science education professor at a state university in Florida whom I have known professionally and personally for many years. To help ensure confidentiality and privacy and demonstrate a respectful stance, I used the pseudonym of Dr. B when referring to this participant and I used the pseudonyms of Student A, Student B…Student G when referring to the college students in the follow-up study. Bogdan and Biklen (1998) and Miles and Huberman (1994) note that the use of a pseudonym to provide a degree of authenticity, while maintaining anonymity.

The pilot study specifically focuses on the nature of change, the change process, inquiry-based teaching, and the professor’s views on the role of beliefs and self-reflection in the change process. The pilot study is composed of 10 observation sessions; eight were videotaped, and all followed by debriefing sessions immediately after each class with Dr. B at a local restaurant. These debriefing sessions are audio recorded, and expanded field notes from these same structured discussions are recorded. After each session I immediately made the transcriptions of the audio recordings and field notes. Additionally, I took the opportunity to reflect extensively on the observations that I had documented, and I archived these data for future analysis. The methods course met for 12 formally scheduled sessions, and two classes are individual appointments for the students. During these individual appointment times Dr. B examines the college students’ reflective journal and I am able to use these individual appointments as opportunities for data collection and further reconstructions, revisions, and elaborations (Guba & Lincoln, 1989).

To better understand Dr. B’s views on teaching secondary science methods from a historical perspective, I use structured discussions extensively. These sessions of structured discourse provide opportunities for interpretation and the building of shared meanings (Bogdan & Biklen, 1998; Guba & Lincoln, 1989). These structured discussions provide Dr. B with an opportunity to discuss with me those events that
precipitated her desire to change her teaching approach. Field notes from these sessions provide a basis for follow-up focused questioning with Dr. B and the college students.

Method for Data Collection

To best inform the aforementioned areas of investigation and to develop the desired portrait for the reader, this study extends the pilot study investigation to include the perspectives, experiences and viewpoints of seven college students who participate in this professor’s secondary science methods classroom. The college students are found with the support from the university’s Registrar, Alumni Services, the Office of Sponsored Research and the participating professor. I conduct additional observations of Dr. B and structured discussions with her related to reflection and beliefs. This approach parallels what Guba and Lincoln (1989) describe as constructivist methodology.

The research methodology is designed to construct and share meanings and interpretations among the professor, the college students and me using guiding research questions focus on change, pedagogy, beliefs, and perceived impacts and outcomes. Although my personal perspectives are expressed on what implications there may be for the professional development of future science teachers the time, place, context and culture are important consideration for readers who may wish to apply the constructions in this study to other situations (Guba & Lincoln, 1989). Unlike what researches in the conventional paradigm may seek to control or negate, my observations and the observations of the participants are couched or mediated by time, context, individual frameworks, genetic capacities, beliefs, and personal biographies.

The following guiding research questions provide the overarching framework for which to make sense out of a complex area of investigation.

1. What pedagogical assumptions and beliefs are related to the teaching of secondary science methods courses?
2. What changes in teaching approaches to the secondary science methods course are desired and what changes occurred? (in college students and professor)
3. What is the nature and process of change as observed by this researcher?
4. What impacts occurred for the university professor and her college students related to changing the teaching practices in the secondary science methods course?
5. What is the role of self-reflection and beliefs in using inquiry-based approach to teaching science methods?
6. What perceptions do the college students have related to the influence of the professor on their classroom practices or on their work life?
7. What changes in perspectives occurred as college students transitioned from this methods class into actual teaching?
Data Analysis

As indicated in Chapter 1, this study uses the Professional Development Design Process for Mathematics and Science Education Reform (PDDPMSR) Model (Loucks-Horsley, Hewson, Love, and Stiles, 1998) for analysis, interpretations and perspectives on necessary reform. This model, conceived by practicing teachers, provides a framework for diagnosing educational change from many perspectives including context, self-reflection and beliefs. I use the PDDPMSR Model (Figure 3-1) to record observations, to analyze the philosophical and professional perspectives of the participants and to report changes in Dr. B’s teaching practice. Information key to this examination includes collaboration among learners, the selection of classroom assessments, the learners themselves, the nature of the inquiry-based approach, the role of beliefs and reflections, changes in the participants’ framework resulting from a structured discourse related to observations and emerging interpretations and the perceived effectiveness by the college students of the inquiry-based teaching approach. Additional detail related to data descriptions and methods for data collection is specifically aligned to each of the guiding research questions is provided in Table 3-1.

To provide a schemata for codifying observations, constructions, recurring themes, and providing personal insight, this investigation draws heavily on the Professional Development Design Process for Mathematics and Science Education Reform (PDDPMSR) Model as displayed in Figure 3-1 (Loucks-Horsley et al., 1998). This framework or model also provides a potential methodology for understanding the professional development design process. Additionally, this model, when used diagnostically, is instructive in understanding the confluence of factors on change including the role of self-reflection and beliefs on strategies, knowledge, critical issues, context, goal setting, planning and doing. This model is similar in focus to a widely accepted model in corporations for continuous improvement and leading change (M. L. McLaughlin, personal communication, April 15, 2002).

In social phenomenological research the legitimacy of a particular representation or interpretations of reality are reflected in the selected methodology and methods. The PDDPMSR Model provides the framework for describing the process of change and the reasons for the change. The logical and systematic utilization of this model provides legitimate confidence to readers in constructing their own meanings from the observations and interpretations and allow them to see how I made sense of the data.
Figure 3-1. PDDPMSR Model (Loucks-Horsley, Hewson, Love and Stiles, 1998) - the figure is a graphic representation of the influence that reflection can have on strategies, knowledge and beliefs, critical issues, context, goal setting, planning, and doing.

Some of the challenges associated with the qualitative type research used in the study include the ability to be precise in reporting experiences, to capture the tacit plurality of perspectives in recording observations and outcomes, to explore the subjective influences of reported meanings, and to recognize the influence of my own conceptual orientation (Bogdan & Biklen, 1998; Erickson, 1994, 1998). While understanding these challenges, I acknowledge that qualitative inquiry, in this case interpretive research, views me and my personal insights as important dimensions in a study. Nonetheless, to provide the reader with the confidence to draw meaning from the
data analysis, I recognize my responsibility to fully account for interpretations and reported meanings.

As Eisner (1991) reminds us, observing what counts “as knowing what to neglect means having a sense for the significant and possessing a framework that makes the search for significant efficient” (p. 34). The stated purpose, the guiding questions, the PDDPMSR Model, and the methods for data collection as outlined in Table 3-1, all serve as the framework for the study.

In this follow-up study, I integrate the recorded pilot study observations with stories, explanations, documents, and reports from the college students and others to add to the richness of the research (Bogdan & Biklen, 1998; Erickson, 1998). Follow-up interviews with Dr. B are to determine to what extent, if any, her thinking changes as a result of reflection on the researcher’s interpretation of the data.

Field notes from these structured discussions contain rich information related to feelings, perceptions, and frameworks. The value of these discussions is perhaps best described by Bogdan and Biklen’s (1998) model for how structured discussions facilitate the process by collecting detailed field notes as the interview takes place. The structured discussions “captures in detail the setting, including the sights, smells, impressions, and extra remarks said before and after the interview that might otherwise be missing” (p. 108). Field notes from the pilot study, replete with impressions and those extra remarks provide the perfect starting point from which to create a rich context for the interviews with the participating college students.

Table 3-1. Data Collection/Analysis

<table>
<thead>
<tr>
<th>Questions for Analysis</th>
<th>Description of Data</th>
<th>Methods for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>What pedagogical assumptions and beliefs are related to the teaching of secondary science methods courses?</td>
<td>Previous course syllabi, past course critiques and evaluations, varied artifacts</td>
<td>Participant-observations recorded as field notes, audio recording of structured discussions and personal stories, videotaping of eight classes, personal journals, internal and interpreted explanations, external and observed explanations. Categories and themes emerge as the data are filtered through the PDDPMSR.</td>
</tr>
<tr>
<td>What changes in teaching approaches to the secondary science methods course are desired and what changes occurred? (college students and professor)</td>
<td>Course syllabus, personal reflections, previous course syllabi, attendance at every class meeting, community of learners, activities, college student, interviews</td>
<td>Participant-observations recorded as field notes, audio recording of structured discussions and personal stories, videotaping of eight classes, internal and interpreted explanations, external and observed explanations, and interview protocol use with college students. Categories and themes emerge as the data are filtered through the PDDPMSR.</td>
</tr>
</tbody>
</table>
Table 3-1 – continued

<table>
<thead>
<tr>
<th>What is the nature and process of change as observed by this researcher?</th>
<th>Course syllabus, artifacts such as readings, handouts, Power Point presentations, scheduled school visits, attendance at every class meeting, activities, interviews with participants</th>
<th>Participant-observations recorded as field notes, audio recording of structured discussions and personal stories, videotaping of eight classes, internal and interpreted explanations, external and observed explanations. Categories and themes emerge as the data are filtered through the PDDPMSR.</th>
</tr>
</thead>
<tbody>
<tr>
<td>What impacts occurred for the university professor and her college students related to changing the teaching practices in the secondary science methods course?</td>
<td>Previous course syllabi, past course critiques and evaluations, personal reflections, interviews with college students and professor</td>
<td>Participant-observations recorded as field notes, audio recording of structured discussions and personal stories, internal and interpreted explanations, external and observed explanations, and videotaping of eight classes. Categories and themes emerge as the data are filtered through the PDDPMSR.</td>
</tr>
<tr>
<td>What is the role of self-reflection and beliefs in using inquiry-based approach to teaching science methods?</td>
<td>Papers presented at state and national conferences, redesign of future courses, published work, dissertation, observations, interviews with participants</td>
<td>Audio taping of structured discussions and personal stories, internal and interpreted explanations, external and observed explanations. Categories and themes emerge as the data are filtered through the PDDPMSR.</td>
</tr>
<tr>
<td>What perceptions do the college students have related to the influence of the professor on their classroom practices or on their work?</td>
<td>Personal reflections, interviews with college students and professor</td>
<td>Audio taping of interviews using Interview Protocol Survey Questions, internal and interpreted explanations, external and observed explanations. Categories and themes emerge as the data are filtered through the PDDPMSR.</td>
</tr>
<tr>
<td>What changes in perspectives occurred as college students transitioned from this methods class into actual teaching?</td>
<td>Personal reflections, interviews with college students and professor</td>
<td>Audio taping of interviews using Interview Protocol Survey Questions, internal and interpreted explanations, external and observed explanations. Categories and themes emerge as the data are filtered through the PDDPMSR.</td>
</tr>
</tbody>
</table>

The college students selected for the study are those individuals who consent to participation after receiving a request from me. Although individual responses to the interview questions are likely to vary among the participants regarding such factors as: completeness of response, non-verbals associated with the response, definition of inquiry, and the degree of emotion associated with the response, a set of guiding questions for the interview is presented in Table 3-2.
Table 3-2. Guiding Questions for Follow-up Interviews

<table>
<thead>
<tr>
<th>Questions for Analysis</th>
<th>Description of Data</th>
<th>Methods for data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>How was the secondary science methods course different from other teaching methods classes?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>What aspect of the course did you find most helpful, least helpful?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>What influence, if any, did this science methods class have on how you think about teaching?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>From your perspective, how does an inquiry approach to teaching science differ from other approaches?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>What student impacts, if any, have you observed when using inquiry-based approach to teaching science?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>How has reflection (reflecting on your teaching practices) affected your teaching?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>What personal beliefs that you hold influence the way you teach?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>Can you describe a lesson that you have taught that incorporates the aspects of inquiry you learned about in the science methods course?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
<tr>
<td>How often do you teach using such methods?</td>
<td>Personal reflections, interviews with college students and professor, personal reflective journal</td>
<td>Interviews using Interview Protocol Survey with extensive note-taking for capturing the responses. Questions emerge.</td>
</tr>
</tbody>
</table>
Standards for a Quality Study

Critical in all research endeavors is determining whether a finding or findings are adequate to draw conclusions, to build theory or to guide and inform practice. Guba and Lincoln (1989) identify criteria for determining research adequacy of interpretive research. I identify these criteria: truth value, applicability, consistency and neutrality, with corresponding concepts for quantitative and qualitative methods in Table 3-3, Criteria for Judging Adequacy of Fourth Generation Evaluation.

Table 3-3. Criteria for Judging the Adequacy of Fourth Generation Evaluation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Quantitative Research</th>
<th>Qualitative Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truth-Value</td>
<td>Internal Validity</td>
<td>Credibility</td>
</tr>
<tr>
<td>Applicability</td>
<td>External Validity</td>
<td>Fittingness</td>
</tr>
<tr>
<td>Consistency</td>
<td>Reliability</td>
<td>Auditability</td>
</tr>
<tr>
<td>Neutrality</td>
<td>Objectivity</td>
<td>Confirmability</td>
</tr>
</tbody>
</table>

In determining, the truth-value of research in the qualitative domain, Guba and Lincoln (1989) refer to a construct called credibility. Descriptions or interpretations made by a researcher that are easily recognizable to research participants and to those who read the research have credibility. Determining credibility requires taking data and information to the source from which data were drawn to determine whether those participants find the interpretation plausible. In meeting the criteria of applicability, fittingness is achieved when research findings fit into contexts outside the study. Consistency or in qualitative research, reliability, is established when another researcher can clearly follow the decision trail used by the author of the study. This concept is referred to as accountability. Neutrality is concerned with ensuring that observations and outcomes of inquiry are not solely rooted in the frameworks or the imagination of the inquirer. In quantitative research neutrality as addressed through the criteria of objectivity. Similar to objectivity, confirmability in qualitative research is “concerned with assuming that data, interpretations, and outcomes of inquiries are rooted in contexts and persons apart from the evaluator” (Guba & Lincoln, 1989, p. 243). In qualitative research, the integrity of the data, confirmability, is “rooted in the data themselves. This means that data (constructions, assertions, facts and so on) can be
tracked to their sources, and that the logic used to assemble the interpretations into structural coherent and corroborating wholes is both explicit and implicit in the narrative of the case study” (Guba & Lincoln, 1989, p. 243).

Guba and Lincoln (1989) also propose additional criteria for judging the quality of a study relevant to this study. These criteria, called authenticity criteria, include fairness, ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity. I consider each of these in turn.

Fairness “refers to the extent to which different constructions and their underlying value structures are solicited and honored within the evaluation process” (Guba & Lincoln, 1989, p. 246). My role as the researcher, cognizant of this fairness criteria, is to seek out from all participants an understanding of the underlying value systems that may drive the multiple constructions of experiences.

Ontological authenticity “refers to the extent to which individual respondents’ own emic constructions are improved, matured, expanded, and elaborated in that they now possess more information and have become more sophisticated in its use” (Guba & Lincoln, 1989, p. 248). Educative authenticity refers to what extent are participants’ understanding and appreciation enhanced for different constructions that are made by others.

Catalytic authenticity cuts to the core purpose of many educational research endeavors; to what extent are participants stimulated to action as a result of the research process? Tactical authenticity “refers to the degree to which stakeholders and participants are empowered to act” (Guba & Lincoln, 1989, p. 250). This study meets these criteria for a quality study through the use of multiple sources of data including the follow-up interviews. Thus, this meets what in Eisner’s (1991) vernacular, is structural corroboration, the complete openness with all participants while providing opportunities for participants to help build and shape interpretation from the recorded observations. To achieve aspects of the aforementioned criteria for a quality study, I actively seek an understanding of the underlying value systems that may drive the participants’ individual constructions. I substantiate information, perspectives, and methodologies from other researchers, and explore all actions so the participants feel empowered towards improving their own teaching practices.

The continued analysis of data occurred through coding recurring themes and meanings, reflecting upon the accumulated data, and reporting on the actual observations and interviews, within the setting (Bogdan & Biklen, 1998). Collecting and analyzing the data with certain codes and themes are part of the constant comparative method. (Bogdan & Biklen, 1998). I use simple descriptive techniques to analyze data and report in subsequent chapters. These descriptive codes are context, critical issues, knowledge and beliefs, strategies and change (see Table 3-4, PDDPMSR Model Categories).

Although the category of Change does not directly appear on the PDDPMSR Model; this separate category as a focus of this study greatly enlightens the discussion regarding implications and, therefore, is included in the pilot study findings. The Change Section also serves as a framework component to organize and report on any unintended outcomes.
Table 3-4. PDDPMSR Model Categories

<table>
<thead>
<tr>
<th>Codes</th>
<th>Recurring Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context</td>
<td>Describe location, room population, follow-up group</td>
</tr>
<tr>
<td>Critical Issues</td>
<td>Minority representation, attendance, attitudes of learners, fairness to learners,</td>
</tr>
<tr>
<td></td>
<td>flexibility of syllabus, coaching, assignments, reform, grades, modeling</td>
</tr>
<tr>
<td></td>
<td>behaviors, power of teacher educator</td>
</tr>
<tr>
<td>Dr. B’s Knowledge</td>
<td>Attendance issues, learning and learners, science communicated and shared, meeting</td>
</tr>
<tr>
<td></td>
<td>the needs of the learners, science content changes, inquiry, assignments, listening</td>
</tr>
<tr>
<td></td>
<td>as inquiry, reform issues</td>
</tr>
<tr>
<td>Beliefs/Values</td>
<td>Tardiness, students not coming to class, seriousness of learners, community of</td>
</tr>
<tr>
<td></td>
<td>learners, emergent topics, science as inquiry, flexibility, standards</td>
</tr>
<tr>
<td>Change</td>
<td>Written consensual agreement, topics for course emerge, inquiry, reform issues</td>
</tr>
<tr>
<td>Strategies for secondary science methods course</td>
<td>Discovery of students, coaching, planning, future course design, course reform, journals, standards</td>
</tr>
</tbody>
</table>

Loucks-Horsley et al. (1998) describe the codes used for analysis, context, critical issues, knowledge and beliefs, and strategies as the pieces of the PDDPMSR Model, which influence the setting of goals, planning, doing, and reflecting. Influence is represented on the PDDPMSR Model with arrows. Loucks-Horsley et al. characterize context as the factor related to the location of the study, in this case the classroom.

Critical issues used as a starting point for analysis by Loucks-Horsley et al. (1998) are equity and diversity, leadership, professional culture, capacity for sustainability, public support, effective use of standards and frameworks, evaluation, and assessments.

According to Loucks-Horsley et al. (1998), knowledge and beliefs influence the planning and goal setting. Knowledge is viewed as the professional knowledge of teacher educators, whereas, beliefs have been internalized from experience and socialization.

The issue of ethics cannot be understated in any research endeavor. In the constructivist paradigm, the aspect of ethics is significant because of the social aspect the participant values (Guba & Lincoln, 1989). This study of teacher-educator change makes every effort to bring all issues to light hidden values from any party involved.
Dr. B is well known as a caring individual within the community of learners. She demonstrates this care through her time and commitment for helping college students grasp and make sense of concepts explored in her science methods courses. This ethic of caring as described by Noddings, (1994) and Taylor, (1998) may be exemplified by building an environment in which the college students can explore their meanings without fear. Emancipatory ethics (Taylor, 1998) that uphold respect for human dignity and the equal freedom to learn also serves as the model in conducting this study.

Factors such as trusting the feelings, sharing openly, revealing any perceived power differential between the participant and me, freely communicating feelings, and using feelings are methods used for appropriately sharing possible misinterpretations and managing potential problems. Throughout the research process, as Bogdan and Biklen (1998) note, I validate and analyze the research questions by trusting the feelings and documenting all hunches, notions, and ideas.

Guba and Lincoln (1989) argue that constructions are built from experiences and that a most effective way to change them may be through new experiences. Experiences, however, need not be direct, they can be vicarious. I provide rich narrative accounts of this study using multiple sources of data that form a compelling whole, providing a vicarious experience for the reader. I strive to develop joint and shared constructions and meanings that honor the perspectives and value systems of all participants. Guba and Lincoln (1989) remind us that the “relativist ontological position of constructivism provides the warrant to consider emic constructions of stakeholders (those held individually prior to the onset of the process) legitimate, rather than regarding them simply as biased perceptions” (p. 185). Guba and Lincoln (1989) describe the case report, as the preferred mode for writing on constructivist inquiry. They remind us that purpose of the case report, a joint construction that emerges as a result of the hermeneutic dialectic process, includes “providing thick description, giving vicarious experience, serving as a metaphoric springboard, and challenging constructions in ways that lead to reconstructions” (Guba & Lincoln, 1989, p. 193). In reporting on different experiences and perspectives, perhaps strong enough to change one’s existing paradigm, and inspire one to action, the case study approach is a powerful way to gather in-depth information in a particular area of study (Miles & Huberman, 1994). Teachers readily embrace change when student learning is a factor (Guskey, 1986). From research concerning classroom teachers, Guskey (1986) states that the implications for student benefit are the primary motivators for teacher change. If knowledge is based on constructions, thoughts, and belief frameworks, it logically follows change in teachers and teacher educators’ thoughts and beliefs influence the choices and strategies that they plan to use in their classroom.

**Researcher Perspectives**

Prior to ending this chapter, it is important to note that a perspective that influences this study is that I have been a classroom teacher of middle school science in the public schools for more than ten years, while at the same time I served as an Adjunct Faculty member at the university where the main participant is also a professor.
My experiences led me to believe that an effective method for teaching science to middle school students or to college students is through a reflective, inquiry approach to instruction. I arrived at this conclusion over a period of time through reflection on my own teaching practices, action research (Barnes & Foley, 1999; Foley, 1999), laboratory experiments, and discussions with colleagues. The readers may wish to consider these experiences when constructing their own meaning from the information provided in the following chapters.
CHAPTER 4
RESULTS FROM THE PILOT STUDY

Overview

This chapter reports and organizes observations from the pilot study. I designed this pilot study to describe and analyze changes and implications of these changes in a university professor actively implementing and enacting an inquiry-based teaching by changing her teaching approach to a secondary science methods course. Blake (2002) clarifies the difference between implementation and enactment: “Implementation is merely putting the desired curriculum into action. Enactment is the process by which the students interact with the teacher as well as how they interact among themselves and with the curricular material” (p.16).

As stated previously, the Professional Development Design Process for Mathematics and Science Education Reform (PDDPMSR) Model (Loucks-Horsley, Hewson, Love, and Stiles, 1998) is the framework for categorizing the data collected in this study and for analyzing, interpreting and providing perspectives on necessary educational reform. This PDDPMSR Model, developed by practicing teachers, provides a framework for understanding the nature of educational change in Dr. B’s secondary science methods course. Educational change from many perspectives including the role of teacher beliefs, the role of context, self-reflection strategies and teaching methods are areas of concentrated focus that I review from the data in this pilot study. Although this model serves as a filtering mechanism for which to process the voluminous amounts of data collected, general groups, domains or themes are somewhat familiar to me prior to data coding and sorting. I review the descriptive observations filtered through the PDDPMSR Model, while I looked for emerging patterns and themes that relate to Dr. B’s beliefs about: learning; science reform and science teaching; how the change she envisioned came to be demonstrated; and what the overall patterns related to inquiry as a method to reform the teaching of science are. The analysis of the data led to the four categories, themes or domains as described below but, clearly my mental framework regarding what I was looking for in the data and the themes that I initially noted prior to the application of the PDDPMSR Model in many ways serve as an influencing force in looking for corroborating evidence among the data. Thus, in essence, the PDDPMSR Model serves as both a forward and a backward mapping of the data (Elmore 1929, 1980; Blake 2002).
Detailed observations and structured discussions related to the change process in this university professor enacting an inquiry-based approach for teaching a science methods course and the subsequent structured discussions with this professor serve as primary data elements for the pilot study. Areas of concentrated focus in this pilot study include the beliefs of the professor, the collaboration among learners and among the professor, the nature of the inquiry-based approach, the influence of inquiry-based teaching on the community of learners, and changes in the professor’s framework resulting from discussions of observations. The professor’s pedagogical beliefs that inform how and why she desires to enact inquiry-based teaching at a deeper level, how she constructs learning experiences, how she engages the students in learning and how she moves forward with enacting the pillars of mandated reform measures in science teaching are also areas of significant focus. Adaptations in teaching practices as a result of enacting, inquiry-based teaching, and the impact of self-reflection are also areas of focus and are reported in this chapter. Utilizing the categories from the PDDPMSR Model to organize and to code the data from structured discussions, field notes, journals and observations, the following themes emerge and are used as a system for reporting and sharing in this chapter: 1) the nature of learning and learners; 2) reflection and relationship building; 3) inquiry-based teaching; and 4) science teaching.

Review of the Data

The University and Classroom Setting

The setting is in a secondary science methods classroom in a university in Northeast Florida which was built in the middle of a wildlife preserve. Like many university settings, the feel one gets is often different at various times of the day. During the morning and afternoon hours the university was populated primarily with students who were 18-22 years of age. The atmosphere is one of an extended high school but with many apparent additional freedoms and responsibilities. Skateboarders, fraternity and sorority students and crowds of students carrying backpacks fill the walkways and tables where there are many lively conversations and a variety of sounds blaring from individual CD players. Students use personal cell phones everywhere. However, the tenor of the campus atmosphere seems to change as evening classes began. It is during the evening that the university seemed to be largely attended by students who are approximately 30-60 years of age and held full-time jobs during the day. The campus surroundings are quieter. Students at outside tables appear more focused on getting a quick dinner or snack after work and reading their textbooks and class notes before their evening class. The students do not gather very long on the walkways for conversation, in contrast to what I observe during the day. Overall the university atmosphere during these evening hours is comparatively quiet and appears more focused as a learning atmosphere.

I observe Dr. B teaching a science methods class in the evening hours. On a Tuesday evening in August I enter Dr. B’s classroom and I find that the course consists
of both undergraduate and graduate college students. The class met every Tuesday and Thursday from 6:00 p.m. – 8:45 p.m. throughout the fall semester. In the class are 14 female students and eight males. Four of whom are currently teaching, three teaching at local high schools and one at a local community college. The secondary science education majors are either undergraduates or post baccalaureate students with a disciplinary concentration in one or more of the following areas: biology, chemistry, physics, and/or earth-space science.

Dr. B’s classroom is similar to many university classrooms used by multiple professors. The room is not overly large yet could comfortably accommodate the 22 students. The walls are painted antique white color with many scratches and marks that you might expect after years of use. The walls are empty except for a clock and a cork board which contained outdated advertisements for credit cards, student trips, apartment vacancies, roommates wanted, and a few items for sale. Six chairs are placed around each of six tables for a total of 36 chairs. Frequently Dr. B wheels in a computer to class to highlight different concepts. The carpet is spotted in places but for the most part it is clean and appeared suitable.

As the first night progressed, it is increasingly heartwarming to watch how Dr. B interacts with the students. Dr. B, a seasoned professor and a personal friend, exudes warmth, interest in others and a real concern for her students. Although heartwarming, these initial observations are not unexpected. I spent a significant amount of time at this university over several years as a student and as an adjunct professor, and it is through my graduate studies in science education that I came to know Dr. B. She enjoys a very strong reputation among her peers and among the student body as an effective, caring professor. As noted by one university student:

I was enrolled in the newly planned doctoral program at X University. I remember many professors noting the effectiveness of Dr. B and how she spent so much time with students. I ran into Dr. B many times during my program and although she didn’t teach in the doctoral program at that time, she always asked how I was doing and what was I doing in terms of research. I remember thinking that she took her role as a university professor very seriously, that she thought it was important to reach out to students in a brand new program on behalf of the university. I also remember how much she smiled and how often she had a line of students outside her office door. (RJ, p. 13)

Dr. B seems to gain the interest and attention from her students by her natural ability to teach by talking in a relaxed, interested and friendly manner with the students and by incorporating a variety of vocal dynamics, inflections, and narratives. She moves throughout the classroom as she talks stopping to make eye contact with students. This seems to captivate the attention of her students, and they continue to make eye contact with Dr. B throughout the class period visually following her around the room. This is different from what I experienced in other classes as a student and professor, where students often gazed-off or became distracted when the instructor is talking (NB 2, p.2).

I attend Dr. B’s class for the remainder of the fall semester and assume varied roles as an observer, co-participant, co-learner, and co-researcher and yet I make every
effort to minimize the effect my presence has on the classroom. However, I am well aware that at a minimum the students are cognizant of my presence and likely are impacted by an observer in class. I take copious notes of my observations, paying particular attention to how the students interact and collaborate with each other, the selection of learning experiences by Dr. B, the learners themselves and how they reacted to various experiences, the nature of the inquiry-based approach and how Dr. B’s beliefs and reflections are demonstrated in the classroom. Although cognizant of my presence, the students in general seemed to pay little if any overt attention to my note taking. At the end of each class, Dr. B and I met at a local restaurant to review my notes, expand on these field notes, to clarify Dr. B’s beliefs and perspectives as they pertain to the class, to education as a discipline, and to share observations that I made that evening. These sessions prove tremendously helpful to me in understanding Dr. B’s hopes and intentions, her beliefs, the thinking process that went into the class, and the class preparation process that took place behind what I observed.

**Categorizing the Data and Data Sources**

As referenced earlier, I utilize the PDDPMSR Model to organize, code, and analyze the voluminous amount of data collected before and throughout the fall semester I observe Dr. B enacting what she described as a deep level of inquiry-based teaching. The data are coded, filtered and are reported here through the five categories of the PDDPMSR Model: Knowledge and Beliefs, Context, Critical Issues, Change, and Strategies (Figure 3-1). These categories are defined as follows:

**Knowledge:**
Knowledge is information that is sure, solid, dependable, and certain although limited because knowledge is rapidly changing (Loucks-Horsley, et al., 1998). Beliefs are the knowledge that we claim as our own, personal knowledge reference. Blake (2002) reminds us that beliefs are difficult to study because they “cannot be observed directly and must be ascertained by what people say or do” (p. 36).

**Context:**
Context is the setting where the teaching and learning took place at a particular time. The notion of context is expanded to include the physical setting at a given time and situation, the constraints of the university or institution, the length of the semester, and the curriculum mandates of the course.

**Critical Issues:**
Critical issues refer to the common challenges and concerns that teacher educators have and face across the nation; these critical issues may vary by region and geographic location.

**Change:**
This category refers to the changes and the process of change in the course that might occur through personal beliefs, self-reflections, expectations and intent by Dr. B throughout the course.

**Strategies:**
Strategies include the various activities, plans or methods for implementing Dr. B’s beliefs about learning and teaching, reform, and inquiry-based teaching; the perspectives gained through self-reflections, structured discussions, and current research trends related to teaching and learning and reform.
The data sources that inform the discussion in this chapter include; a notebook with readings and structured discussions between Dr. B and me, a researcher journal of my personal reflections, a notebook of expanded field notes, a transcription file, and three college student journals. The journals are from a mixture of male and female, undergraduate and graduate students. These different sources of data (see Table 4-1) are coded using a schemata described in Table 4-1 and are referenced throughout this chapter.

Table 4-1. Data Source Coding Summary.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notebook: Readings and Structured Discussions</td>
<td>NB 1</td>
</tr>
<tr>
<td>Researcher Journal: Personal Reflections</td>
<td>RJ</td>
</tr>
<tr>
<td>Notebook: Expanded Field Notes</td>
<td>NB 2</td>
</tr>
<tr>
<td>Transcription File</td>
<td>TF</td>
</tr>
<tr>
<td>College Student Journals</td>
<td>CSJ 1-3</td>
</tr>
</tbody>
</table>

Theme Definitions

Through what can be described in the lexicon of qualitative research as a hermeneutic dialogic process related to observations between Dr. B and me (Guba & Lincoln, 1989) and through subsequent coding, analysis and reflection, several themes or categories emerge from reviewing and studying field notes, college student journal entries, field observations, and the structured discussions with Dr. B. Themes, as used here in Figure 4-1, generally represent educational patterns or recurring issues that serve as a schemata or method for reporting and sharing what occurs throughout this study. Specifically in mapping the data, four general themes as shown in Table 4-2 emerge as a way to categorize and share my observations, experiences and other sources of data. These are Nature of Learning and Learners, Reflection and Relationship Building, Inquiry, and Science Teaching. The first and perhaps what could be viewed as the overarching theme encompasses the Nature of Learning and Learners. This theme refers to the noted observations of Dr. B’s beliefs and classroom behaviors. Loucks-
Horsley, et al. 1998, refers to the *Nature of Learning and Learners* as an intensely personal activity that is imbedded in and enabled by social interaction. Included in the discussion on the *Nature of Learning and Learners* are the beliefs Dr. B held about teaching and the theoretical framework she subscribes to related to educational practices. Additionally, the *Nature of Learning and Learners* as a theme in this study is reported through the filters of Knowledge & Beliefs, Context, Critical Issues, Change and Strategies.

Table 4-2. Emerged Themes from Data Analysis through the PDDPMSR.

<table>
<thead>
<tr>
<th>CODE/FILTER</th>
<th>THEME</th>
</tr>
</thead>
</table>
| Knowledge and Beliefs | • The Nature of Learning and Learners  
|                     | • Reflection and Relationship Building  
|                     | • Inquiry  
|                     | • Science Teaching  |
| Context            | • The Nature of Learning and Learners  
|                     | • Reflection and Relationship Building  
|                     | • Inquiry  
|                     | • Science Teaching  |
| Critical Issues    | • The Nature of Learning and Learners  
|                     | • Inquiry  
|                     | • Science Teaching  |
| Change             | • The Nature of Learning and Learners  
|                     | • Reflection and Relationship Building  |
| Strategies         | • The Nature of Learning and Learners  
|                     | • Reflection and Relationship Building  
|                     | • Inquiry  
|                     | • Science Teaching  |
The second theme that emerged from coding the data relates to Reflection and Relationship Building. In this theme, the observations and perspectives of Dr. B’s self-reflection throughout the course and the relationships that she implements throughout the course are described. I portray a compelling story of Dr. B’s processes of change by
linking together the many pieces of data related to reflection and relationship building teased out through the application of the PDDPMSR Model.

The purpose of this study is to investigate the implementation and enactment of a deeper level of inquiry-based teaching by a college professor who had experimented with this teaching approach earlier. Thus, as any reader would expect, a natural theme for discussion to emerge from the application of the PDDPMSR Model to the varied sources of data would be Inquiry. The third theme, Inquiry follows the same discussion format of the first two aforementioned themes. Inquiry-based learning experiences, how students develop knowledge, and understanding of inquiry methods and science content are three of the areas explored in this discussion. The fourth theme or category to emerge relates to Science Education and Science Teaching. The focus of reform measures and the beliefs stated and demonstrated by Dr. B that relate to Science Education are among the areas of focus in this section.

Undoubtedly the reader will discover overlapping data and duplicative teachable points of view between themes. This type of research resembles what Blake (2002) refers to as “messiness” (p. 107) where the evidence for each theme is not isolated but embedded within the activity and surrounded by examples of the other themes. Thus, it is easily arguable that five themes could have been chosen instead of four or that three themes could have been selected for which to share the details and learning from this qualitative study. Regardless of the number of “data cuts” the reader judges to be appropriate, the sharing of my experiences with Dr. B, her classroom and her students via a four theme approach will convey to the reader a thick description of my experiences and this thick description of implementing the inquiry-based approach by one professor adds to our knowledge base for how to improve the teaching of science.

The Nature of Learning and Learners Theme

It seems incontrovertible that teachers, in general and in the present case, Dr. B, are critical links between the call for reform measures and the actual enactment of reform. Thus addressing the data categorized in this study as The Nature of Learning and Learners will help the reader judge for him or herself how the teaching of science is improved. The main points that emerge through the application of the PDDPMSR Model are summarized in Table 4-3 followed by an expanded discussion of these points.
Table 4-3. The Nature of Learning and Learners Theme-Summary of main points using the PDDPMSR Model.

<table>
<thead>
<tr>
<th>Codes/Filters</th>
<th>Main Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and Beliefs</td>
<td>Building a personal relationship with students is critical in learning Science must be communicated, shared and experienced in a population of learners Experience is key to learning inquiry Students need time to reflect so that learning is improved Peer teaching should be a school based internship – with experts at each school to mentor new teachers</td>
</tr>
<tr>
<td>Context</td>
<td>• The University, Dr. B’s classroom, and other sites • The students at a particular time and place</td>
</tr>
<tr>
<td>Critical Issues</td>
<td>• Minority issues are important considerations in learning • Gender and Ethnic Issues • Attendance Issues • Teachers who are hired without methods courses are at a disadvantage</td>
</tr>
<tr>
<td>Change</td>
<td>Reflected under Knowledge and Beliefs</td>
</tr>
<tr>
<td>Strategies</td>
<td>• Collaboration among students • Building a community of learners is important • Coaching is critical • Observing “best practices” provides the students with another context for learning</td>
</tr>
</tbody>
</table>

To summarize, learners must mediate their own learning through reflections on varied assignments from inquiry-based science teaching to experiences from “best practices”.

**Knowledge and Beliefs**

Hillocks (1999) posit that teachers cannot simply transplant their knowledge into the heads of their students. Lortie (1975) confirms the same stating that it is through “apprenticeship of observation” that teachers obtain a posture of modeling via schools, or throughout textbooks, or through association with other teachers. Dr. B subscribes to this belief.

It is clear that Dr. B firmly believes in the importance of building a personal relationship with the students. During my first post-observation structured discussion with Dr. B and in planning meetings over the summer, we devote time to reviewing Dr. B’s beliefs about students and teaching or what it referred to here as the Nature of
Learning and Learners. It is during these initial meetings that Dr. B discusses the importance of knowing the students and having the students know each other. This belief is perhaps best demonstrated by the “warm-up” activity she facilitated that first evening of class using a roll of toilet paper (NB 1, p. 3; NB 2, p. 2). Prior to this first evening of class Dr. B describes to me that in past courses she would typically have students make personal introductions, pass out the syllabus and review the assignments and course requirements. For this science methods course, Dr. B said that she wanted to do something more: “I want the college students to see how we are all connected and committed to learning science; we are all learners. So I went on the Internet and got an activity that I thought would be fun” (RJ, p. 6). The exercise or activity that first night of class included a roll of toilet paper that was passed from person to person whereby each person shares his or her perception of science teaching and learning or, they relate personal experiences with science to the group. Each student continues to hold onto the toilet paper as the roll passed. The closing remarks from a male student, “I guess the purpose of this activity was to see how we were connected to each other” (TF, p. 4) seems to best reflect the intent of Dr. B.

Following this exercise, Dr. B reviews the course outline with the students, and I recall that one particular component of the outline that caught my attention was that Dr. B was going to use two full classes to meet individually with each student. I remember thinking, “Gosh that will be so time consuming and will require a great deal of focus” (RJ; p. 16).

Throughout the time I spent with Dr. B during the summer preceding the teaching of the course, I understood that she believes that scientific inquiry refers to the activities of students whereby they develop knowledge and understanding of scientific ideas. In a follow-up structured discussion she expands her definition of inquiry to include pedagogical content knowledge and states “it was the development of and understanding of scientific ideas but also to include teaching ideas” (TF, p. 6). The following summarizing quote from Dr. B seems to offer clarity as to her beliefs related to inquiry,

When developing models for teaching science methods courses we, as methods instructors need to share power with our prospective teachers. We need to provide opportunities for them to both experience and evaluate methodologies, in groups and as individuals. In this study, students experienced three approaches to hands-on learning, only one of which was true inquiry. Students discussed their reactions immediately after engaging in them by sharing their experiences, their emotional reactions, and their perceptions of success or failure. (ESJE, 1999)

It is during this time that I learn the heavy emphasis that Dr. B places on learning, experiences, reflection and discussions. A classroom activity that demonstrates these beliefs in action was the use of a Foam Activity (NB 2, p. 7; ESJE, 1999) that she located on the Exploratorium web site on July 25, 1998 from (http://www.exploratorium.edu/IFI/activities/foam/foam1.html). The purpose of this foam activity is to compare and contrast three approaches to hands-on science learning
and to analyze these approaches using the lens of inquiry. The students rotate through three stations, each with a different task. The first station for this foam activity is a guided activity where students follow a worksheet that explains how to make foam using detergent, water, and eggbeaters; they are to answer specific questions comparing two foam preparations. At the second learning station, students are challenged to build a tower of foam that is at least twelve inches high and is contained on an 11-inch plastic plate. At the third station, students are asked to share with each other examples of foam through discussion and they are asked to make and observe foam, note its properties, and devise questions and experiments with the foam. They have access to more materials at this third station but do not receive guidelines on how to make the foam. Dr. B believes this activity will demonstrate the relationship between inquiry and hands-on activities for a science class which I discover from a structured discussion with Dr. B. This foam experience is one of many activities that Dr. B includes in this science methods class that incorporates experiential learning and that are powerful for me to observe.

Consistent with Dr. B’s stated belief that relates to the importance of having time for reflection and developing relationships, a discussion of the students’ experiences follows this activity. “The students can gain knowledge about foam as they experience inquiry through a hands-on activity.” Dr. B adds, “But I also want the students to have time to discuss their reactions, ideas, and notions after this experience” (NB 2, p. 34). The students critique the entire foam lesson and share insights about the three approaches to hands-on learning, this includes their feelings at each station, their personal preferences for their own learning style, and their ideas about implications for this type of experiential approach in their own classrooms. They record their reflections of this activity in their journals. Dr. B refers to many of these reflections in future classes.

The following comments from three different college students’ journals relate to this foam activity, and perhaps best characterize the discussion that I observe:

To me, this gave me great excitement. A direct challenge of my abilities and brains was offered. I love these challenges! I love them because they allow me to stretch my thinking to solve the problem. I love to experiment and see what works or does not work, and why. Joe (pseudonym) and I successfully constructed a twelve-inch high tower in about 10 minutes. At the conclusion of the time, our tower reached over twenty inches! I love challenges and I usually succeed when one is given to me because I put all of myself into solving the problem. This is my environment. This is when I am most successful. (CSJ 1, p. 2)

My first station was a total discovery lesson. We were given no rules or goals. We could do what we wanted to do. We all looked around to see if we were doing it right. I was surprised to see how tentative everyone was without any guide or directions. The inhibitions wore off quickly and everyone quickly joined in. I noticed that in each group one or two people seemed to take charge. It was a fun learning experience and we did learn a lot about foam and its
properties on our own. Their [sic] was no pressure other than getting started of course. I was surprised at how much we actually accomplished and learned. It would be very interesting to see how this type of lesson would go over in a classroom full of sixth graders. (CSJ 3, p. 3)

Our next station was again foam but, in [sic] was totally structured we had a procedure sheet, which told us exactly what to do it was very bland and step by step. We were finished in about 15 minutes. Once we finished we just sat their [sic] and wait to move on to this next station. It was then that I looked at the other groups I noticed that the group that was at the station that I had just left was laughing and still going strong, just as we had before them. They were continuing to discover new ideas. I realized that with the structured lesson that once we were finished, that was it! Just like students do in Junior High or High School. They do what is required of them and that is it. Structured lessons may be easier to evaluate but, they also seem to put limits on learning. (CSJ 2, p. 2)

Linked to Dr. B’s belief about inquiry, time for reflection and discussion, and the importance of personal relationships in teaching and learning is her belief that effective teaching requires change on many levels and that facilitating change requires time and commitment. In preparing for this course over the summer, Dr. B reports that she spent many hours in reflection on previous semesters, and many discussions with Dr. B and me focus on how to reconstruct the syllabus to include new activities and ideas in future science methods courses. In addition to the time and effort devoted to developing an approach indicative of a deeper level of inquiry-based teaching, this desired change in Dr. B’s teaching approach also requires risk and creativity when developing new activities to teach lessons on inquiry. Risk that the students would reject the activities as lacking creativity or practicality, risk that Dr. B would be perceived as teaching a course with little if any real content.

Moving towards this type of teaching and learning envisioned by Dr. B requires the teacher to let go of some classroom control. Dr. B asks students to go and look for evidence of inquiry and barriers to inquiry during field assignments. For example, the students sign up to go to parks, museums, the zoo, etc. and look for evidence of inquiry and barriers to inquiry. These types of activities require Dr. B to give up control that is often perceived as necessary by many teachers when using more traditional approaches.

Providing students with the opportunity to view what Dr. B believes are teachers of “best practices” demonstrates her beliefs in the importance of modeling for students and in having models available. In one structured discussion with Dr. B, whereby she reflects on many previous semesters that she taught and compares these to how this course is structured, she notes that a perceived lack of time seems to prohibit her from including opportunities for the observation of “best practices” into her course syllabus. In forming the course syllabus for this semester’s course, she prioritizes this “best practice” activity and arranges the syllabus to include these observations. In taking this approach to the course outline, Dr. B notes many advantages: college students could participate in an inquiry lesson in her class, observe the “best practices” teachers that modeled inquiry, and obtain input on content and methods for future science methods
courses. These highly skilled teachers are inclined to mentor to the college students on a continuous basis.

In addressing the needs of individual students, Dr. B dedicates time more than she has in previous semesters to check the journals that students kept. In previous semesters, she typically waits until the end of the semester to check the journals but she has come to realize that this method is not effective in implementing changes or strategies that might help the individual learner prior to the end of the semester. I clearly believe that by asking the students to write in their journal after each class session, Dr. B demonstrates the importance she places on reflection as a critical component in reforming the teaching of science. Dr. B discusses another change from previous semesters taken place with her teaching practice; “It was a change for me to ask for past experiences from the students, to actively seek the connections of where they are” (NB 1, p. 47; RJ, p. 10).

In addition to the increased time and effort required by the teacher to elicit or drive change Dr. B indicates that she is well aware that college students need time to adapt to change. She states “college students hold their judgments for a long time. They don’t change with one activity, I believe experience is the key to having change come about with the students” (NB 1, p. 41; RJ, p. 12). College students are accustomed to passive learning, not interactive teaching, and an inquiry-based type teaching approach requires more effort and involvement from the student. Thus to encourage more effort from the students, involvement and accountability for learning, Dr. B designs this secondary science methods course so that the students will experience inquiry. Every activity in this course including field assignments, classroom discussions, the journal that students kept, and the assigned readings are all designed to reflect and reinforce and inquiry-based type approach to the teaching of science.

Additional evidence of Dr. B’s belief in the importance of experiential learning pertains to her views on the preparation of teachers. Dr B believes that the preparation for teaching or the education of teachers should be revamped to include a peer based internship whereby experts at each school would mentor and develop new teachers. Dr. B reports that in her opinion, students must have the subject knowledge but of equal or more importance is the ability to deliver or craft the content in such a way that lends the learner to discover in a method that addresses the learners’ needs (Shulman, 1986). Dr. B emphasizes that methods courses and peer-based teaching opportunities are imperative for educators and urges public officials to advocate this perspective particularly in areas employing teachers without educational degrees.

To provide the reader with a summary type perspective on Dr. B’s beliefs as they pertain to the Nature of Learners and Learning I underscore the importance of a building a personal relationship with the college students and for them to build a personal relationship with each other. Additionally, science must be communicated, shared and experienced in a community; experience is the key to learning science; college students need to reflect more; change requires time and commitment; college students need time to adopt reform measures; and teaching preparation should be a school based internship—with expert mentors at each site.

Dr. B’s introductory activity with the toilet paper roll is likely indicative of the primary importance she places on relationships within the classroom. Her
acknowledgement, often non-verbal, of what each student says reflects the care and trust that she has for and in students. Trust in and care for the students are reflected by the importance and time she places on the journals.

Dr. B’s perspectives and beliefs about the Nature of Learners and Learning as described in the preceding pages seem to reflect a feminist post-modern view of teaching (Noddings, 1994). We see evidence of her view that science teaching must reflect and support: a community of engaged learners, an environment where discourse involves individual stories including a variety of complex narratives, and an environment where experience lends itself to alternate forms of interpretation (Cannella, 1997, 1999) and does not claim to have a “lock on truth” (Duran, 1991, p. 87). Arguably this reflects the tenants of a feminist post-modern perspective. Dr. B is well known as a caring individual within the community of learners in which she works. As we see throughout this chapter she demonstrates this care through her time and commitment for helping college students grasp and make sense of concepts explored in her science methods courses. This ethic of caring Noddings (1994) describes as exemplified by building an environment in which the college students can explore their meanings without fear. Factors such as trusting the feelings, sharing openly, revealing any perceived power differential between the learners through continued hermeneutic dialogic processes, freely communicating feelings, and using reflections on these feelings as the tenants of Dr. B’s feminist post-modern perspectives.

In reflecting on the data I encounter and record, I note how strongly Dr. B wants the changes that she makes and implements through this science methods course to result in real changes in how her students taught and facilitated learning in their classrooms. We know from many data sources (Nespor, 1987; Richardson and Anders, 1994, that beliefs play a major role in behavior and we see how Dr. B’s beliefs are manifested in how she taught this science methods class. Whether the college students teaching practices are impacted or changed as a result of Dr. B’s teaching approach would or could be determined in part by whether their beliefs about the Nature of Learning and Teaching are changed. The nature and degree of this impact is a topic of concentrated focus in the follow-up study with the college students. This follow-up study is the subject of discussion in the next chapter.

Context

*The University.* The university where I observe Dr. B is in operation for over 25 years with all of the students commuting to the campus until 1985 when the first on-campus housing opened. The university is a public urban university whose mission is to educate students through a broad array of undergraduate and select graduate programs. The university reflects in their catalogue their dedication to excellence in teaching, scholarship, and service; and the engagement of students in a personal, supportive, and challenging learning environment. In fulfilling its mission, the university seeks to contribute to the betterment of society. Academic programs at the university are coordinated through five colleges with other learning opportunities provided through a Division of Continuing Education and Extension.
The Students Themselves. With some slight variations, the demographics of the college students resemble those from many previous semesters that I encountered in the last several years. Of the 22 students in Dr. B’s class, 64 percent (fourteen) are female and 36 percent (eight) are male. Ethnic composition consisted of 18 percent (four) African American, 9 percent (two) Latino and 73 percent (sixteen) are Caucasian.

The influence of Context on the Nature of Learning and Learners is perhaps most evident by the fact that the class took place during the evening. Dr. B shares with me that “many of the students will come to class exhausted having taught all day….and expect a course of note-taking and assignments listed on the syllabus…..still others who have not been in class in quite awhile will be nervous and uncertain about their expectations” (NB 1, p. 41). The influence of gender and race although reported above and considered in this section on Context are discussed below as Critical Issues.

Critical Issues

Critical Issues refer to common challenges and concerns of teacher educators across the nation and may vary by region and geographic location (Loucks-Horsley, et al., 1998). Critical concerns that Dr. B notes regards the college students or The Nature of Learning and Learners are minority issues, gender and ethnic issues, attendance issues, and her perspective that many teachers are hired without having been exposed to or completed necessary methods courses. These concerns are expanded upon in the several pages that follow.

“You have to recognize that each student comes to class with a different set of experiences ... you need to understand these experiences to enhance the learning process,” explains Dr. B during one post-observation interview (NB 1, p. 8). Dr. B repeats this view many times throughout the time period associated with this study. This quote is representative of how in our pre-semester discussions and throughout the semester Dr. B considers the integration of students’ individual backgrounds into teaching as a critical component of effective teaching. She recognizes that one of the challenges in this secondary science methods course is that the students’ come from diverse backgrounds. In planning how to best address the needs of the individual students, Dr. B considers her past experiences with the demographics of students enrolled in science education classes. She believes that many minority students have obstacles facing them that often non-minority students do not have and she is particularly concerned that “many times female African Americans have children with nobody to care for them at home while they come to class.” She notes to me that many of the students in this methods class will have worked a full-time job during the day. These students have different time demands than those who are full time students. She recognizes that some students came to class with fear associated with not having been in a formal educational setting for years. She speaks of how incentives are lacking to encourage traditional science majors to go into teaching and of particular concern is that the recruitment of minority students as significantly lacking any focus (NB 1, p. 34). In communicating these concerns, Dr. B refers to a class she once had, stating “… I had four minority students in my class—two who are having difficulty, and I have to do more to retain these students” and that two females who are lost had no direction and
are feeling like nobody is there to help or mentor them. Her commitment to the learner is clearly evident and touches me as she discusses many of her past students. Dr. B acknowledges the criticality of the diversity in educators, stating many times students are in need of role models that reflect diversity. She acknowledges that an educator has a significant responsibility to help those students who are struggling and to mentor them in order to retain them in school. Dr. B states that “the personal and professional experience the students have had will influence how they teach ... it is critical that we need to help them become more aware of these influences” (NB 1, p. 21).

Attendance issues also emerge as a critical issue. “How do you fill in the experience when the student isn’t present? Dr. B underscores and demonstrates her beliefs in the importance of attendance when she implements a consensual agreement form (Appendix A) which students sign agreeing to actively participate in the class (NB 1, p. 14). This attendance issue is revisited later in this chapter under the theme of Reflection and Relationship Building.

The importance of experience in knowing how to teach is also coded as a Critical Issue that emerge from my observations of Dr. B. “Teaching is a profession which needs a whole preparation and an induction period. People are being hired with no methods courses and are being put into the classroom expected to teach” (NB 1, p. 10). Dr. B strongly believes in the importance and criticality of methods courses to effective teaching yet she also believes that “teaching preparation should be school-based with experts at each school to help the new teacher” (NB 1, p. 10). Her encouragement and requirement for observing teachers recognized by their peer group as “best in class” is confirming evidence of this belief.

Strategies

During the first night of class, it is readily apparent what primary teaching strategy Dr. B will rely upon in this course. Teaching through building relationships with students and establishing a community of learners is a strategy that is evident each and every night that I observe Dr. B. She works that first night of class on getting to know the students and building, what is described, as a sense of community (NB 2, p. 2). She circulates throughout the room as students enter and smiles to acknowledge each person. She relays to the students the importance of working collaboratively, sharing ideas, and working together as a learning community.

Attendance is not stated as a requirement but encouraged as a commitment to the learning community to provide the opportunity to build camaraderie, responsible learners, and a sense of belonging. Dr. B stresses the importance of forming personal relationships with the students and that she will provide time in the course schedule for one-on-one meetings with them (NB 2, p. 2). These interviews or on-on-one meetings seem to reflect a teaching strategy that includes coaching students and building relationships, ultimately enhancing individual learning as well as partly addressing individual learning needs.

A second strategy observed and noted relates to the importance and use of hands-on learning, Dr. B states, “students expect a course of note taking and assignments; however I believe that students of teaching need to be in classrooms.” Dr.
B refers here to the “hands-on” learning strategy of observing and participating in classrooms of “best practice” teachers. Dr. B arranges for the use of four classrooms led by exceptional teachers in the local area for her students to observe “best practice teaching.” She is confident that this strategy will help build future professional collaboration opportunities for the students, foster relationships, develop community relationships, and provide coaching and feedback opportunities for the students.

The powerful impact that these participative strategies have on students is perhaps best reflected by the journal entry made by one of the college students in this methods class. In demonstrating what appears to be sheer excitement the students writes:

This week we visited Sample Hill High School, home of Bob Brown, teacher magnificent. WOW! What a program! When you first listen to Mr. Brown, you are sure that he must have nothing but gifted, honors, and AP students. When you learn that not only are they none of the above, but they are often students who have never before been successful in science classes, you realize what an incredible feat Mr. Brown has accomplished. (CSJ 1, p. 9).

In the preceding pages, I describe Dr. B’s perspective on the Nature of Learners and Learning using information that results from filtering data through the PDDPMSR Model. Before turning to the second theme, Reflection and Relationship Building, it seems worthy to note that I am left at the end of the observation component with the firm conviction that Dr. B strongly believes that if she can affect the beliefs and teaching practices of her college students she will contribute to having planted the seed for reforming the field of science teaching. She will provide a view of educational reform with individuals that through their teaching will touch the lives of so many learners. This indeed will be an accomplishment for all and any of us who teach.

**Reflection and Relationship Building Theme**

The issue of reflection and relationship building in utilizing an inquiry-based teaching method is a prominent theme that emerges through the application of the PDDPMSR Model to the data collected by this investigation. Main points relate to Dr. B’s implementation of a deeper level of an inquiry–based approach to teaching than she previously used are reported here in accordance with the five categories of the PDDPMSR Model.

Traditional methods of teaching are typically viewed as including didactic teaching accompanied by textbooks, rote learning, seatwork, lecture and note-taking, and short answer multiple choice exams (Cosgrove & Osborne, 1985; Tobin, Briscoe & Holman, 1990). Clearly, inquiry-based approaches require a radical deviation from these more traditional type teaching methods and with these modifications, the need for reflection and relationship building are incorporated.
It seems plausible to argue that to change one’s teaching methods, an educator must be willing and committed to self reflection and the analysis of their current teaching practices. In essence, reflection on one’s beliefs and ultimately a change in beliefs would most often be expected to precede a change in behavior. As referenced earlier, the role of self-reflection in changing teaching practices is frequently evident in my discussions with Dr. B as we “processed-out” each evening through what can be described in the lexicon of qualitative research as structured discussions and hermeneutic dialogue.

The following table, Table 4-4 highlights the main points related to Reflection and Relationship Building followed by an expanded discussion of these main points.

Table 4-4. Reflection and Relationship Building Theme in Science Education Methods—Summary of main points using the PDDPMSR Model.

<table>
<thead>
<tr>
<th>Codes/Filters</th>
<th>Main Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and Beliefs</td>
<td>• Beliefs influence action, thus are important in change</td>
</tr>
<tr>
<td></td>
<td>• Self reflection is critical for change to take place</td>
</tr>
<tr>
<td></td>
<td>• Use of peer critiques is important in making change happen</td>
</tr>
<tr>
<td></td>
<td>• Change necessitates a variety of assignments</td>
</tr>
<tr>
<td>Context</td>
<td>• Observing and participating in “best practices” can bring about change</td>
</tr>
<tr>
<td>Critical Issues</td>
<td>• Attendance</td>
</tr>
<tr>
<td>Change</td>
<td>• University professor and investigator discuss current research throughout course</td>
</tr>
<tr>
<td></td>
<td>• More reflection time allotted in the course</td>
</tr>
<tr>
<td></td>
<td>• Less concern about the conclusion of each class in this course</td>
</tr>
<tr>
<td></td>
<td>• More use of stories in this methods course</td>
</tr>
<tr>
<td>Strategies</td>
<td>• Science vision interviews</td>
</tr>
<tr>
<td></td>
<td>• Students committing to participate</td>
</tr>
<tr>
<td></td>
<td>• Meet with college students one-on-one</td>
</tr>
<tr>
<td></td>
<td>• Structured feedback to students</td>
</tr>
<tr>
<td></td>
<td>• Recognizing the needs of learners</td>
</tr>
<tr>
<td></td>
<td>• Building a community of learners</td>
</tr>
<tr>
<td></td>
<td>• Field trips contributed to change</td>
</tr>
</tbody>
</table>
Knowledge and Beliefs

Intuitively, many educators know that the effective use of any method or teaching strategy ultimately requires a strong belief in the methodology. It is clear throughout my work with Dr. B that her beliefs and ultimately the college students’ beliefs have a significant impact on the nature and degree of change that could or would transpire in this current classroom and in the K-12 classrooms of those led by the college students. As referenced earlier, Dr. B strongly believes that the nature of her teaching will undergo further change from previous semesters if she is going to facilitate the development and delivery of a methods course that will effectively fulfill the requirements of reform for science educators. She uses an inquiry-based approach to teaching, but she wants to go deeper into inquiry for the methods class that was the focus of this current study. Dr. B knew that experiencing and discovering science is ultimately more important than lecturing about science content. As evidenced by her actions and the course outline, she strongly believes that exposing students to “best practices”, having them reflect on their beliefs and experiences openly and honestly, and recognizing that one teaches to a whole person, not just the intellectual portion of an individual, are all critical in bringing about real change in the teaching of science.

Changing a teaching practice, self-reflection and commitment are integral parts of successful change. One must acknowledge and analyze his/her current practices and beliefs (Blake, 2002; Loucks-Horsley, et al., 1998). During our pre-semester meetings, Dr. B commits to making significant changes in this science methods class. In subsequent discussions throughout the semester, she relays how she often reflects on her classes on her drive home and continues reflecting during the evening hours at home. Dr. B also shares with me how helpful our structured discussions are because they provide an opportunity for collegial conversations about how to make necessary changes that will result in change in her practices in the classroom. Dr. B reflects on each class session and asks me in our meeting: “What could I have done differently? Should I have challenged the students more? What worked? What did not work?” This reflection and dialogue provides the opportunity for Dr. B to inventory the assets and liabilities of her current and past practices and to continuously improve the teaching and learning by changing or modifying an activity or approach during her course (NB 1, p. 6). For example, in the planning phase for this course, Dr. B reflects on previous courses and reports that the college students are often apathetic and bored during an entire week devoted to student’s presentations of lesson sharing. She recognizes that she needs to redesign this important learning activity. Her new plan, a change from her previous teaching experience, is to organize the class into small groups and ask each individual to then share their lesson sequence within their small group. This smaller group allows more interaction with each other and creates a higher likelihood of maintaining their interest in the presentations. Additionally, this new structure offers more time for peer reviews and interactions within the small group (NB 1, p. 7). In noting the possibility that students may miss a lesson which might be of interest to them, she asks for a volunteer to compile a complete class set of the presentations with copies available for all the students (NB 3, p. 6).
In addition to Dr. B incorporating self-reflection into her daily practice, she urges her students to do the same as demonstrated through a classroom exercise whereby she asks the students to reflect through journal entries on: their learning experiences, the interactive feedback with each other as well as with her and, the class discussions about activities conducted in and out of class. She frequently reminds the students that “Reflection is a daily practice ... you must reflect on your teaching. At the end of each day, ask yourself what felt good – what seemed to work” (NB 2, p. 6).

As Dr. B contemplates about her classroom and her students prior to the commencement of the semester, she describes her vision for developing a community of learners with opportunities for collaboration, peer feedback, relationship building, and openly sharing perspectives which provide great insight into the college students’ conceptions and understanding of teaching and learning. The sharing of reflections in this community of learners influences new ideas for goal setting and for planning future courses by Dr. B and the students as teachers. She seems convinced that these approaches can change learning and teaching in a direction consistent with the reforms outlined in the National Science Education Standards (NSES, [NRC], 1999). Through time Dr. B readily establishes a community of learners in this secondary science methods course by offering and portraying herself as a learner and by structuring the course based upon the needs of the learner. She models herself as a life-long learner and embraces the opportunities for making science teaching better as put forth by reform measures.

Dr. B shares with me her concern that some educators are immersed in, and remain committed to, traditional methods of teaching. She expresses that “some high school teachers sometimes have the idea that they can go in and lecture to a group of students. If the students get it, fine. If they don’t then that’s the student’s problem” (NB 1, p. 25). To illustrate the importance of recognizing and understanding the needs of the learner in creating necessary change and reforms, she shares with her students; “I recognize that there may not be as many educators with this perspective but, now we are saying, you need to shift your role to deal with the learners’ needs. My role as the class instructor is to evaluate the learner’s needs, but in order to deal with needs, with your student needs, we really need to get to know one another. So how are we going to do that?” (NB 1, p. 20) Dr. B believes that it is imperative for students to be encouraged to provide constructive feedback to university professors so that they, the professors, can incorporate their learning needs into future courses. She encourages students to be their own advocate for learning to practice and to demonstrate inquiry in their own teaching and learning (NB 1, p. 20); thus, she creates a more collaborative teaching practice that results in implementing reform measures advocated by the NSES.

As described earlier, building camaraderie within a community of learners for Dr. B is paramount for igniting the students’ desire to effectively learn and to take responsibility for their own learning. Dr. B uses the “toilet paper” exercise to introduce the notion of being connected and to explain the importance of relationships as the first in class example of a change effort. Individual meetings with the college students are conducted so that students have the opportunity to share their successes, concerns, goals and feelings about the course and science teaching to Dr. B. Additionally, the collaboration between Dr. B and me, the shared readings, the structured discussions,
and the constant inclusion of students’ experiences in the class discussion are all strong evidence of her belief in the importance of building relationships with the students (RJ, p. 12). Moreover, students fostering relationships with other students are viewed as essential so that each future educator develops and finds a value in a sense of camaraderie. Dr. B relays to me her hope that these future educators recognize the importance of relationships and bring this perspective of building relationship back to their schools.

**Context**

Pedagogically, Dr. B believes that change emerges slowly, through a change in perspectives or beliefs which emerge through a coaching model. Teaching and learning through inquiry requires some one-on-one coaching. Dr. B frequently advocates to the students the importance of observing theory in teaching. She requires college students to observe “best practices” to stimulate the inquiry process and to meet new teachers who may serve as future mentors and coaches. I believe that by having the college students reflect on the pedagogical aspects of the course she is assisting them to transition from received knowers to reflective knowers.

During the semester, the class participated with or observed six different high school teachers noted for using methods described as “best practices”. The students also participate for eight hours in two to three community/informal learning settings where science is the setting topic. Student’s select settings such as the zoo, national parks or state parks for their field assignments whereby they are required to look for evidence or aspects of inquiry and how inquiry may affect their teaching and their students learning.

The contextual factor presented by having students participate in field-based assignments become an area of focus in the follow-up study with the students.

**Critical Issues**

A critical issue is Dr. B’s belief that attendance has, and the implications on the college students who are not regular attendees and the community of learners which she built are a concern. Dr B recognizes that attendance is critical as she designs and reflects on her classes throughout the semester. She is building a community of learning through shared experience where inquiry takes place and learning is discovered by incorporating stories, sharing personal experiences, and encouraging the college students to share stories of their experiences. Consequently if a student misses a class that evening the sharing with the students of how a change in beliefs about something can cause a change in behavior is adversely affected.

**Change**

The importance of having the investigator as a coach and as a sounding board along with the opportunity for collaboration emerges as critical components for attempting Change. Throughout this course, Dr. B underscores for me that as she is implementing inquiry-based teaching at a deeper level than she did in previous
semesters. As the primary participant in this case study, Dr. B is provided with the opportunity to discuss research, changes, strategies, ideas with me. During the preplanning phase and during the structured discussions that follow each class, Dr. B and I built a collegial setting for mutual sharing to take place. “As she reflects on the changes she is planning for her course she has the opportunity to test these plans with me” (RJ, p.14). I believe in many ways this opportunity provides Dr. B a safe haven to discuss planned change and further clarify the desired changes in her mind prior to implementing the change.

Dr. B’s collaboration with other teachers throughout her career exposes her to philosophies and beliefs that ultimately shape components of her teaching. In sharing an example of how she is able to make change, how she views grades, Dr. B reveals previous experiences that she said influence and shape her beliefs held through the years. Dr. B describes a very powerful experience which she characterizes as a life changing event during her first year as a secondary science teacher shortly after graduation from college. She describes herself as being very rigid and inflexible with her adopted grading scale and shares with me that “one of my female student’s parents locked the student in her room because of an unsatisfactory grade she received in my chemistry class.” She describes the sense of dilemma, struggle, and confusion that she experienced as a result of this parental action. Yet, in reflecting upon the impact her grading actions had on that one student, she recognizes the tremendous influence that teachers and teacher educators can have on or could have on their students (RJ, p. 14).

After this particular grading incident and for a long time afterwards, Dr. B states that she struggled with the issue of grading until she worked with a colleague on a project within the public K-12 school system. She describes how she is finally able to move beyond this struggle with grades, Dr. B shares with me, “While I was working with a veteran teacher and a small group of students on a project the students reported their unhappiness with their final grade to me. I mentioned my dilemma to my colleague who advised me to grade as fairly as you can and then put it behind you” (RJ, p. 15). Dr. B explains how this small piece of advice served as a turning point for her. From the time of her colleague’s comment forward she said she mentally struggles far less with grades and that she believes that students ultimately have the accountability for their grades based on a mutually agreed upon “up front” criteria. I did not make the connection at the time that Dr. B relayed her paradigm shifting experience regarding her conceptions of grading, resulting in a shift of accountability for the students’ grade from her back to the students; however this framework shift is congruent with her perspectives of learners and of learning.

Dr. B incorporates stories into her teaching more than she ever has as a way of sharing with the students of how a change in beliefs about something can cause a change in behavior. She is building a community of learning through sharing experience where inquiry takes place and learning is discovered by incorporating stories, sharing personal experiences, and encouraging the college students to share stories of their experiences.

In reference to change, Dr. B describes her new way of thinking about this secondary science methods course as having emerged from her reflections for many years of teaching. In past semesters, she designed the course syllabus as a way of
meeting her students’ expectations which typically reflects what college students expect of a course; note-taking and a list of assignments. Reflecting on previous courses that she taught Dr. B states that she would have a list of topics that would be covered on the course syllabus that she is committed to and in all practicality the assignments and topics are structured and inflexible. She shares that the quantity of assignments listed on the course syllabus limited her real desire to have the time for the college students to reflect on the readings and to engage in an in-depth discussion of the readings. In short, she said that she felt compelled to teach the content that was outlined on the syllabus. For this methods course, she changed the structure to allow for more flexibility and she grew less concerned for getting to a certain place in the text or completing a lesson by the close of each class. (NB 1, p. 16). Indeed Change is a significant component of what I observe in my interactions with Dr. B. From what she shares with me and from what I observe, Dr. B has made significant changes in her beliefs about learning, about learners and in how she taught and behaves. It seems plausible to argue that her shift in focus away from the compelling feeling to get through the content of the course to the inquiry-based approach used is illustrative of both personal and professional growth. Once again, we see evidence of a shift towards a Feminist Postmodern perspective on education in Dr. B’s stated belief in the importance of relationships, in her view the collaborative nature of learning, in the value she places on varied experiences, the importance and value she places on the students as individuals and the discourse which she encourages among the students. (Cannella, 1997, 1999).

**Strategies**

Throughout our many meetings, Dr. B reports to me that she made changes in the teaching strategies used in her secondary science methods course many times over the years in efforts to enhance student learning. At one point in the semester the students participate in Science Vision Interviews whereby they ask three individuals of their choice the question, “What is your vision for science learning?” During the week after they are given the assignment, the college students’ report their findings to the class which has been divided into four groups. The groups record the vision statements that are collected from the posed question, post the list for the entire class to view and then had an open discussion about the vision statements. Undoubtedly and intended by Dr. B, this activity serves as a catalyst for the students to develop or refine their vision for science learning, perhaps without even knowing that it was happening.

Another strategy that Dr. B employs relates to Reflection and Relationship Building is helping students commit to accepting responsibility for their own learning. Dr. B designs a Consensual Agreement that the student sign to commit to attend class, participate in class, be an advocate for their own learning and be a part of the overall knowledge network of a community of learners (Appendix A). Entering into this agreement seems to provide for a sense of belonging, responsibility and commitment for the students without the typical set of mandates by the professor on attendance, class work, and/or required readings.

This Consensual Agreement strategy also incorporates time for one-on-one meetings with each student so that Dr. B can determine the progress of learning and
provide students with reactions which she describes as coaching. During this time she checks the students’ journals to learn more about the students’ needs and to gain any insights that might prove helpful in providing additional growth opportunities for the students. Dr. B advocates the importance of teaching and learning through one-on-one coaching. She extends a coaching opportunity to the students that is beyond the classroom and into the professional teaching community by arranging for students to spend time with teachers that are recognized as highly effective practitioners of “best practices.”

**Inquiry Theme**

The openness of our early structured discussions prompts Dr. B and me to think more fully about inquiry and the ways to implement this approach into the secondary science methods course that we are planning. Dr. B’s perspective on inquiry, a term that is used often with multiple meanings, is likely best described by the following statements found in The National Science Education Standards (NSES, [NRC] 1996):

- is central to science learning
- includes interrelated processes of science such as observation and inference
- involves questioning and constructing explanations
- involves testing explanations against existing science knowledge via experimentation
- incorporates communication of findings
- involves critical thinking by looking at alternative possibilities
- comprises behaviors such as meeting challenges and acknowledging limitations.

I present and discuss the main points related to inquiry-based teaching derived from my observations of and discussions with Dr. B and her class here in terms of knowledge and beliefs, context, critical issues, and strategies. Using these five filters provides me with the unexpected opportunity to reflect on my own beliefs about and past experiences with inquiry as highlighted in Table 4-5 below.
Table 4-5. Inquiry Theme in Science Education Methods—summary of main points using the PDDPMSR Model.

<table>
<thead>
<tr>
<th>Codes/Filters</th>
<th>Main Points</th>
</tr>
</thead>
</table>
| Knowledge and Beliefs | • Immersion in inquiry is critical  
                           • Inquiry provides opportunities for a professor to be a role model, coach and mentor  
                           • Inquiry improves the quality of classroom discussion  
                           • Increased exposure to “best practices” fits with inquiry  
                           • Inquiry maintains the interest level of the students |
| Context               | • Provide flexible individual field assignments  
                           • Incorporate field trips  
                           • Observe and participate in “best practices”  
                           • Build a community of learners |
| Critical Issues       | • Inquiry takes time  
                           • Attitude of learners is important  
                           • Flexibility with emergent nature of inquiry |
| Change                | • None Noted |
| Strategies            | • Total immersion in inquiry  
                           • Inquiry-based activities  
                           • Varied assignments |

**Knowledge and Beliefs**

Inquiry-based teaching, according to Dr. B, is less teacher-focused than a traditional didactic teaching approach and requires patience and a willingness to let learning happen without telling students what they need to know (Barnes & Foley, 1999). Dr. B expands on this in a follow-up discussion, “inquiry really means processing, looking for patterns, not jumping to conclusion, making hypothesis about the natural world, about your own world, about your personal world, about relating to the diverse ways in which a scientist studies the natural world and the activities of teachers and students” (TF, p. 14). Recognizing the plausibility that one’s beliefs over the long-term will influence the degree of commitment one has to a particular methodology, examining Dr. B’s beliefs about inquiry-based teaching and how these beliefs may have developed seems critical if we are to better understand how to bring about science education reform.

Dr. B recognizes that it is not sufficient to teach about inquiry or to teach about teaching; rather it is important that her students experience inquiry and effective teaching. In nearly every aspect of this course including, but not limited to, the assignments, class discussions and activities, the focus is on inquiry. Activities such as
the Foam Activity, the field assignments that the students selected, observations of “best practices” and journal exercises are all part of the design framework for building a deeper level of inquiry into this secondary science methods course.

Dr. B holds the strong belief that immersing students in an inquiry-based method for learning and teaching science will improve the quality of classroom discussions. I observe many lively and robust discussions whereby students passionately comment on issues and disagree with each other, asking for clarification or evidence whenever another student shares a point of perspective or an experience (NB 2, p. 12). It is during these types of fervent exchanges that Dr. B has the opportunity to ‘step back’ and observe the inquiry-based teaching and learning process taking place.

Dr. B indicates many times to me in her belief in the criticality of being a lifelong learner. She presents or models herself to the students as a co-investigator with them in this course and states she will, through inquiry, investigate with the students. Throughout the period of time that I observe Dr. B’s class, her lessons appear structured and yet also appear to be open ended. I also observe how she shares experiences with her students, but also open herself to learn from the students. For example during a class discussion, a college student who is also an educator, comments that she loves when students ask questions and she responds by saying, “well, let’s find out” (NB 1, p. 24). Dr. B adds to this student comment that once an educator becomes more comfortable with that kind of teaching and learning, and not feeling like one has to know everything; it takes a big burden off an educator’s shoulders. (TF, p. 9). She states, “Everyone is participating in the learning process and the learning becomes fun” (TF, p. 9).

In discussing the importance of the field assignments and the opportunity for students to observe other teachers, Dr. B shares with me that she believes these types of assignments are a natural fit with inquiry. She adds that in building discussion around these observations and experiences during class helps maintain the interest levels of the students. I note the students’ interest level “play out” several times during the semester in this methods class. I recall one particular time when a student made a comment about a field assignment in which he observed people in the library. He noted: “I observed adults engaging in inquiry in the library, with the computers. You know you’ll see a lot of adults learning the Internet by sitting down at the computer and just trying to figure it out, and I’m wondering if maybe when you are a child, if you engage in inquiry just because you’re curious and it might be fun. When you’re an adult, you have to have a reason” (TF, p. 7).

Context

Recognizing contextual factors which may impact or affect learning provides valuable information related to improving the teaching of science. Dr. B recognizes the importance of context when providing the students with significant flexibility in their selection of field assignments. College students have the opportunity to select their venue for field assignments from local community resources that are personally appealing to them. This choice-based approach is designed to provide flexibility for the college student and to exemplify the recognition in which learning took place. The variety of sites and experiences available as options, such as observation of a meteor
shower at a state park, marine life centers, nature centers, air-space shows, toy stores, parks, water treatment plants, and libraries allow for rich discussion back in the classroom (NB 2, p. 11 & p. 19).

Dr. B arranges opportunities for the college students to observe and participate in a “best practices” classroom environment. The college students participate in four field trips in which they experience the methods and techniques of inquiry in action by six educators viewed as implementers of “best practices.” During one field trip, the college students participate in a chemistry lesson about chemical bonds where in the instructor facilitates an activity designed to help students conceptualize valence electrons. Working in cooperative groups, the teacher provides each group with a button to represent the nucleus of an atom with a string attached to the center which represents the outermost or valence electron shell. Attached to the string are a series of clothespins which represent the valence electrons. The college students are to determine how many clothespins (valence electrons) an atom will lose when it bonded. This activity emphasizes a cooperative learning approach (Johnson & Johnson, 1986) that results in significant student to student discussion, student to teacher discussion and group discussion. Reviewing this activity back in Dr. B’s class, students discuss their own student populations and ways to adapt the activity for their learners. This cooperative learning activity in the field initiates a discussion for application of the learning activities in their own classroom.

Observing “best practices” in action and engaging in experiential activities with other educators leads to the formation of a bigger circle of a community of learners. Dr. B finds classrooms where inquiry-based approaches are tested, observed and retested, and a community of learners can grow in numbers and teachers can bring the necessary changes to reform the teaching of science.

**Critical Issues**

There are several critical issues teased out from the data related to the theme of Inquiry. Dr. B asks early in the design of this course: 1) How do we move from a prescriptive model for a science course to an inquiry-based science course? 2) Where can we model inquiry? 3) What evidence is there at the end of the course that each student can demonstrate inquiry? and, 4) Could there be some way that they can demonstrate inquiry as a final product? These questions are critical to Dr. B in the planning, focusing, and assessing the strategies and reflections for this course. Changing a teaching methodology to incorporate an inquiry-based approach requires time (NB 2, p. 22; Barnes & Foley, 1999). It takes more class time to experience an activity that teaches or reinforces a concept than it does to lecture about a concept. The course syllabus for this methods class is flexible to allow time for learning, time for the unexpected learning that would or could emerge, and time for robust discussions. Unlike previous courses taught by Dr. B, any constraints on time was minimized or eliminated. At least one college student notes the importance of this and states that during their field assignments not being bound by strict time constraints made learning through inquiry more fun (NB 2, p. 12).
To get comfortable with inquiry means getting comfortable with each individual student. This requires flexibility by the educator; flexibility that cannot always be planned or scheduled precisely into the lesson. When the learner actively participates in his/her own learning, the course of the lesson may vary somewhat to accommodate the needs of the learner. For example, during one class discussion about field assignments, a female student remarks: “When a student comes up and asks you something that is totally unrelated to what you’re planning for them, then they start taking you off into different directions, but, it really shows that they’re thinking about things” (TF, p. 8). This statement exemplifies the significance of flexibility. Additionally, critical to all is the attitude of the learner (whether they are open and motivated, or guarded and not motivated) and the response from the educator because learning and attitudes about school and inquiry is increased or decreased. Dr. B describes her view of how to respond to these teachable moments in sharing:

At these teachable moments where you get away from your lesson plan and you say ... let’s change our focus a bit and let’s work on it. And teachers have done that and reported back that they get such good response from their students and sometimes that can transfer into other things in the classroom too, ... a nice cohesive spirit. When questions naturally arise ...do something with them to continue the spirit of community learning and engage the student. (TF, p. 8)

Different from a more planned traditional approach to teaching, Dr. B shares certain aspects of this methods course may emerge as needs arise. This is the case with the semester when I observed her. For example, Dr. B shares with me that typically she assigns several readings on inquiry and spends several classes reflecting and discussing these readings. However, for this semester, Dr. B says she wants the nature of the readings to emerge throughout the course (NB 1, p. 16). Thus, demonstrating the ability to be comfortable with letting some things remain undefined is a critical success factor in advancing the teaching and learning of science teaching through inquiry.

**Strategies**

To reach a deeper level of inquiry in this methods class, Dr. B designs the course to immerse the students in inquiry at a deeper level than previously taught courses. She indicates to me that she wants approximately 80-90% of the class time related to inquiry-based teaching. From the first class evening of this course, Dr. B focuses on understanding the college students’ knowledge of inquiry by asking, “What is science?” and in sharing how she uses individual experiences as a way of teaching about science, she states, “I concentrate on open-ended kinds of investigations which I think epitomize inquiry” (NB 1, p. 17). This initial method to immerse the students in inquiry is a way of helping the students think of themselves as both learners and as teachers and this continued through the course.
Science Teaching Theme

The Science Vision Statement included in the Sunshine State Standards is the “vision for science education, developed by the statewide curriculum framework writing team. The vision statement is intended to serve as a starting point for encouraging local communities to develop science education visions for their students, their classrooms, their schools, and their district.” The vision statement follows:

Learning science is a lifelong adventure that positively affects people in their daily lives and careers. As students do science, they see the relationship between science and other areas of human understanding; therefore, science instruction is relevant and recognizes the different ways and settings in which people learn. A major consequence of science education is the awakening of a feeling of excitement and adventure. Students are engaged in multiple science experiences that nurture curiosity about their own world and foster joy in their increasing understanding of the phenomena they observe and investigate. They increase their ability to offer reasonable explanations, make predictions, and they can engage in more fruitful observations.

Through a basic knowledge of science, students learn about the world, its technology, and its environment and the decisions that must be made to preserve the planet. Science strengthens their ability to think objectively and creatively. (SSS, FL. DOE, 1996)

I believe this vision statement, as illustrated by descriptions provided throughout this chapter, accurately reflects the views of Dr. B and is representative of what she is trying to accomplish in the course. The notions set forth in this vision statement serve as a guidepost for Dr. B, who served as a team member, who helped to develop the statewide vision. The importance she places on learning about learning (i.e., metacognition) science and teaching science are areas of concentrated focus in this methods course. Dr. B believes in and emphasizes to her students the importance of life-long learning. The vision statement reminds us that science instruction is relevant and recognizes the different ways and settings in which people learn. Dr. B recognizes the importance of context. She provides multiple and varied experiential opportunities for the students. She emphasizes flexibility and choice as methodologies to generate and sustain student interest and commitment and through choice she provides students the prospect to nurture or explore their curiosity.

Similar to the reporting formats for the three themes reviewed thus far, Table 4-6 illustrates the main points related to Science Teaching that are observed and noted during this study.
Table 4-6. Science Teaching Theme-summary of main points using the PDDPMSR Model.

<table>
<thead>
<tr>
<th>Codes/Filter</th>
<th>Main Points</th>
</tr>
</thead>
</table>
| Knowledge and Beliefs | • Quality of science teaching depends in part upon the subject matter expertise of the teacher  
                           • Science is best learned through inquiry-based teaching and robust learning experiences  
                           • Collaborative learning is critical in the teaching of science |
| Context               | • Student attitudes are important considerations in teaching science  
                           • Time allotted for accommodating change in science education is important |
| Critical Issues       | • The importance of educator reform regarding methods courses  
                           • Methods courses should include more inquiry-based science teaching |
| Change                | • None Noted                                                                                                                                 |
| Strategies            | • Students involvement is key to science teaching  
                           • Varied assignments help reinforce science content  
                           • The importance of field assignments in bringing about change  
                           • Total immersion in inquiry is critical for reform |

**Knowledge and Beliefs**

Dr. B often shares with me the importance she places of having key experiences in teaching science. She believes that the quality of teaching science is in part dependent on the subject matter expertise of the teacher (NB 1, p. 47). She strongly believes that teachers need multiple opportunities to experience the actual content of science if they are to effectively teach science. They need key experiences in chemistry, biology, and earth and space science. Thus, in keeping with these beliefs, Dr. B selects teachers who are very strong and respected subject matter experts and are models of best practice. Specifically, their content areas of expertise are chemistry, advanced placement chemistry, earth space science, environmental, biology, and technology.

Educators, perhaps most strongly among science educators, generally accept that passive learning leads to little retention of content; whereas, content learned through inquiry-based experiences results in significantly more content retention, more student enthusiasm for learning science, and more positive experiences with schooling (Bruner, 1960; Foley, 1999; Gilmer & Alli, 1997; Roth, 1996; Roth, McGinn & Bowen, 1998;
NSES, [NRC], 1996, 2000; Schank, Fano, Bell & Jona, 1994; Spiegel, 1997). As
described throughout this chapter, Dr. B seems to consistently demonstrate her belief
students learn science best through inquiry-based teaching and robust learning
experiences.

An interesting insight related to the retention of content appears in the journal of
one of Dr. B’s students. The student states that initially she preferred the guided activity
station from the Foam Activity, as described earlier, because she thought it would be
more feasible in an actual classroom. However, upon reflection a few weeks later, she
found that she could recall very little about the structured guided activity, whereas she
could remember the open inquiry station. Additionally, she indicated that she needs to
rethink her initial assessment of the worth of the activities because retention of content
certainly influences learning over time. Her comments about the class follow:

Although I thought that I would HATE the last exercise (written instructions), it
provided more focus and made us consider specific questions. Strangely enough,
although I can remember the questions my group generated from the first (free
inquiry) exercise, I cannot remember the questions that we had to answer in the
more directed exercise. (CSJ 3, p. 12)

During one particular class period, Dr. B demonstrates the concept of a Learning
Cycle where the learner experiences something prior to directions or explanations. A
journal entry from another student may best describe this concept: “She grouped us to
work collaboratively - each group was given an object covered in foil that was egg-
shaped and solid. Initially she provides no information about the object’s content or
origin thus increasing our curiosity. When we remove the foil and examine the contents,
it is clear that the contents were animal remains. After some time of free exploration,
we are told that the object is an owl pellet.” The students are then provided with the
necessary materials to determine the diet of the owl through identification of small
animal remains (CSJ 3, p. 18). I vividly recall that the enthusiasm among the students is
very high and the questions, challenges and discussions among the students are very
spirited.

Dr. B frequently draws upon the college students’ strengths in asking them
about their experiences and their areas of expertise (NB 1, p. 41). One particular time,
she focuses on a male student who, as a result of a biking accident, is not able to
function as a Podiatrist, but did discover that his science knowledge and experience
would serve him well as a teacher. When sharing their experiences, the students at times
seem to recognize that they knew more about science than they originally realized.
When they talk about their experiences I note many times that they seem increasingly
confident in what they knew (NB 2, p. 5).

The importance of experiencing science collaboratively, the criticality of
individual experiences with content, and the need to accommodate the diverse needs of
students are all observed or noted as fundamental to Dr. B’s pedagogical frameworks,
assumptions and beliefs (NB 1, p. 36). As described throughout this chapter by the
classroom exercises, field observations, and development of a community of learners,
Dr. B exhibits commitment to the value of collaborative learning in stating “that
collaborative learning provides an arena to learn from each other’s strengths and expertise, to share in resources, and to engage in thought and debate. This is what scientists do. While some students may not have strengths in one branch of science and others do, collaborative learning provides an opportunity to share knowledge and learn from each other” (NB 1, p. 37).

**Context**

As the reader would expect the student’s attitudes appear critical contextual elements in teaching and learning science as evidenced by one “best practices” educator who shares with the college students during one of the class observations. The teacher states that “their students were already bored because they’ve seen this ...” (NB 2, p. 17). The “best practices” teacher adds that students come to a classroom with pre-existing knowledge and beliefs and that it is imperative to discover the level of knowledge of individual students in order to better meet their needs (CSJ 1, p. 4). The notion of recognizing students’ attitudes about a particular method, experiment, lecture, or assignment and the notion of recognizing the importance of individual needs and preferences is counter to a traditional type approach to teaching science where “one size is expected to fit all” (NB 2, p. 7).

Another contextual factor impacting the achievement of the Science Vision Model is, and is or more accurately stated, the lack of time. Educators continue to be measured and evaluated by new and emerging standards and yet, little if any time is provided for reform to be planned and implemented. Educators and students appear to need time to prepare for, and adapt to new methods of teaching and learning. Changing teaching practices in the midst of daily demands could easily exceed the capacity of the most experienced educator. Confirming the importance of having time, a college student comments, “I’ll have no time to do all of these ... which the community believes science teachers should be doing (NB 2, p. 4).

**Critical Issues**

If reform is to take place in science education Dr. B believes it is critical to incorporate the mandates of the National and Sunshine State Standards and Reform into this methods course (RJ, p. 5 & p. 6). The state encourages the teaching of science through inquiry with hands-on and minds-on activities (SSS, 1996). Strand H, as reported in The Nature of Science, directs the student to work collaboratively, share findings, explain, and justify their own individual conclusions (SSS, 1996, p. 33). While the state is recommending this model, most universities have not incorporated this new model into their teaching methodology courses (NB 1, p. 22; NB 2, p. 30). Simply making incremental changes to methods courses and the lack of a mobilized commitment to change in teaching practices will likely perpetuate a cycle of ill-prepared educators teaching in classrooms where the Sunshine State Science Vision is not realized (NB 1, p. 63). To change science methods, Dr. B shares that “we (educators) have to free ourselves to try something different ... change is very hard for teachers due to time, lack of support, and no collegial interaction opportunities to share
ideas ...” (NB 1, p. 65). She adds that “Our role is to design our methods courses as inquiries into the teaching and learning of science” (EJSE, 1999).

In seems arguable that methods courses must change to include more inquiry-based science teaching if the current mandated standards are to be met and the vision for science teaching in Florida is to be realized or achieved. Educators familiar with research based established “best practices” are well aware of the need for inquiry-based teaching in their classroom as a way of maintaining students’ interest and in ensuring knowledge retention for continued learning (CSJ 3, p. 16). These teachers who exemplify “best practices” will need to lead and participate in bringing about fundamental changes to the teaching of science. A best practice educator states that he “disliked traditional labs - or cook book labs [sic] where a teacher says do this do this...now sit down” (NB 2, p. 18). A “best practice” educator reports that she attempts to encourage the students into chemistry during the first week with a traditional cookbook laboratory activity to get them interested and achieve success.... then as the course continues; this educator encourages free thinking and pushes the students to question more (NB 2, p. 19). Dr. B recognizes the importance of the “best practice” educators involved with restructuring the secondary science methods course.

**Strategies**

Keeping students involved is critical in learning how to teach science using inquiry-based approaches. Collaboration, varied assignments, and enriched discussion, are key strategies to methods for teaching science.

For total immersion in inquiry, as described in detail in the previous sections of this chapter, the provision of flexible individual field assignments seem to build enthusiasm and bring a sense of authenticity to the student’s learning. During one college student’s field assignment, he seems to discover the science learning that could take place by watching an air show and reflecting on the experience. The following is the transcript from the discussion that occurred in class (TF, p. 14).

A question was asked by a male student: Did anyone else go to the air show?
Dr. B: Oh, yes, let’s talk about that.
Male voice: It was really neat. They had a lot of static displays; you know just sitting on the runway, which they had roped off with the basic statistics of the jets and airplanes. They had, you know the most current jet all the way back to World War II models. No, they can’t show and tell at air shows.
Laughter....
Male voice: they told me that they can’t.
Female voice: We saw one three or four years ago at an air show, one of the big bombers, yeah, you could go up to it.
Male voice: Yeah?
Female voice: Yeah, pretty big ones, when I was there.
Dr. B: Oh my goodness.
Male voice: Oh yeah, well, when I was there, they wouldn’t show them because they were probably....
Dr. B: So what about the air show prompted inquiry?
Male voice: Well, the way that I wrote it up, is that I think it would be a good place for a Physics class, mostly to go or a chemistry class, if you wanted to talk about the chemistry of jet fuel, or something. Um, I thought physics because you could do a lot of interesting things with high speed, you know you could do G Force and the high speed climb, because it was an F15 air force jet that did a double loop within 3,000 feet, like this……that would have been phenomenal and then it did a climb straight up to twenty five thousand feet.
Dr. B: Ooooh
Male voice: and it was just like, I mean, I’ve seen these things take off before and I’ve never seen it do that before. It was just incredible, so I mean you could have estimated or done a physics problem to the effect of what does the pilot feel, or what is the G Force, when you are climbing twenty five thousand feet at over 25… whatever, I forgot the air speed, but pretty fast.

Dr. B’s comments reflect encouragement and a real sense of involvement with the student. She uses ample acknowledgement as a way for motivating and engaging the students and she models behavior to foster encouragement, exploration and the bringing of physics to a more understandable level for all learners.

Dr. B demonstrates an interest in providing the students a bigger arena than the confines of the classroom allow. She fosters collaboration and continued learning by encouraging students to provide their email addresses and phone numbers for a directory for each other thus once again, expanding the context and opportunities for learning about science.

As the college students progress through this methods course, evidence of individuals becoming part of a bigger network of learners/educators is apparent in classroom discussions as well as in journal entries. An example from the journal of one student provides evidence of this:

It just gets better and better! (“best practice” educator) is incredible. I have already been on the phone this evening and passed her name along to several of my friends as a teacher with a gift for tremendous creativity. The best part about all of (teacher’s) demonstrations is that they are low-cost and low-tech. Perfect for my self-paced classroom! (CSJ 2, p. 23).

By consistently immersing the college students in inquiry-based approach, and reflecting about science, students begin to change how they thought about learning, and realize the value of experiences. Dr. B believes that all students should become involved in the learning process and become life long learners. This correlates with observations that Blake reports, (2002) “if we are to improve student learning in science, we need to understand what good teachers do.” “… by teaching those future teachers of younger children we help improve learning at the lower grades, so that students develop skills, knowledge, and habits of mind (AAAS, 1989) at an early age, we help foster growth in understanding and enjoyment of science, and come to understand the teaching that promoted such improved learning”(p.12). Following one of
the assigned class readings from *NSTA Pathways to the Science Standard*, (National Science Teacher’s Association [NSTA], 1996) one of the college students reflects on the reading, “Are we preparing students for college, for the workplace, or for personal fulfillment in adult life? ... So the destination is clear: It’s not college, but adult life.” The college student states in a journal entry that:

I want my students – whether they attend college or not to possess science literacy. I want them to be able to read the newspaper and to apply their science knowledge to evaluate issues in their community that my impact their life. ... I realize that the philosophy that the national and state standards intend to express moves us in the direction of science for all students as opposed to science only for the academically gifted or college-bound students. The statement is meant to be inclusive, not exclusive (CSJ 3, p. 21).

Dr. B’s comments and perspectives are captured during my observations and then through our follow-up structured discussions she offers feedback which provides additional clarification. Dr. B reflects the model for lifelong learning. I capture this perspective in several of my observations.

Dr. B offers reflections at length on the themes that I describe in this chapter: she clarified a theme for me by offering a suggestion to rename the Change theme to Reflection and Relationship Building ... “because, Kathy this is my heart of science teaching” (RJ, p. 45). Additionally the feedback that she provides via a story where we sat sharing coffee one evening is so profound for me as a science teacher. We were reviewing the Florida Department of Education Sunshine State Standards Vision Statement, Dr. B served as a team member who helped develop the statewide vision. Her story went like this...

Kathy the word ‘joy’ almost divided our group. We debated this word for many days. Can you imagine that there were members of the team who did not approve of the word ‘joy’ to be included in the vision for science teaching? I find that hard to believe. (RJ, p. 73)

Throughout this chapter, I describe the events of one classroom, the practices of one professor and the varied experiences of all participants where the adoption of a deeper level of inquiry-based teaching is an area of concentrated focus. Providing the reader with “thick descriptions” of the events associated with this one class, the reader will discover new insights for improving the teaching of science. Dr. B strongly desires to make a contribution to the reform of science teaching. She desires to impact the beliefs that her students hold about teaching and learning and she wants inquiry-based practices used in this methods course incorporated into the teaching practices of her students. In the next chapter, I describe the impact of Dr. B’s class on the teaching practices of her students.
CHAPTER 5
THE FOLLOW UP STUDY: THE STUDY OF THE COLLEGE STUDENTS

Introduction

In the previous chapter I described the observations and inferences made during the semester I studied with Dr. B in her teaching of a science methods course. Perhaps more important than what transpired in Dr. B’s classroom is the longer term impact the course would have on Dr. B’s students in their lives as teachers. This dissertation describes an investigation of teacher educator change that began as a pilot study that was designed to describe and analyze changes and the implications of these changes in a university professor actively implementing and enacting a deeper aspect of inquiry-based teaching by changing her teaching approach to a secondary science methods course. In the course of conducting the observations and interviews for the pilot study, it became apparent that extending the investigation beyond the primary participant would provide a more comprehensive description of the impact of inquiry-based teaching on teacher educator change. The follow-up to the pilot study described in this chapter is intended to investigate and to provide, after the conclusion of the course, an understanding of the impacts related to educational change on the students, now classroom teachers, who participated in Dr. B’s course on the educational change and science methods.

In continuing this investigation related to educational change, I am particularly interested in the role of beliefs and self-reflection in the change process, the use of inquiry-based teaching methods by the former students, now teachers, and the perceived impact of these methods on their K-12 students. To ensure I maximize my opportunities for learning in this follow-up study with Dr. B’s former students, I select nine interview questions that help guide or frame each discussion as well as bring some degree of consistency to the conversation with each of the students. These follow up study questions, developed in consultation with Dr. B, are focused on three general areas. These areas include: 1) General post-course perspectives of the participants in Dr. B’s secondary science methods course; 2) Each participants’ views of the role of beliefs and self-reflection in their current teaching practices; and 3) Each participant’s degree of enactment of inquiry-based teaching, and perceived impacts on the participants’ K-12 students as a result of inquiry-based teaching as reported by the participant interviewee.

The following questions are asked of the students:
General Post-Course Perspectives
1. How was Dr. B’s secondary science methods course different from other teaching methods classes?
2. What aspect of Dr. B’s course did you find most helpful? Least helpful?

Role of Beliefs and Reflections
3. What impacts, if any, did this science methods class have on how you think about teaching?
4. How has reflection (reflecting on your teaching practices) affected your teaching?
5. What, if any, personal beliefs that you hold might influence the way that you teach?
6. From your perspective, how does an inquiry approach to teaching science differ from other approaches?

Enacting Inquiry-Based Teaching
7. What student impacts, if any, have you observed when using an inquiry-based approach to teaching science?
8. Can you describe a lesson that you taught that incorporates the aspects of Inquiry you learned about in the science methods course?
9. How often do you teach using inquiry methods?

Concurrent with the development of these guiding questions for interviewing the students, The Office of Alumni Affairs at the university where the pilot study took place prepares the e-mail addresses and telephone numbers of those students who agreed to participate in any follow-up study. I contact the participants through telephone, leaving messages on answering machines, calling back, and having students call me back. Two students had telephone numbers changed so I use e-mail and successfully make contact this way.

As reviewed in earlier chapters, in Dr. B’s class are 14 female students and eight males, four of whom are teaching at the time of the study, three teaching at local high schools and one teaching at a local community college. From a list of the 22 students, 10 students respond positively on a form upon graduation to the Office of Alumni Affairs indicating they agree to be contacted. Of these 10 students, I make contact with seven, one female and one male are interviewed via electronic mail (e-mail), three males and two females are interviewed over the telephone. Of the seven students with whom I make contact, all but one is currently teaching. Table 5-1 provides a description of the participating students.
Table 5-1. Participants in Follow-Up Study

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Approx Age</th>
<th>Response Type</th>
<th>Years Teaching</th>
<th>Current Employment</th>
<th>Frequency of Inquiry Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student A</td>
<td>Male</td>
<td>50</td>
<td>Telephone</td>
<td>3</td>
<td>High school (9th Grade-public) Science</td>
<td>Used inquiry on a daily basis</td>
</tr>
<tr>
<td>Student B</td>
<td>Male</td>
<td>26</td>
<td>Telephone</td>
<td>2</td>
<td>Middle school science (public)</td>
<td>Inquiry lesson about once per week—Labs every 3-4 weeks</td>
</tr>
<tr>
<td>Student C</td>
<td>Female</td>
<td>40+</td>
<td>Telephone</td>
<td>2</td>
<td>High school DOP math &amp; science (public)</td>
<td>Used inquiry on a daily basis</td>
</tr>
<tr>
<td>Student D</td>
<td>Male</td>
<td>26</td>
<td>Telephone</td>
<td>1</td>
<td>State agency</td>
<td>Taught Anatomy and Physiology for one year only</td>
</tr>
<tr>
<td>Student E</td>
<td>Female</td>
<td>40+</td>
<td>Telephone</td>
<td>4</td>
<td>High School (9th grade public) science</td>
<td>Used inquiry on a monthly basis</td>
</tr>
<tr>
<td>Student F</td>
<td>Male</td>
<td>30</td>
<td>E-mail</td>
<td>3</td>
<td>Student (Masters degree in Biology-state university), Teaching Assistant for 2 semesters</td>
<td>Varied but at least on a monthly basis</td>
</tr>
<tr>
<td>Student G</td>
<td>Female</td>
<td>30+</td>
<td>E-mail</td>
<td>7</td>
<td>Middle School Science (private school)</td>
<td>Used inquiry on at least a weekly basis</td>
</tr>
</tbody>
</table>

Throughout the interview process in this follow-up study, I maintain a journal, which contains detailed interview notes and some of my own personal reflections of the interviews. Additionally, as the interviews take place I ask follow-up questions to probe for a deeper understanding of the teachers’ knowledge and beliefs with regard to the course and their reflections about their learning. I reflect on their comments and analyze the data after the interviews using the questions as framework.

The format for this chapter’s discussion follows the three major areas of focus described earlier: Secondary Science Methods General Post-Course Perspectives, Role of Beliefs and Reflections, and Enacting Inquiry-Based Teaching. Each category and its associated questions, the participants’ responses, and a discussion of these responses to include specific examples are reported here. Before turning to the discussion of the three areas, a description of the seven students who participated in the follow-up study may be helpful in providing a context for the reader.
The College Students

Student A, a male teacher, is teaching ninth grade science at a local high school in the same county as the university where Dr. B serves on the faculty. Student B, also a male teacher, is in his second year as a middle school science teacher in the mid-west. Student C, a female teacher, is a high school teacher of Drop out Prevention classes and Student D taught high school Anatomy and Physiology for a short period but at the time of my interview with him, he is working for a local state agency. Student D expresses to me that teaching is just not for him. Student E is a national board certified middle school science teacher enjoying her teaching career after staying at home for many years to raise her children. Student F, a male teacher who taught science for two years at a local private college preparatory high school at the time he is taking Dr. B’s course for certification, has relocated to south Florida and is teaching an introductory level Algebra course. At the time, I spoke with Student F he is also enrolled in a Biology Graduate Program. Student G is a biology instructor at a local community college at the time of Dr. B’s secondary science methods course and she has relocated to another town in Florida where she is teaching middle school science at a private school. Student G excitedly shares with me during the interview that she was recently married. Without exception, the seven students I interviewed seem very positive, very willing to talk about Dr. B’s course and are very forthcoming in answering my questions and in sharing their perspectives. The students interviewed are eager to share their understandings with me in hopes that this shared knowledge will benefit future college course designs, beginning teachers, themselves, and their students. I form this impression because many of the students in the beginning of the interview shared that they hoped whatever information I obtain will be helpful to future college students.

The Secondary Science Methods General Post-Course Perspectives

The first area of concentrated focus for these interviews centers on the general perspectives held by the students about Dr. B’s science methods course. Following a few minutes of polite conversation I begin with the formal interview questions by asking, how Dr. B’s secondary science methods course differed from other classes related to teaching methods? I then focus on determining what aspect of the course did the students find most helpful and what aspect was least helpful? Comments related to these two questions are illustrated below in Table 5-2 and Table 5-3. Direct quotes from the students are used throughout this chapter as paraphrased statements.
Table 5-2. How was Dr. B’s secondary science methods course different from other teaching methods classes?

| Student A | - Best methods course I have had- it provided a flexible learning environment. Non-traditional teaching and learning. Provided much better preparation for utilizing technology in the classroom than I received in other methods classes. Provided information on ways to increase student use of computers in the classroom |
| Student B | - Was the only inquiry-based methods course throughout my higher education experience. Thoroughly addressed the Nature of Learner by tuning into the learner’s needs. Focused on student-directed learning |
| Student C | - Promoted and used hands-on experiences in the classroom which was tremendously helpful |
| Student E | - More unstructured learning environment than other methods classes |
| Student F | - Modeled and utilized reflection as an important component to improving teaching |
| Student G | - The professor actually demonstrated and modeled inquiry-based teaching rather than just explaining what it was. More non-traditional teaching and learning method than other classes. Dr. B’s course rejuvenated my desire for teaching and learning much more than other course I have taken-she models what she teaches. |

Table 5-3. What aspect of Dr. B’s course did you find most helpful, least helpful?

<table>
<thead>
<tr>
<th>Most Helpful Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student A</td>
</tr>
<tr>
<td>Student B</td>
</tr>
<tr>
<td>Student C</td>
</tr>
</tbody>
</table>
It seems worthy to note, in comparing the students’ responses in these two tables, there is a high degree of overlap in the students’ responses and comments in describing their general perspectives of Dr. B’s course and in sharing information as to what was the most helpful and least helpful aspects of the course. As I emphasize, all of the students respond to my guiding questions in an enthusiastic and what appeared to be a very uninhibited manner. This enthusiasm is particularly noteworthy in Student A who is in his third year of teaching science at an area high school (as a second career). Although, his background for his first career was in Science, he sounds very surprised at the level of preparation that he got in Dr. B’s methods course. Student A excitedly exclaims, “Dr. B’s class helped me prepare for the use of technology in my classes, and my kids [sic] use computers and technology everyday. They love it” (RJ, p. 43). Student B in sharing what seems to be a widely held perspective by the students who participate in this follow-up study, indicates that Dr. B’s inquiry-based methods course is very atypical in his higher education experiences: “Dr. B modeled and demonstrated inquiry throughout the course, it helps me to plan and increase the frequency of using hands-on experiences in my classroom” (RJ, p. 36). Student B also stresses that the Nature of the Learner activity had a major effect on him and on his classroom practices. He indicates that this activity made him recognize how teacher-centered some classrooms truly are. Additionally, he states he tries to incorporate student directed inquiry activities as often as possible (RJ, p. 36).

The students’ responses to the first two guiding questions, as indicated in Tables 5-2 and 5-3, seem to reflect a deep appreciation for Dr. B’s science methods course and for the inquiry-based approach to teaching. Several students comment that Dr. B’s class was their only methods course that emphasized an inquiry-based approach to teaching focused heavily on the learner and on using hands-on experiences. The non-traditional style of Dr. B’s classroom, cited by several students as a key difference from other
methods classes, is also cited by several students as one of the most helpful aspects of the course.

The flexible or unstructured environment reported to characterize Dr. B’s class is also highlighted as a key difference when compared to other methods classes and what the students report to be one of the most helpful aspects of Dr. B’s course. In observing Dr. B over the course of many weeks, as the reader has likely noted by now, I developed a tremendous respect and admiration for the way in which Dr. B conducts her classroom. She demonstrates warmth, flexibility, interest, awareness of the students’ needs and tremendous skill in relaying the content of her course. Thus, it is personally rewarding for me to hear the excitement, enthusiasm, and interest level of the students in regards to both Dr. B and her methods course. I am also pleased, though not really surprised that aspects of Dr. B’s course that are cited by the students as being least helpful are limited to time constraints and some technical problems that are encountered during the semester.

The role of reflection and the provision of a flexible learning environment is reported by several of the students as differentiators from other courses and are also perceived as being helpful aspects of Dr. B’s course. These students indicate that Dr. B’s course is also different than other courses in part due to the concentrated focus on the needs of the learner that Dr. B continuously demonstrated. Student G in describing the times when she wrote reflections in her journal, insights are revealed that she had not previously considered. She states “... if we were not asked to reflect on the activities and keep a journal I probably would not have had such a positive experience” (RJ, p. 39). The non-traditional nature of the course is also cited as the key difference for Students B, E, F and G. Student B states, “I was used to note taking and memorization—this was typical. Inquiry and professors wanting to know what I learned or knew is not my experience. This course changed my only view of teaching” (RJ, p. 36). Similarly, to Student B, Student G describes her reflections on the course saying “it reawakened my interest in teaching and learning” (RJ, p. 39).

As is the case throughout the interviews, Student B, who at the time of the interview is in his second year of teaching, responds to the first question with a tone of excitement, “I loved that course. I was well prepared to teach in this district because they require all teachers to be familiar with inquiry-based methods. During my interview, I felt very comfortable with the questions regarding this methodology—I was fully prepared” (RJ, p. 36). Student B adds that he attributed this preparation solely to Dr. B’s secondary science methods course in sharing that he was not exposed to any of these teaching concepts in other courses. Student E, who went on to become a National Board Certified teacher, shares with me that she believes Dr. B’s course prepared her for the testing and the many other requirements for National Certification. (RJ, p. 25).

In describing how Dr. B’s course differs from other courses, Students C and D indicate that they derived much value from Dr. B’s class indicating this is not the case with all their teacher preparation courses. Both of these students said the inquiry-based methods approach taken by Dr. B provides “lots more hands-on learning” and Student C indicates that the most helpful aspect of the course is “demonstrating the variety of different learning styles and observing the inquiry-based approach” (RJ, p. 21). Students E and G highlight the trips to area high schools where they participate and talk to “outstanding teachers” as being most helpful (RJ, p. 25; p. 39). Both of these students
share that they enjoyed the experiences these trips provided and said that the trips gave them ideas on different teaching styles for their classrooms. Student G also states there are so many helpful aspects of the course that it is hard to narrow an answer to one; she states emphatically that there are not any aspects of the course that are not helpful. (RJ, p. 39).

All of the students who participated in this follow-up study imply that they could not express any aspects of Dr. B’s course that are not helpful with the exception of two students who had what appear to be very minor concerns. One student indicates that there are some slight difficulties with computers. Student E describes a lesson regarding the use of the CD ROM as one where there are computer difficulties and exploring the lesson ended up being cumbersome. After some thoughtful delay, another student, Student A, indicates that his only disappointment is that “there is just not enough time in using many of the concepts shared by Dr. B” (RJ, p. 43).

Having explored the more general aspects of the participant’s perspectives on Dr. B’s course and exploring which aspects are reported by the students as being most or least helpful, the next section of this report is focused on the second area of questioning which is related to the college students’ beliefs and perspectives.

**Role of Beliefs and Reflections**

As noted in earlier chapters, what teachers believe with regard to their teaching and learning will drive their practice (Blake, 2002; Clark & Peterson, 1986; Kagan, 1992; Nespor, 1987). Pajares (1992), as reported in Chapter 2, echoes the importance of beliefs:

> Few would argue that the beliefs teachers hold influence their perceptions and judgments, which, in turn, affect their behavior in the classroom, or that understanding the belief structure of teachers and teacher candidates is essential to improving their professional preparation and teaching practices (p. 307).

Despite widespread agreement regarding the impact of teacher’s beliefs on classroom practice, Blake (2002) reminds us that, while inquiry into the topic of teacher beliefs is central to a complete and useful understanding of the thought processes of teaching, research on teachers’ implicit beliefs is considered the smallest and youngest part of the literature (p. 35). Notwithstanding Blake’s reminder many educators do agree that teachers’ beliefs may in some way affect teachers’ instructional practice (Fullan, 1991; Hargreaves, 1994; Intrator, 2002; Lee & Yager, 1986; Nespor, 1987; Pajares, 1992; Palmer, 2000; Richardson & Anders, 1994). In exploring the role of beliefs and reflection in this follow-up study, I pose four questions to the students. These questions are: What influence, if any, did this science methods class have on how you think about teaching? How has reflection (reflecting on your teaching practices) affected your teaching? What personal beliefs that you hold influence the way you teach? From your perspective, how does an inquiry-based approach to teaching science differ from other approaches? Tables, 5-4, 5-5, 5-6, and 5-7 provide the students’ comments that illustrate what is believed by me to be the essence of what the students stated when responding to these four questions.
Table 5-4. What influence, if any, did this science methods class have on how you think about teaching?

<table>
<thead>
<tr>
<th>Student A</th>
<th>I discovered that utilizing technology and questioning in the classroom is more important than I realized.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student B</td>
<td>I began to realize how much more effective student-centered teaching is for the students than is teacher-centered teaching, and I realized how many courses are really teacher-centered. The course helped me recognize the importance of encouraging individual student designs and answers rather than always stating the correct answer for the students after they have tried just once. The course underscored for me that freedom from traditional structured teaching was a good thing and how much more effective it could be.</td>
</tr>
<tr>
<td>Student C</td>
<td>It gave me a fresher approach to my teaching, inspired me, much more realistic and many more hands-on methods to teaching.</td>
</tr>
<tr>
<td>Student E</td>
<td>It made me recognize the importance of incorporating reflection into teaching practice which is what I have tried to do. The course influenced my thinking quite a bit in that it made me recognize that we have to find a way to make science enjoyable for all students. Building a community of learners became an important area of focus and one that I still concentrate on.</td>
</tr>
<tr>
<td>Student F</td>
<td>Mentoring became important in my teaching and in my planning. Provided inspiration for engaging more student participation</td>
</tr>
<tr>
<td>Student G</td>
<td>Found ways to inspire me and my students</td>
</tr>
</tbody>
</table>

Student A did not have any classroom teaching experience before participating in Dr. B’s course. As already stated, he is pursuing a second career as a classroom teacher, and according to him, his use of technology in the classroom seems to provide his students with positive experiences and with a real sense of excitement for him and his students. He shares, in response to this third question, that this course makes him realize how important technology in the classroom is for student learning; something he had not understood previously.

Student B’s description of the influences of Dr. B’s course on his thinking are quite moving for me. His voice during the interview is very strong in relaying how profoundly this course has changed his conception of a teachers’ role. Student B describes that as a result of participating in Dr. B’s course, he is trying to emulate in his current practice the ideas set forth by Dr. B in the secondary science methods course. He describes his teaching experience prior to Dr. B’s course as more teacher-centered and because he believes his views on teaching are greatly expanded by Dr. B’s class, he is
now working towards a more student-centered learning environment. Student C in response to this question on the impact of the course states, “the course gave me a fresher look, more hands-on, more realistic view of how to improve teaching” (RJ, p. 21). She also relays that the influences of Dr. B are exactly what she needed at the time from a practical point of view and confirms that she believes teachers are more likely to change their practices when the needs of students become an area of focus. Student C indicates that Dr. B’s course really helped her think through the needs of the students. (RJ, p. 21)

Student E describes the impact of the science teacher methods course, “The course influenced my thinking quite a bit. I try to focus on making science fun and I now try to convince my students that they can learn, they can do experiments. I think about my classes all the time, evaluating the day’s lessons and modifying them accordingly” (RJ, p. 25).

The desire for building a community of learners is reported by several of the students I interviewed as an area of impact and influence. Student E describes her current role as a coach and leader working with lower level students in a Drop-Out Prevention program. She relays that her students have “self-esteem and self-confidence issues regarding their abilities to learn and that I constantly encourage them to do their best” (RJ, p. 25). She shares with me that she needs ways to boost them up about their beliefs in their capabilities to learn and that Dr. B’s course gives her many ideas as to how to provide her students with hands-on activities where there are many opportunities for learning successes. Another student reports that while working with an intern assigned to him, he is much more aware of the importance of mentoring and providing individualized opportunities for the intern’s learning. He attributes this heightened sense of awareness to Dr. B’s course and how she stresses the importance of mentoring.

Most of the students comment that the structure of Dr. B’s science methods class provides them with an impetus to change their classroom practices by varying from a more traditional didactic teaching approach to a more student centered environment and teaching approach. Student G shares that she was specifically inspired by Dr. B’s course to diversify her teaching methods and engage students more fully in their own learning.

As I previously mentioned, having enough time for thinking back or reflecting regularly on one’s teaching is viewed as a luxury for the few; however, it seems plausible that real or lasting educational change is dependent heavily on reflection (Loucks-Horsley, Hewson, Love, and Stiles, 1998; Richardson & Anders, 1994). This topic and recommendations related to reflection are explored in Chapter 6. Reflecting on one’s practices may create a burning platform for change and reflecting on the positives, negatives and the neutrals of past behaviors, personal or professional, can be a powerful catalyst for the genesis of change (Hargreaves & Fullan, 1992; Hargreaves 1994). The responses by the participants in this follow-up study as illustrated in Table 5-5 appear to confirm that reflection plays a significant role in creating educational change.
Table 5-5. How has reflection (reflecting on your teaching practices) affected your teaching?

<table>
<thead>
<tr>
<th>Student</th>
<th>Reflection on Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student A</strong></td>
<td>I believe reflection has improved the quality of my lessons - it gives me the opportunity to say to myself “what went right,” “what went wrong” Reflection helps me feel free from the disappointments of the previous day</td>
</tr>
<tr>
<td><strong>Student B</strong></td>
<td>It helped move my teaching toward more student-centered lessons because I would always ask myself daily, “did I do things because I liked it, it was easy, it kept the kids occupied or were my lessons focused on the students and their needs?”</td>
</tr>
<tr>
<td><strong>Student C</strong></td>
<td>– Gives me the avenue to build on small successes and make small goals</td>
</tr>
<tr>
<td><strong>Student E</strong></td>
<td>My daily practice of reflection has provided me with more creative and fresh ideas Reflection has given me the opportunity to really think about how I am teaching</td>
</tr>
<tr>
<td><strong>Student F</strong></td>
<td>– Reflection is daily and continuous provides the venue for change</td>
</tr>
<tr>
<td><strong>Student G</strong></td>
<td>– Over time reflection was a catalyst to restructured curriculum and activities to better accommodate individual learners and their needs. It seems to keep me from getting burned out by forcing me to ask, “why are you doing this –what are you trying to accomplish?”</td>
</tr>
</tbody>
</table>

Student A indicates that this change to his practice is possible only through regular reflection and practice. (RJ, p. 43) Student B shares that he uses reflection daily as a focus for making change. He states he wants to continue getting more comfortable in shifting his perspective from one of believing he has to have all of the answers to one where he can encourage students to find their answers with his guidance and direction. (RJ, p. 37)

Student C explains that her students are a challenge and that she finds a “need for reflection daily to keep inspired, free from the disappointments of the previous day, and fresh with new ideas for motivating and challenging my students.” She adds, “reflection keeps me fresh, thinking about my classes, students, and my role as a teacher, and it keeps me from getting burned out, this (reflection) keeps my practice exciting and new” (RJ, p. 22).

Student C also shares that reflection plays an important part in designing her lessons through building on student’s previous successes. She expresses that she believes her students have been lost in the educational system that they lack confidence in learning, and that reflecting on her day helps her identify lessons that can be built on other successful lessons thus giving students the encouragement they need. I am particularly impressed, despite having only two years of teaching experience that Student
C is able to articulate the value she places on reflection. I often wonder to what degree did Student C’s current teaching assignment (high school drop-out prevention) contribute to the importance she placed on reflection and to what degree did Dr. B’s course contribute to this belief. (RJ, p. 22) Student A explains that reflection provides him creative time to design lessons that incorporate technology. (RJ, p. 44) Similar to Student A, Student E states that reflection helps her take note of her teaching style. She indicates that through reflection she discovers that her often used traditional type teaching strategy really is not igniting a passion in her students for lifelong learning. (RJ, p. 25)

Throughout the last several pages, I share with the reader the perspectives of the participants, and I explore the role of beliefs regarding the impact of the science methods course on how they think about teaching and how they view the role of reflection. I now turn to the third question in this second area of focus: What personal beliefs do you hold that might influence the way you teach?

Table 5-6. What personal beliefs do you hold that might influence the way that you teach?

<table>
<thead>
<tr>
<th>Student A</th>
<th>I believe inquiry-based teaching is very challenging. Perseverance and dedication is key to success in any arena. Change is difficult and most of us tend to resist change.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student B</td>
<td>Students learn best when motivated to learn and good teachers motivate their students. Students seem to learn best through activities that are hands-on although I believe lecturing and approaches that are more traditional are easier and at times appropriate.</td>
</tr>
<tr>
<td>Student C</td>
<td>All students can learn, I have to learn to let them feel “I can do this”</td>
</tr>
<tr>
<td>Student E</td>
<td>I believe letting go of control and allowing students the opportunity to struggle (invest in their learning) is the best teaching approach but is very hard for me to do. Inquiry-based learning is more difficult to transition into after becoming accustomed to a more traditional approach.</td>
</tr>
<tr>
<td>Student F</td>
<td>I strongly believe that all students can learn with appropriate guidance. Students need guidance from the teacher on a regular basis.</td>
</tr>
<tr>
<td>Student G</td>
<td>Exploring students’ prior knowledge is critical before introducing new material.</td>
</tr>
</tbody>
</table>

88
Student A seems very excited about his role as an educator and about having the opportunity to affect the lives of students; however, he relays to me that he is still developing confidence in his abilities using inquiry-based teaching. He also shares that he believes “teaching using inquiry is a challenge, just gotta [sic] stick with it.” Student A said it became clearer to him that as he spent more time in the classroom he recognizes that there are many constraints and challenges, which he has to overcome. These constraints and challenges include limited time available for all lessons, the normal disruptions of being in a large setting and the number of students one has to “deal” with using a variety of methods.

Two students, Student E and F, believe that their strong comfort with a traditional type teaching approach make incorporating inquiry-based methods somewhat difficult stating that “inquiry-based teaching is somewhat difficult to transition into after becoming accustomed to a more traditional approach” (RJ, p. 25). One follow-up study participant, when describing her classroom, reports that it is “harder to get kids to go off the beaten path and to discover on their own.” She also states,

It was hard for me personally to let go of control and let the students play with the ideas because for so long I believed that teachers should have control and should be actively directing learning. I know I would use inquiry-based methods much more frequently if I didn’t struggle with this belief. I also know that when I do let go of control of having direct guidance, most times students meet with success and are excited about their success. (RJ, p. 26)

Students A and E also express some apprehension regarding their feeling of letting go of direct control and yet they also are very positive about their observations that students do overcome struggles when determining some of their own learning. Other participants voice similar struggles in standing back, away from providing the correct answer, watching, listening, waiting, and guiding as students request help. These struggles are described as counter to the participants’ traditional framework but consistent with their own emerging practices. Students A and E also share that from their experiences in Dr. B’s course that although they know all the advantages of inquiry-based methods, the beliefs they held for so long and the way in which they were taught did cause some level of mental conflict when implementing inquiry-based teaching. These challenges and belief struggles these participants describe seem consistent with what Blake (2002) describes as intent within the enactment of science,

Teachers do struggle with the tension of allowing students opportunities to explore on their own and to guide them to predetermined goals set forth by the curriculum. Hence, the balance that a teacher strikes between the need for content through direct teaching, along with allowing for student-centered learning, is considered what the National Science Education Standards, determine as ..enacted curriculum-the planned curriculum as it is modified and shaped by the interactions of students, teachers, materials, and daily life in the classroom. (p. 187; p. II-10)
All of the college students interviewed report that they believed when using hands-on activities students become more involved in their own learning, and that when using inquiry-based teaching approaches, all students can learn at some level. Believing that “all students can learn at some level” has important implications in light of the Florida Comprehensive Assessment Test (FCAT). This area is explored in the next chapter.

An additional area of investigation in this follow-up study focused on determining what the students in this follow-up study view as different in inquiry-based teaching as compared to other approaches. The insights from the teachers interviewed about their perspectives on inquiry-based teaching, as reported in Table 5-7, are both interesting and rewarding for me. The college students in reporting on how inquiry-based teaching is different from other approaches emphasized the tremendous positive difference with inquiry teaching and the many benefits to the students using this type of teaching. One participant, Student G, states, “Doing inquiry can be complicated” because of the level of questioning involved, the time factor can be large yet it is a very worthwhile effort. (RJ, p. 40) Although some of the participants indicate that inquiry-based teaching is not an effective approach for all lessons, they all indicate that their students seem to enjoy this type of teaching more than note taking, memorization, and a more traditional type approach to teaching.

Table 5-7. From your perspective, how does an inquiry-based approach to teaching science differ from other approaches?

<table>
<thead>
<tr>
<th>Student A</th>
<th>Inquiry-based teaching is atypical from other approaches, more time intensive – very worthwhile though. Students are more actively involved in the process of learning science.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student B</td>
<td>Less teacher directed and more student experiential learning thus students seem to really engage. Very different from note taking and rote memorization. Raised the level of engagement initially, frustrating for students to change to a different learning style.</td>
</tr>
<tr>
<td>Student C</td>
<td>Students experience a WOW effect that typically would not happen with other approaches- not as effective with every lesson. Students are taught to learn from mistakes as well as from successes and that “being right” is good but “being wrong” provides an opportunity for more learning.</td>
</tr>
<tr>
<td>Student E</td>
<td>Difficult for some students to be self-reliant and to learn from all their experiences – self-reliance is less of an issue in traditional type teaching methodologies yet students do overcome their struggles with inquiry. Students have to reorient themselves to their role as a learner and many are not comfortable with not being told what to do.</td>
</tr>
<tr>
<td>Student F</td>
<td>In inquiry-based teaching, students learn concepts with hands-on activities-more student focused – may not be equally effective with all lessons. At times more difficult to prepare and facilitate inquiry-based lessons than traditional type teaching. Flexibility is key</td>
</tr>
<tr>
<td>Student G</td>
<td>Doing inquiry is very complicated yet very worthwhile.</td>
</tr>
</tbody>
</table>
Student C states that her students are thrilled when they make the connection with the concept she is trying to have the students discover. She adds that after a struggle they experience the “WOW” effect, which she said does not happen with other types of teaching approaches. Some of the students express that the inquiry-based method of teaching despite being worthwhile is different and at times somewhat harder in that, it requires more flexibility with the students. One college student shares that this method is different in that students have to “reorient themselves to their role as a learner” because they are not being told what to do and students at times find this difficult. She adds that inquiry requires the students to think and participate in the process of learning. Student B finds teaching through inquiry “raised the level of engagement initially, but that at times students could become frustrated because they have to adjust to a change in learning methods within a specific course” (RJ, p. 37). To help alleviate with some of the frustration, he often uses other students’ work as models and examples to give the class different ideas to instill confidence and motivation. Also Student B expresses that he is confident using, and enjoys teaching with an inquiry-based teaching approach.

The Impact of College Students’ Teaching

In exploring the role of teacher beliefs on teaching practice and educational change in previous chapters, I present several premises regarding contextual influences on teacher decision making during curriculum enactment. This notion of context according to Oakes (1985, 1990) and Sizer (1985) can have a great influence on the decisions that teachers make with regard to their choices for instruction. Blake (2002) reports:

Constraints relating to the classroom context, overcrowding, curricular mandates, and teacher time in the classroom all influence the decisions a teacher makes in regard to their practice. These contextual components may be many and can include teacher beliefs, experiences, knowledge, expectations, and attitudes toward teaching and learning (p. 40).

In response to the question, “Can you describe a lesson that you have taught that incorporates the aspects of inquiry you learned in the science methods course?” many of the participants provide a description of their learners and their inquiry-based lessons with much pride in their voices. Each student/teacher also shares contextual type references ranging from the students in their classes and their own belief systems, the varying levels of parental support, the availability of administrative support, their principal, requirements, and their students’ socioeconomic background. Additionally, each student indicates that some of these contextual factors influence the frequency of using inquiry-based lessons.

Tables 5-8 and 5-9 below highlight the participants’ responses when asked to describe a lesson using inquiry and when asked to indicate the frequency in which they used an inquiry-based approach.
Table 5-8. Can you describe a lesson that you have taught that incorporates the aspects of inquiry you learned about in the science methods course?

<table>
<thead>
<tr>
<th>Student A</th>
<th>“I posed a question, which was broad based, and open-ended for a laboratory assignment, it incorporated creative/higher order thinking for the students and was loosely guided to allow for individual solutions to the posed problem. My role was to mediate and moderate the lesson, coach the process.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student B</td>
<td>A lesson on the absorbency of paper. Several types of paper and liquids were provided for the students and the students were asked about which paper absorbs which liquid the best. The students were free to design the method to test for this question and work on the problem, My role was to guide, watch, help them learn and learn from them.</td>
</tr>
<tr>
<td>Student C</td>
<td>I planned a lesson where students were part of the process of making connections to math via “Connected Math”. Students were asked a general question, and they come up with the different processes to the answer or the “WOW”. I provide the examples early in the year, materials and the space, they problem solve with the unit that we’ve been covering.</td>
</tr>
<tr>
<td>Student E</td>
<td>The class conducted a Bottle Rocket Lab last year. Two boys in the class were so incredibly excited with the information they found on the Internet. They designed their own rocket, tested the design, modified, then we launched it in class. You could see students’ enthusiasm. All the students had to use the information from the boys and from the rocket experiment to discover answers about how the rocket was constructed and what made it fly. The success experienced, “I believe carried over to the other students.” The class conducted a White Powder Lab-lots of powder to test, students play, have fun with the mixing, they come up with the test—sort of like the “Foam activity with Dr. B” (Barnes &amp; Foley, 1999). They record different reactions, record the analyses and come to their conclusions to share with the group.</td>
</tr>
<tr>
<td>Student F</td>
<td>In my current role as a student and as a TA for two semesters, I am mentoring a high school biology student from a local public magnet science school. Her placement is in the laboratory on campus with me, I designed a study and she will be in charge of data collection and analysis.</td>
</tr>
</tbody>
</table>
Table 5-9. How often do you teach using inquiry-based methods?

<table>
<thead>
<tr>
<th>Student A</th>
<th>indicated they used inquiry—stating this type of teaching has so many advantages for the students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student B</td>
<td>indicated one inquiry laboratory per unit or every three-four weeks and probably teach inquiry-based lessons once a week.</td>
</tr>
<tr>
<td>Student C</td>
<td>indicated they used inquiry daily and every new lesson - typically once a week and more often using just some aspects of inquiry- trying to build a community of learners</td>
</tr>
<tr>
<td>Student E</td>
<td>three labs per quarter or about monthly</td>
</tr>
<tr>
<td>Student F</td>
<td>use of inquiry varied, but usually monthly</td>
</tr>
<tr>
<td>Student G</td>
<td>indicated that they used inquiry at least weekly</td>
</tr>
</tbody>
</table>

Student B explains that his current school district adopted inquiry-based teaching methods as an area on which to concentrate, and that he was selected to assist with further development of several of his past lessons for statewide use. Responding to the question in Table 5-9, Student B states that his best lessons seem to be when he poses open-ended questions whereby the students design “testing” methods on their own and then test possible solutions. (RJ, p. 37) Another lesson described by one student includes involving students in the design of a science experiment early in the year, conducting the experiment and then assessing the experiment by using questions leading to reflection. Throughout the year, this activity is repeated but built on previous aspects and learning. The participant indicates using this model repeatedly throughout the school year and it connects to the learners’ prior knowledge, encourages reflection and reinforces the content of the earlier lessons. To emphasize and encourage the building of a classroom that reflects a community of learners, Student C reports that she evaluates her students individually and as a team and she assesses them on both the process they use as a team and the product they end up with. (RJ, p. 22) It seems clear to me that this student is influenced by Dr. B’s notion of building a community of learners.

Student E indicates it is difficult for some students to be self-reliant, describes a lesson with much excitement in her voice. As she told the story, I could not help but make connections to my past experiences in science classrooms where I knew the sounds and sights of student’s excitement and enthusiasm as they took charge of their learning. Student E describes her lesson as “the two boys were so excited when they used the internet to find an activity where they would design, build and test a model rocket. I approved their plan and watched them day to day as they set about working, getting the rocket built, testing the model, reworking and on the final day of the launch, the class
dressed as astronauts, we had a space day. The enthusiasm has a big carry over value to the other students” (RJ, p. 25).

Student B stresses the importance of motivation and worked diligently to achieve a student-centered classroom environment, had a lesson related to the absorbency of paper posted on the state website. His lesson is selected as the state lesson for inquiry. He describes his role for this lesson as one who guides, coaches, and watches. (RJ, p. 37)

Student A stresses the importance of discussion in inquiry-based teaching stating, “Whenever we finish an activity, there is always a discussion. (RJ, p. 44). Student F, who emphasizes the importance of mentoring in our discussion, indicates that his mentee uses data collection methods and analyses for a study he has designed. His role is to guide, coach and at times direct. (RJ, p. 27)

I did explore with the participants that it seems like there could be a widely varied frequency among teachers using inquiry-based teaching. Several participants indicate that the classroom environment, varied time constraints and lesson topics often influenced the specific frequency of this method. Where the students choose the topic of the class, develop the questions, design an experiment, set up and test their questions, re-test and assess their learning – indeed all of this can be very time-consuming and yet very rewarding.

**Participant’s Enactment of Inquiry-Based Teaching**

Research suggests that teachers readily embrace change when the implications for student benefit are the primary motivators (Guskey, 1986). If knowledge is based on constructions, thoughts, and belief frameworks, it logically follows that the processes of change depend upon teachers, teacher educators’ thoughts, beliefs, and the influence of these thoughts and beliefs on the choices and strategies they use in their classrooms.

As referenced earlier, inquiry is a term defined by the National Science Education Standards (NRC, 1996) and refers to the “diverse ways in which scientists study the natural world and propose explanations based on 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). For the purposes of this follow-up study, the term inquiry-based curriculum in science teaching refers to the many processes and scientific skills associated with: observation, inference, record keeping, sharing of results, and experimentation combined with scientific knowledge and critical thinking skills. Six of the seven interviewed participants state that their learners were excited and loved the inquiry approach. Challenged, engaged, fascinated, eager, and inspired are words used by the participants to describe how their students react when engaged in an inquiry oriented activity. Thus, the following discussion may seem familiar to those who have experience with science teaching.

For some students, the inquiry-based teaching method seems to spur unlimited questions as students inspire other students to ask questions. Student A encourages his classroom students to list questions at the beginning of the year that the class could explore through inquiry throughout the year. He states that he believes that by listing these questions, the students immediately are affirmed that their ideas and thoughts are
important and that they have a say on what we explore. Similarly, to what Dr. B did with
her college students, one college student implements the student-teacher interview
process in her classroom. By doing so, she reports her students could reflect on their level
of learning and engagement in the class. She believes that this approach provides an
opportunity for coaching and individual assessment of the needs of the learner.

Table 5-10. What student impacts, if any, have you observed when using inquiry-based
approach to teaching science?

<table>
<thead>
<tr>
<th>Student A</th>
<th>Classroom students love to ask questions—they seem much more involved in learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student B</td>
<td>Students share ideas more freely with each other. Students are and feel they are part of the process of learning. Student interest in activities is held longer then it loses their interest. Some students experience frustration perhaps because of less structure than when more direct teaching is taking place.</td>
</tr>
<tr>
<td>Student C</td>
<td>Some students are slow to adjust to change, thus inquiry-based teaching takes sometime for some students to get comfortable.</td>
</tr>
<tr>
<td>Student E</td>
<td>Teachers can implement student ideas to build more learning from their ideas thus seeming to build their self-confidence. Students experience learning with more excitement than other methods.</td>
</tr>
<tr>
<td>Student F</td>
<td>Students not familiar with this style they are more familiar with teacher-centered—Inquiry at times becomes a trial and error with them—They learn from mistakes.</td>
</tr>
<tr>
<td>Student G</td>
<td>Students can see, touch, and hear science, thus student retention is stronger.</td>
</tr>
</tbody>
</table>

All participants, in this follow-up study seemingly express what Blake (2002) states regarding incorporating the aspects of inquiry-based teaching, that regardless of the perceived ability level of their students that all children can learn. Several of the participants express the view that initially some of their learners have to struggle with inquiry-based learning activities and report that they let the struggle happen and unfold until the learners in their classrooms work out their frustrations in a variety of ways. For example, one college student will help assuage student frustration by using follow up questions designed to provide additional guidance. According to several of this follow up
studies participants, many students are not used to being a part of a community of learners. Being comfortable with learning from each other and with each other through trial and error is a process that occurs through the year.

In hearing these experiences of these teachers, I am both fascinated and left to wonder what so many science classrooms must be like without the enthusiastic willingness to engage in inquiry-based teaching methods. For those seven participants who so graciously gave their time and openly shared their experiences, I do hope for them what Nespor (1987) so eloquently states (in Blake 2002) that a person’s memory can serve as a template for future action and that revealing these memories through interviews can provide insight into one’s belief structure that guides their practice.
This study has a focus on the nature of inquiry, the enactment of inquiry-based teaching, the role of beliefs, and the role that reflection has in the practice of university teaching. The reasons for focusing on these dimensions of teaching are to improve the efficacy of science education and to meet the challenges of science education reform.

For many years changing curriculum was the key to the effective reform of science education and yet Yager and Lutz (1994) remind us that “changes in teaching, not curriculum are the key to effective reform” (p. 338). This study underscores what I believe to be critical elements in effectual science teaching.

The importance of this type of research is noted by Lederman (as cited in Southerland, Gess-Newsome, and Johnson, 2003):

The importance of teachers’ instructional intentions and students’ perceptions of classroom tasks has been virtually ignored in research on the nature of science. It is not adequate to simply observe a teacher and draw inferences without also investigating the teachers’ intentions and the reasons for instructional decisions. (p. 352)

To more fully address the goals of reform with a focus on the enactment of inquiry-based science teaching, the role of beliefs, and reflection it is valuable to investigate through dialogue, structured discussions and a lens which I call reflectional inquiry. This lens gave Dr. B, the participating university professor, the opportunity to express, reflect, share, and build meaning as she was enacting inquiry on a deeper level.

In this concluding chapter of this study, I underscore for the reader that the heart of this research effort is in keeping with advancing the goal of science education reform: to enable inquiry-based approaches to teaching science that emphasize learning how to learn, that begins with the exploration of a particular phenomenon, and that delays the teaching of terms and principles until they are needed. This dissertation Science Teacher Educator Change: A Case Study Report describes an investigation of teacher educator change that began as a pilot study, designed to describe and analyze changes in university teaching. The beliefs and frameworks that influence the changes in a university professor enacting a deeper aspect of inquiry-based teaching is the primary focus of this study.

While conducting the observations and interviews for the pilot study, it became apparent that extending the investigation beyond the primary participant would provide a more comprehensive description of the impact of inquiry-based teaching on teacher
educator change. A follow-up study with seven of the participants who are currently K-12 teachers provide the lens for understanding the influence and impacts that this secondary science methods course had on the participants and their current classrooms.

This concluding chapter reviews the findings and connects with the existing literature and existing practices. The chapter describes the implications of the findings from my perspectives and is followed by a brief dialogue related to future research in this area. I conclude this chapter by sharing with the reader the influences and impacts that this research has had on me and lastly — what I learned from the journey that I took with a group of willing and giving participants, to whom I am eternally grateful.

In addition to observations of Dr. B, I focus on the classroom context, the reactions of the students, and the nature of the enacted curriculum. The intentions driving the observations that I note were investigated through weekly interviews and debriefing sessions throughout the course and continue to be a part of the dialogue with Dr. B and me. The consequences and importance of this opportunity is underscored by Erickson (1994) who states that social facts are embedded in social action; just as social meaning is constituted by what people do in everyday life. These meanings are most often discovered:

By hanging around and watching people carefully and asking them why they do what they do. . . [Given] this orientation toward social meaning as embedded in the concrete, particular doings of people, qualitative researchers are reluctant to see attributes of the doing abstracted from the scene of social action and counted out of context. (p. 58)

I owe a great debt to Dr. B and so many others, for the opportunity to observe and to “hang around”, and ask many questions in the context of which I was investigating. To have the opportunity to take a set of observations and explore the mental frameworks that drove Dr. B’s behaviors that I observed is a remarkably rewarding experience.

The Secondary Science Methods Course-A Review

_Inquiry_ is a term defined by the National Science Education Standards (NSES, [NRC], 1996) and refers to the “diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work.” The reader will recall that “inquiry also refers to the activities of students whereby they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world” (NRC, 1996, p. 23). This definition reflects the essence of how Dr. B and I perceive science teaching and it is the definition that serves as a guiding framework for Dr. B in her journey to reform her secondary science methods course.

In organizing and categorizing my observations and interactions with Dr. B and her students using the Professional Development Design Process for Mathematics and Science Education Reform (PDDPMSR, Loucks-Horsley et al., 1998) four general
themes emerge that I use as a format for sharing my experiences and perspectives. As referenced previously, to provide a framework for sharing my observations, constructions, recurring themes, and for providing personal insight, I draw heavily on the PDDPMSR Model, Figure 3-1 in Chapter 3. This model is instructive in understanding the confluence of factors on change to include the role of self-reflection and beliefs, knowledge, critical issues, context, goal setting, planning and doing. Readers may note that the PDDPMSR Model is similar in focus to a widely accepted model in corporations for continuous improvement and for leading large scale change (M. L. McLaughlin, personal communication, April 15, 2002).

The first theme, viewed as the overarching theme, is the Nature of Learning and Learners. Loucks-Horsley, et al., 1998 describe this theme as an intensely personal activity that is imbedded in and enabled by social interaction. Reported include the beliefs Dr. B holds about teaching and the theoretical framework she subscribes to related to educational practices.

Dr. B repeatedly demonstrates, through conversations, behaviors, her syllabus for this course, and her modeling and coaching, the beliefs she holds about the Nature of Learning and Learners. These beliefs include: the importance she places on building a personal relationship with her students, the importance of communicating in science environments, the criticality of experiencing inquiry, the importance of encouraging the practice of reflection by all participants, and the importance of providing mentoring for developing teachers in schools. The need for teachers to consider minority, gender, ethnic, and attendance issues in their classrooms, to acknowledge the significance and importance of methods courses, for building collaboration and a community of learners, to provide coaching and, to facilitate observations of “best practice teachers” are also included as important findings within the Nature of Learning and Learners theme. Dr. B values the teaching of science in schools, and she focuses much of her energy and devotes an enormous amount of time to improve her secondary science methods course. I frequently note the strong vision Dr. B holds regarding the changes for the secondary science methods course and for change in science education, which result in teaching practices and facilitate student learning in their K-12 classrooms.

We know from many data sources (Blake, 2002; Dewey, 1933; Kagan, 1992; Nespor, 1987; Richardson & Anders, 1994; Siegel, 1985; Spradley, 1972), beliefs play a major role in a teacher’s behavior. We know that beliefs play an important role in perception of self-efficacy and additionally, as Yero (2002) notes, we recognize that belief systems can serve as regulators of how much effort and energy a teacher will expend on activities. Dr. B’s firmly held belief that through her secondary science methods course, she makes a difference in many classrooms in many schools was manifested in the care in which she taught this class. In Chapter 5, the impact of Dr. B’s beliefs, her caring and her energy are reported. Dr. B’s conviction that through her teaching practices she could be a catalyst for educational reform with individuals who would in their own teaching careers touch the lives of so many learners is in many ways very humbling for me. The cascading of real educational change that results in the improvement of science education through generations of students is indeed an accomplishment for all and any of us who call ourselves educators.
The second theme, *Reflection and Relationship Building*, emphasizes the importance of self-reflection in improving the practice of teaching. Prominent points under this theme include: 1) How beliefs influence action? 2) How self-reflection is critical for true and real change to take place? 3) How building relationships for input and peer critique can assist in the process of bringing about positive change? and 4) How varying assignments will positively influence student learning? Additional reports under this theme are: 1) The role of best practice observations as fuel for thought for reflection and the implementation of educational change; 2) The use of stories to build relationships and opportunities for thinking differently; 3) The way teachers shifting their focus from achieving a predetermined stopping point for each class can bring about change; and 4) The importance of greater time for reflection. These individual teaching behaviors observed, cited and described by the participants including their assertions that reflection play a key role in their efforts to “make the next day” better than “today” are cogent reminders that through reflection and relationship building with peers and students, positive change in classrooms and in teaching can emerge without additional curriculum mandates. Similarly, Blake (2002), Tobin and Fraser (1988), Pajares (1992) argue that education reform is predicated more on the beliefs, behaviors, and perceptions of the teacher than it is on the curriculum.

*Inquiry*, the third theme which emerged through the application of the PDPPMSR model, includes how modeling inquiry, coaching and mentoring, and the exposure to “best practices” are critical in effectively implementing inquiry-based teaching. Other observations are: 1) That inquiry is perceived to maintain the interest level of students; 2) That flexible field assignments and field trips help to build a community of learners; 3) That inquiry often takes more time than other teaching methods; and 4) That learners’ attitudes are worthy of significant consideration by the teacher. Here we are able to note the importance of process in the teaching of science without diminishing the importance of content. A more traditional view of teaching and of teaching science places a significant degree of importance on content and on the transmission of scientific knowledge. Those of us committed to implementing reform measures might be easily swayed to forgo any real concentration on, or consideration given to the body of scientific knowledge referred to as content (Hart, 2001). However, all of us, both teachers and students must live and thrive in a world and society that discusses, reports, values, and utilizes scientific principles and content as a means to describe and advance the human condition. As science educators we cannot abdicate our accountability to help ready students to thrive in this world. Yet through frameworks, beliefs and actions of Dr. B and her students, the power of the actual teaching process seems real, significant and at times seems to transcend the importance of content. Perhaps it would be best to find a way for both process and product or content to co-exist as equals; neither more important than the other.

Related to this third theme of Inquiry, the participants in the follow-up study reference the significant investment of time required for effective inquiry-based teaching and the pressures to accomplish so much in the course of a day. We know that the context of the school and district where curriculum content and guidelines are established and communicated as teacher expectations frequently result in a hindering environment for promoting critical thinking, collaborative learning and the independent exploration of
phenomena. The fundamental platforms that represent the essence of science education reform and supported by inquiry-based teaching methodologies provide significant challenges for teachers who strongly believe in these platforms and yet are constantly faced with demands and pressures of accountability and the ever-changing externally generated curricular mandates.

The fourth theme, **Science Teaching**, includes observations and interview data related to reform measures and beliefs and frameworks specific to science education. For example: 1) How the quality of science teaching depends on the subject matter expertise of the teacher; 2) How inquiry-based learning provides powerful learning experiences; 3) How the individuals experience learning can be powerful; and 4) How collaborative learning is a critical component of effective classroom teaching are noted under this fourth category. Additional issues within this **Science Teaching** theme are: 1) The amount of time that true change takes; and 2) That university methods courses should reflect more inquiry-based teaching.

The NSES (NRC, 1996) recommend that teachers of science provide students opportunities to engage actively in activities that develop knowledge and understanding. This notion seems logically generalized to the teaching of developing teachers: that pre-service teachers should spend time in methods classes developing knowledge and understanding that require active engagement. Additionally, the NSES calls for individualizing the opportunities for science learning. This is a strategy that Dr. B uses in her secondary science methods course through activities, journal writing, field observations and one-on-one meetings with each student.

**The Follow-up Study**

Reference is frequently made to the follow-up study component throughout this chapter. Thus, a brief review of this component may assist the reader, in the concluding sections of this chapter, and in making linkages to their own classrooms. The follow-up study begins in the summer of 2002 and my writing and discussions with Dr. B continue throughout 2004. I established contact with seven students in the follow-up study who were selected with the help from the Office of the Alumni Affairs at the university where the pilot study took place. At the time I interviewed the participants, all but one of these former students of Dr. B’s was teaching. Furthermore, several of the participants had relocated to another county or state. I utilized questions as a framework for discussion and as a method for optimizing my time with each participant. The questions focus the interview to the areas of educator change, reflection, beliefs, inquiry-based science teaching strategies, and the impact of Dr. B’s course on the current teacher and their K-12 students.

Without exception, all of the participants make very positive comments regarding the secondary science methods course. At least on one level it appears to me that the energy, focus, commitment, and interest that Dr. B brought to her class has made a positive and seemingly lasting impression and effect on her students, and on their classrooms. The seven participants offer feedback which I believe supports Dr. B’s stated
intentions as desired outcomes for her methods course. Regarding inquiry-based teaching and the utilization of reflection, they describe their willingness to and practices of, reflecting and adjusting their teaching practices as a consequence of this reflection.

The teachers in the follow-up study report incorporating direct teaching as appropriate and using an inquiry-based teaching method to better align their practices with the needs of the learners. They shared with me that given the myriad of internal and external demands on them that significant flexibility is required if they are to incorporate a variety of teaching strategies into their classrooms to meet the varied needs of their K-12 students. Indeed it appears that what these then students observe in, and heard from, Dr. B is being carried out in their own classrooms.

The importance of this influence and impact that Dr. B seemingly has on these seven students is best described in a captured quote by a former teacher, icon, and an American hero, Christa McCaulife. As paraphrased by Christa, who accepted the honor of being the first teacher to travel in space proudly described her career as “I get to touch the future, I teach.”

Throughout this process as I focus on Dr. B, her classroom, the college students, and ultimately those teachers in the follow-up study, I reflect many times on the true uniqueness of teaching and of the teacher. I make many mental comparisons between my own style of teaching and Dr. B’s style of teaching. We are both teachers of science possessing knowledge and experience in the field of science teaching and in science, and yet the specific way we share this content with our students is very different. Perhaps, because my teaching is at a middle school level I am more cognizant of the curricula demands that I feel obligated to meet. Therefore, I may not have the same amount of time to extend to discovery that Dr. B does.

In this research study, the role of beliefs, reflection and inquiry as a teaching methodology are areas of considerable focus. We see how Dr. B’s beliefs and the beliefs of the follow-up study participants influence, affect, and perhaps drive what each teacher stresses in their classroom and how they place different emphasis on issues and context and, react to the pressures of mandated curricula.

These differences in teaching styles, in emphasis, in methodologies have critical implications when considering the continued clarion calls for science education reform. It seems common sensical that effective schools need excellent teachers, that students deserve excellent teachers, and that the goals of science education reform should be directed at teachers and the art of teaching. Yet, as Leiberman (1995) reminds us, “teachers have often been excluded from the process, both of planning reforms and the professional development opportunities necessary to implement them” (p. 325).

Similarly, Sykes (1996) notes that more than 40 years after the 1957 recommendation by the National Society for the Study of Education that schools and their staff’s become collaborators in providing in-service education, “teachers are frequently the targets of reform, but they exert relatively little control over professional development” (p.465) armed at achieving reform.

The lack of focus on the process of teaching and perhaps the over emphasis on the content of teaching are noted by Andy Hargreaves and Michael Fullan (1992) who report, “It is what teachers think, what teachers believe and what teachers do at the level of the classroom that ultimately shapes the kind of learning that young people get” (p.218), and
by Yero (2002) whom states we have thousands of books available for teachers — written for teachers but very few about teachers.

My experience with Dr. B and with the follow-up study participants provides a “first-hand” opportunity for me to observe and hear the tremendous influence that beliefs and belief systems of teachers have in shaping the curriculum, in emphasizing personal preferences for content, the classroom and in setting the overall climate and environment of the classroom. It seems plausible to argue that in the words of Yero (2002), “We can’t have educational reform or change without a focus on how teachers think, what they believe and how they can identify and examine their own thought processes” (p.202). Those readers who teach are likely to experience “in-service” or professional development sessions where new curricular mandates are issued, and external parties, knowing little if anything about the contexts of teaching, portray these new mandates as the new “silver bullets”. Additional support for substantially increasing the role of beliefs and thinking in preparing teachers for teaching is echoed by Fullan and Hargreaves (1992) in their statement “teacher development....involves more than changing teachers’ behaviors. It also involves changing the person the teacher is” (p.220).

If we are to believe what Yero (2002) asserts that much of what teachers believe about school comes from their own experiences as students, we must accept that true reform will come as a result of continued and sustained attention to what is asserted here. We cannot expect that true reform will occur as an “event” or that true change will happen quickly. Yet George E. Deboer (1991) reminds us that inquiry, as the primary method for learning science, was advocated as far back as 1850 and so it is ironic that today, just as I assert throughout this study, the clarion call continues for enacting inquiry-based teaching methods in science teaching. Why then has it taken so long for inquiry to “make significant headway” as a preferred or widely used method for teaching science? It seems plausible to argue that true change does take time and not all ideas that ultimately flourish, flourish at the same time. It also seems plausible to argue that the social and theoretical perspectives that prevailed throughout most of the twentieth century better supported the more traditional methods of teaching. The long held belief that knowledge is stable, objective, eternal, and relatively unchanging, is often referred to as objectivism. This likely manifests itself in the belief that knowledge could be transmitted and that lecturing and closely directing students’ learning is viewed as an efficient means of transmission. Jonassen (1991) presents another view of objectivism in the following summary:

Knowledge is stable because the essential properties of objects are knowable and relatively unchanging. The important metaphysical assumption of objectivism is that the world is real, it is structured, and that structure can be modeled for the learner. Objectivism holds that the purpose of the mind is to mirror that reality and its structure through thought processes that are analyzable and decomposable. The meaning that is produced by these thought processes is external to the understander, and it is determined by the structure of the real world (p. 28).
Expanding this objectivist perspective to a view of learning, Jonassen (1991) shares that: “Objectivists believe in the existence of reliable knowledge about the world. As learners, the goal is to gain this knowledge; as educators, to transmit it” (p. 28). The road to more widespread acceptance of inquiry is likely lengthened by the ethos of scientific management, which dominated businesses and industries for many decades after World War I, and penetrated American schools. This leads to believing students were “raw material” to be processed in the school “plant” (Guba & Lincoln, 1989, p. 25). Moreover, the long life of traditional teaching methods that met the expectations of families and communities that teachers and schools build knowledgeable citizens with strong moral character. This may seem easier when teachers deliver information and the students receive it.

Despite the initial call for inquiry-based teaching which was made over 150 years ago, I do believe there is much reason to hope that this method may be well on its way to finding its niche in our system of education. In the last 20 years, our understanding of how individuals learn has significantly changed (Northwest Regional Laboratory [NWRL], 1999). We see the emergence of a new paradigm called constructivism. Arguably, constructivism is described by a multitude of views, perspectives, and definitions. This paradigm of constructivism, whose descriptions are well beyond the scope of this study and in sharp contrast to objectivism, emphasizes the individual construction of knowledge. This paradigm also allows for the existence of multiple truths and where learning is concerned, concept development and deep understanding are primary areas of focus (Fosnot, 1996) in learning. In the constructivist paradigm, learning emphasizes the process and not the product (von Glasersfeld, 1996) and making sense of one’s experienced world takes the place of learning the so-called “objective truths.” From a constructivist perspective, as argued by von Glasersfeld (1995) learning requires “self-regulation and the building of conceptual structures through reflection and abstraction” (p.14). Jonassen (1991) like von Glasersfeld, in describing constructivist learning environments notes the importance of real-world environments in learning, the role of the teacher as coach, the importance of negotiating goals and objectives rather than imposing them and allowing for the internal control of learning. Thus, it does seem reasonable to believe that the theoretical concepts and constructs associated with a constructivist paradigm may help accelerate the relatively slow, wide spread implementation of inquiry-based approaches to teaching science.

Yet, regardless of the speed in which inquiry comes to enjoy widespread acceptance, we must recognize that the complexity of enacting an inquiry-based approach to teaching science, what is called for in the measures for reform with regard to public secondary science classrooms, and what is made more difficult and complicated in light of the increasing acceptance of standardized tests as a measure of student learning and thus of teacher and school effectiveness. In many ways we are asking teachers to practice in two worlds, to focus on both “product” and “process” and to fulfill the expectations of contrasting views. The more traditional view of science teaching emphasizes the transmission of knowledge and information and then measuring how effectively this content is transmitted via successful performance on standardized tests.

A more progressive perspective of teaching science emphasizes the ability to think critically, to explore, to test phenomena, to make judgments, to consider and ponder
and, to actively participate in the process of learning. The pendulum swings back and forth in terms of the degree of influence or power that each of these contrasting sides have and yet both sides have merit and both sides have influence and power. Therefore, we must include in pre-service teacher education methodologies the mechanisms for teachers to successfully operate somewhere between these two camps.

Although unspoken, the beginning teacher knows that classroom management is held in high regard by the administration and by parents and therefore survival skills, focused on “keeping their neck out of the noose” is of utmost concern. Additionally, controlling students by giving them information with the expectation that it will be reproduced later is likely easier for teachers who are still developing their confidence in the course content and who are still developing their teaching skills. Because inquiry-based teaching methods are more complicated than traditional type methods, these methods often require well-developed classroom skills that teachers early in their careers likely have not yet gained.

I currently have a practicing teacher-intern assigned to me and I often take the opportunity to address the subject of classroom control with her. We talk about how often classroom teachers become comfortable with the sense of control, and that in an effort to maintain that feeling of comfort, they rarely venture out of traditional types of teaching methods. We discuss how these traditional type methods may contribute to the placement of undue importance on classroom control and how either consciously or unconsciously administrators, who are desirous of orderly and relatively quiet classrooms, reinforce these methods. This reinforcement by administrators then may ultimately strengthen the classroom teacher’s belief in the merits of traditional typical teaching methods. Thus as Blake (2002) states, it seems imperative to help teachers recognize and “change their beliefs to fit “new” curricula and “new” instructional practices” (p.184) that lead to more effective student learning. To underscore this point, Blake (2002) reminds us that it may be “futile to ask teachers to implement a curriculum without first asking them to address their beliefs, finding out where they fit with the intended curriculum, and then preparing them to innovate and to use associated instructional techniques” (p. 184). I advocate that to do as Blake suggests, pre-service teachers need more than early field experiences and a student teaching experience to enter the classroom full time. They need time to observe multiple teachers, time to reflect on their beliefs, time to discuss their beliefs with other educators, and time to reflect on their own early practices with a mentor and with other teachers.

**Future Research Areas**

The importance of beliefs in driving teacher behavior and the daily operation of the classroom appears to be well established. Certainly, I wholeheartedly believe that Dr. B’s teaching practices are driven by her beliefs about learning, about teaching, about science education, and by her commitment to science education reform. It is likely that we as educators and researchers accept as plausible that the way one teaches and what
one believes about teaching, students, and learning, is a result of, at least in part, how he or she was taught or how he or she experienced teaching.

An area for future investigations related to beliefs might be to determine the degree of impact that direct discussions of beliefs and belief systems have on pre-service teachers’ implementation of inquiry-based teaching methods. Pre-service teachers exposed to in-depth discussion about their beliefs and experiences could be contrasted and compared to other pre-service teachers who did not explore their beliefs and belief systems.

Future studies related to beliefs, reflection and inquiry, although very time intensive, might move beyond interviewing teachers who participated in a methods class to actually observing them in their classrooms and interviewing them on why they did what they did. This approach would likely reduce the reliance on self-report data and strengthen assertions that the experiences in a methods class, as I describe here, actually influence their teaching actions and practices.

**Study Limitations**

A limitation in this study may be the relatively few number of students who participate in the follow-up study. Questions that are not answered include: 1) What were the reasons some students chose not to participate? 2) Would they have echoed what I heard from the seven students who did participate? and 3) Were they a representation of the entire class? Additionally, this study is confined to one state, one university, one professor, and seven students who volunteered to participate. Another limitation in the research may be the reliance on self-reported data in the follow-up study. As already referenced, a more in-depth study might include a venture into teachers’ classrooms to observe them in their context and then an interview with them regarding their current teaching strategies.

**Concluding Thoughts**

As I look back on this research study, I find myself particularly moved by what I learned from Dr. B. and her students. I have had the unique opportunity to observe effective teaching, to see how questions from students were answered, to watch inquiry-based teaching methods unfold, to talk with Dr. B. about her beliefs and her reflections, and finally to talk with a group of her students who participated in the methods class described in this research. Additionally, as I reflect on this study, I recognize the commitment that Dr. B. and her students brought to the classroom each week, which is to make teaching and learning better for teachers and for students. In these reflections, I also find myself thinking about this strong commitment that I observed and wondering how we could further develop this sense of commitment among more stakeholders. I have come to believe that for us to communicate about what resources we need to improve the
development of pre-service teachers requires that we as educators develop a clear sense
of what we are trying to accomplish with pre-service teachers. Perhaps the description of
effective teaching by Raizen and Michelson (1994) best describes what our goal is. In
using information from the 1991 National Board of Professional Teaching Standards,
Raizen and Michelson provided what amounts to a laundry list of the qualities that
“effective” science teachers possess. This list includes: 1) A dedication to making
knowledge accessible to students; 2) A belief that all students can learn; 3) The treatment
of all students in an equal manner; 4) The ability to recognize and account for individual
differences; 5) The ability to adjust practice to fit the needs of the students; 6) The
understand of learning and development of the child; 7) The ability to provide a wide
range of role models for the students; 8) The ability to provide a wide variety of
experiences; 9) The ability to be proactive instead of reactive; and 10) The ability to be
skilled as a coach to help the students move forward as opposed to backward and to
promote the pursuit of lifelong learning.

Approaching the end of this research, I develop a deeper appreciation for the
importance of inquiry in advancing the teaching of science. I continuously reflect and
analyze what I believe about teaching, teachers, schools, and students. I find comfort in
knowing that I emphasize active student involvement, research, discussion, and student
projects in my science teaching for many years. Through reflection, I find affirmation
that I made the right choice in ending my two-year leave of absence from teaching to
work in corporate America. Yet, when reflecting on the many observations that I made of
Dr. B, I am also somewhat saddened that her teaching style and that what she asserts as
important in the teaching of science is not demonstrated by the typical teacher that I
encounter in my daily work. I do not find the aforementioned laundry list of effective
teaching qualities ubiquitous in the educational system of which I am a part.

The excitement about teaching and the willingness to try new techniques in the
classroom at times seem to be the exception rather than the norm. Yet in looking back on
the long journey of this study, I also find myself more in tune, perhaps more patient, with
how many demands there are on the classroom teachers. The constant pressure from
parents, the growing personal needs of students to be addressed, the overwhelming
security and safety concerns for which teachers must now be more aware, the personal
circumstances that may affect their work, the constant mode of giving of one’s self, and
the conflicting messages between emphasizing product over process – thinking and
concept development over content memorization, all while preparing for standardized
tests are daunting challenges for teachers.

Despite these challenges, including the lack of role models that I encounter on a
regular basis and despite being reminded many times in this study that Dr. B and her
students are more likely the exception rather than the “norm,” I am encouraged about the
prospects of true advances in the teaching of science. I intuitively sense that society, state
education boards, politicians, and school districts place additional emphasis on the
importance of teaching and learning science.

As a result of my work on this study, I believe I am more aware of how changes
in beliefs and belief systems must be addressed with the same vigor, energy and financial
investment that are made in developing new curricula designed to meet the challenges of
reforming science education. Changes in teaching practices are intricately linked to the
way that individuals see the world and how they behave in it. I recognize the critical importance to explore, examine, and align the long-held beliefs by educators at all levels with the reform measures called for by the NSES (NRC, 1996).

Through my interactions with Dr. B., I realize that growing as a teacher means growing as a person. The willingness to practice the kind of teaching I believe best prepares students for the communities of today and the communities of the future requires the courage and confidence to be authentic. It is a privilege to have the opportunity to witness an authentic teacher doing what she strongly believes. My reflection on this study helped me to discover that what may be the most important dimensions of effective teaching could be found in the sandboxes of our childhood. We learn best by doing and by watching, by asking questions, by listening to the views of others, by accepting the differences in others, and by seeking to understand and appreciate the world of others just as we want others to understand and appreciate the world that we have constructed. I know and I suspect it is the same for others, that all of these were lessons learned in the playgrounds where we grew up. I believe we all desire the feeling of being listened to and of having the choice to pursue what we alone may find interesting and worthy of our efforts. I find myself wondering much more often about this concept – why should we expect that children, our students, would desire anything less in their classrooms than what they found in their sandbox.

I shared in the previous few paragraphs some sobering reflections on what I learned through this research journey, and I share reflections very much filled with hope. I believe that as our understanding of learning continues to evolve, that technology will enable individuals to more easily explore their own interests in and out of classrooms and that our increasing acceptance of, and comfort with diversity are all beacons of hope that suggest the practice and profession of teaching will meet its intended and desired destiny.

In my current middle school teaching, I continue my efforts in building a community of learners where we can leverage the strengths of all learners so that learning is improved. Perhaps resulting from my involvement with this study, I find myself being much more concerned with the development of my current intern than I was with previous interns assigned to me. I place emphasis on helping my intern allow more time for learning to emerge by planning fewer tasks for the students. I encourage her to seek greater understanding of issues by asking questions and listening to me, the students and other teachers. I commit to working with her in a mentoring relationship and feel a sense of ownership for her development. Her positive acceptance of my sharing current readings and research findings and what I view as best practice strategies with her is rewarding. Also, I recently agreed to chair the School Improvement Plan (SIP) so that I may help influence the context in which my colleagues must teach.

In the closing weeks of this study as I reflect on the impact that Dr. B has on me, I begin to wonder; what impact this research study has on her and whether she shares many of the perspectives that I have just shared. I recognize many months have past since I observed and interviewed Dr. B, and yet because I have gained so much from her, I very much hope that she might remember what she learned through this research process. She graciously accepted a dinner invitation at what was at one time a favorite restaurant of ours. Because it was a dinner meeting and because she has already given so much time to me during the more formal parts of my study, our time together was to be more of a
conversation than an overly structured interview. My prepared questions were few, very
open-ended and, in general focused on exploring what this research study means to her
and what she learned from it. The following quotes from Dr. B, a wonderfully gifted and
effective teacher for whom I have incredible admiration, represent the essence of what we
discussed that evening.

In response to asking Dr. B what impacts this study has had on her, she responded:

... what occurred to me instantly, was our meetings after class at the Mexican
Grill, we were debriefing immediately after the class. I think that the immediacy
of the debriefing, sometimes we don’t have the luxury of doing that, we go from
class to something else, we forget what had happened...you were there asking the
questions and we were having a dialogue so it was, I’m sure, I don’t remember
everything I said. So after many years, memories change too, the fact that it was
caught right after the class, I think was probably one impact. The idea of talking
to, at that time we called you the co-researcher, that talking to you and talking
aloud I think that there is something different about because we can write and
think but to talk aloud about something. I think changes it a bit too. I think that
very few of us get the opportunity unless you talk about one maybe incident like
when I started this conversation, which is kind of systematic thinking about what
happened in the class. I think that the other thing that happened was a heightened
awareness...of the whole working of the class and planning ...

Thus, Dr. B’s notions of collaboration, of building a community of learners where
each learner learns from the other, rings true for her even now. She appreciates the
scheduled time for structured discussion because it enables and ensures the process for
review and reflection. The term of reflective inquiry best describes this time.
Regarding the role of reflection, Dr B. shared:

... so there are so many interpretations of reflection and I think that perhaps that
after going through this process with you that it would be important to me and
somebody in science methods education position...needs to realize, when you look
and study your own behavior, and not looking for all negative...and not looking
for all positive, your looking for a balance and then you are saying to yourself
okay, it’s okay if you have some failings okay if you are not all things to all
people I think you have to know that but you don’t have to be I think that I felt
liberated in teaching, The other thing that I think reflection does the importance of
reflection, I have a strong belief that we need to work as hard as possible in
establishing the relational aspects of teaching. I believe that teaching is relational
the relationship you are developing with students as students and that relationship
can really vary from student to student I’m sure you have some of the same kinds
of relationships with your students And then some of things you deal with when
you are addressing the composition of your class, for instance, there are certain
people who think like I do, and it is so easy to gravitate toward them because it
isn’t hard they just expand what you are already thinking.

109
Again from Dr. B’s perspectives, the idea of self reflection is more of a balance, where one can analyze the strengths and weaknesses, build upon this knowledge so that the pursuit of lifelong learning is truly lived out in the life of the professional.

In summarizing her views on reflection Dr. B. shared:

I would say to sum up, the study has served as a catalyst for reflection. I think the study established a pattern, if you will, at looking at my practice. I didn’t have that opportunity every semester after that to go and discuss with a particular person after every class period....

On the subject of educational change, Dr. B responded:
This may sound somewhat trite I think that it is really true. Educational change is extremely complicated. When we talk educational systems, one of the old time educators made a statement that we had been back to the basics four times but probably every time we had to come back to a basic, there is no doubt it was a little bit different because the concepts had changed. I think that beliefs about educational change, I think that, that somehow science educators at any level, elementary teachers, middle, high school, college science teachers, college science educators all of them, somehow have to figure out a way to be more proactive in the change process itself...

Continuing on in the discussion of the change process she stated:

...I think that a research study like this definitely forces you to be thinking about what you are doing to be thinking about what is supposed to be for your class which is part of a larger system the class has students who are parts of family, who are then parts of other groups so we don’t really know what they are thinking about when they are there. We need to be more open to studying one another’s practice and when what we are doing isn’t working be willing to try something else. Value, I believed in this but which became apparent while working with you Kathy, that we need colleagues at all levels. I have colleagues at other state universities but we don’t have many science educators I can talk with...probably my best colleagues in science are teachers...

In other words, according to Dr. B, a good practice for educators, college professors, teachers, principals, and school systems might be the need for self inventory. This done without any idea in mind other than to improve the teaching and learning proved to Dr. B to be a vital part of the success of her teaching practice.

Implications of Research

Elliot Eisner (1991) in his typical style of eloquence reminds us that,
The aim of the enterprise, like education itself, is normative, not simply descriptive. Thus the toughest test of educational criticism (and it is the same test I would apply to any form of educational research) is, does it contribute to the improvement of education? (p. 114)

The intention of Eisner in the above quote as it appears in the chapter on “Validity in Educational Criticism” (p. 107) suggests that valid educational research “…should contribute to the enhancement of the educational process and through it to the educational enhancement of students” (p.14; as stated in Blake, 2002). The question of “So What?” for research studies is a critical question for media, government, parents, reformers, legislators, teachers, students, principals of schools, and business communities who continue to plea for improvements in the area of science education and student learning (Matthews, 1994). I believe it is also a critical question to ask myself at the end of this study.

I portray the findings in a way that readers may find them of value and may use them by making connections to their own experiences and their own practice of teaching. As stated earlier, one must exercise caution when trying a one-size fits all when attempting to enact a change in the teaching process or in content through changes in curricula. The caution for those who facilitate or lead learning is to model a variety of strategies for their learners, whether the learners are future classroom teachers or classroom students.

In closing, I share with the reader that Dr B’s system of beliefs is complex where meanings might not have been evident by either interviews or observations alone. By focusing on her actions and exploring her beliefs through interviewing and structured discussions, I came to more fully appreciate the complexity and difficulty of implementing change through an inquiry-based approach to teaching science. Readers interested in observing other teachers to determine their beliefs and frameworks may wish to recognize that observation or conversation alone may not be enough to improve one’s own teaching. Securing insight about beliefs through reflection and conversation provides the opportunity for the development of strategies for teachers and teacher educators. To accommodate these beliefs Dr. B asserts that the teaching process is often more important than the product and empathizes with classroom teachers who often bear the heavy burden of federal and state mandated improvement in standardized test scores.

As I reflect on my long involvement with this study, I continue to consider what is important in teaching and learning of science. I find the issues, observations, inferences, frameworks, and beliefs reflected in this study to align with, confirm, and challenge, many of my beliefs regarding the teaching and learning of science. The emphasis on the importance of process, and not always product, the importance of discussions, journaling, the asking of questions and the involvement of the students are all areas I believe are important in advancing the reform measures designed to improve science education. As a middle school teacher in a public school, I remind myself to continuously be cognizant of the external expectations regarding product and content. I recognize that there is no best method of teaching for every teacher and thus as Blake (2002) asserts — exposure to a variety of strategies or multiple approaches to teaching with time for discussion and reflection of one’s beliefs seem to be important components to include in pre-service teacher education. Practices associated with inquiry-based teaching to include reflection,
creating a learning environment where students work collaboratively on widely varied assignments while remaining flexible enough to allow for the needs and interests of the students to influence the class sessions, do indeed present challenges. Although it is not without challenges; I include many of the practices in my middle school practice and advocate them in mentoring my intern. Dr. B, who I firmly believe is strongly committed to her beliefs regarding educational change, students, reflection, science education, and the creation of a learning environment strives to build a community of learners where science teaching and learning are improved. I assert that Dr. B is a tremendously positive role model, mentor, and coach for her students in her secondary science methods course as she was for me as a researcher. I truly had the opportunity to experience the art of inquiry; a wonderful opportunity to focus on a teacher desirous of making a difference and teaching in the most innovative way. For this I am eternally grateful.
APPENDIX A

Dr. B’s Consensual Agreement Form
Dr. B’s Consensual Agreement Form

The secondary science methods course is committed to furthering inquiry into science and science teaching and learning. One approach to supporting inquiry is coaching, a partnership between parties who accept mutual responsibility for goals through consensual agreements.

The following “contract” is offered to help us reach consensus on overall course goals. Please indicate agreement or disagreement with the statements and any comments you may wish to make on each.

1. I understand that my participation in course activities is necessary to the development of a community of learners in this course. _______
   Comments ________________________________________________________

2. I understand the need to learn about the characteristics and expectations of the reforms in science education. _______
   Comments ________________________________________________________

3. I am willing to actively inquire about science and science teaching/learning as I acquire and/or strengthen knowledge and skills related to effective science education. _______
   Comments ________________________________________________________

4. I am willing to analyze multimedia resources for science teaching and learning. _______
   Comments ________________________________________________________

5. I am willing to interact with school and community resources to enhance my expertise in science teaching and learning. _______
   Comments ________________________________________________________

Other goals (if any) I have for this course are
________________________________________________________________________
________________________________________________________________________

I feel I need special help in
________________________________________________________________________
________________________________________________________________________

Other Comments: _______________________________________________________
________________________________________________________________________

Signature_______________________________________________________________
APPENDIX B

Pilot Study-Focus of Investigation
Pilot Study-Focus of Investigation

The participant in this pilot study and a major participant in this proposed follow-up study is a science education professor at a state university in Florida whom I have known professionally and personally for many years. To help ensure confidentiality and privacy and demonstrate a respectful stance, the pseudonym of Dr. B is used when referring to this participant. As noted by Bogdan and Biklen (1998) and Miles and Huberman (1994) the use of a pseudonym is advocated to provide a degree of authenticity, while maintaining anonymity. Additionally, Bogdan and Biklen (1998) stress the importance of seeking the participants’ cooperation in all matters of the study thus, it is fully expected that this researcher will maintain and renew Dr. B’s cooperation on a regular and consistent basis for the duration of this study.

The pilot study specifically focused on the nature of change, the change process, inquiry-based teaching, and the professor’s views on the role of beliefs and self-reflection in the change process. The pilot study was composed of 10 observation sessions, eight of which were videotaped, and all followed by debriefing sessions immediately after each class with Dr. B at a local restaurant. These debriefing sessions were audio recorded and expanded field notes during these same structured discussions were recorded. Transcriptions of the audio recordings and field notes were made immediately after each session and I took the opportunity to reflect extensively on the observations that I had documented and I archived this data for future analysis. The methods course observed met for 12 formally scheduled sessions, and two classes were scheduled as individual appointments for the students. During these individual appointment times Dr. B examined the college students’ reflective journal and I was able to use these individual appointments as opportunities for data collection and further reconstructions, revisions, and elaborations (Guba & Lincoln, 1989).

To better understand Dr. B’s views on teaching secondary science methods from a historical perspective, structured discussions were used extensively. These sessions of structured discourse provided opportunities for interpretation and the building of shared meanings (Bogdan & Biklen, 1998; Guba & Lincoln, 1989). These structured discussions also provided Dr. B with an opportunity to describe to this researcher events that precipitated her desire to change her teaching approach. Field notes from these sessions are expected to provide a basis for follow-up focused questioning with Dr. B and the college students.
APPENDIX C

Survey Questions
Survey Questions

Hello, (name). Do you remember me? I was collecting data for a doctorate at the time that you were a member of Dr. B’s secondary science methods course, in the fall of 1998. I am following up with several of the college students to ask questions and gather more data to complete the project. I will ask your permission to audiotape the interview today. Is that ok with you? May I ask you several questions?

Questions to the participants:

1. How was Dr. B’s secondary science methods course different from other teaching methods classes?
2. What aspect of Dr. B’s course did you find most helpful? Least helpful?

Role of Beliefs and Reflections

3. What impacts, if any, did this science methods class have on how you think about teaching?
4. How has reflection (reflecting on your teaching practices) affected your teaching?
5. What, if any, personal beliefs that you hold might influence the way that you teach?
6. From your perspective, how does an inquiry approach to teaching science differ from other approaches?

Enacting Inquiry-Based Teaching

7. What student impacts, if any, have you observed when using an inquiry-based approach to teaching science?
8. Can you describe a lesson that you taught that incorporates the aspects of inquiry you learned about in the science methods course?
9. How often do you teach using inquiry methods?
APPENDIX D

Human Subjects Approval Form
Office of the Vice President
For Research
Tallahassee, Florida 32306-2783
(850) 644-8673 4FAX (850) 644-4392

APPROVAL MEMORANDUM
Human Subjects Committee

Date: 8/1/2003

Kathleen Foley
P. O. Box 923
Ponte Vedra Beach, FL 32004

Dept.: Science Education

From: David Quadagno, Chair

Re: Use of Human Subjects in Research
Science Teacher Educator Change: A Case Study Report

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 7/31/2004 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 IRB00000446.

Cc: Dr. Nancy Davis
HSC No. 2003.365
INFORMED CONSENT FORM

I freely and voluntarily and without element of force or coercion, consent to be a participant in the research project entitled "Science Teacher Educator Change: A Case Study Report."

This research is being conducted by Kathleen R. Foley, a doctoral student at Florida State University. I understand the purpose of her research project is to better understand teaching practices, science methods and inquiry-based science teaching. I understand that if I participate in the project I will be asked questions about the case study in which I am involved, as well as my teaching practice if applicable, and general information about myself and my background knowledge.

I understand I will be asked to participate in an interview(s), conducted by Kathleen R. Foley. The total time commitment would be about 45 minutes. I will be asked permission to allow audio recording of this interview(s). I may refuse to participate, or request that the interview be stopped for any reason, and may also ask that I receive audio tape(s) discarded after the interview. The design of the study will be interpretive research using a 4th Generation Evaluation Method, so the ideas will emerge during the inquiry as Kathleen R. Foley incorporates the stakeholders' inputs (i.e., claims, concerns, and issues).

Also, I will be asked permission to allow audio recording of the interview. If I do not wish to be audio recorded, this component of the project will be replaced by written notes, kept by Kathleen R. Foley and shown to me at my request. These audio tapes will be kept locked in Kathleen R. Foley's office and will be destroyed September 1, 2004.

I understand that my participation in this project is totally voluntary and I may stop participation at any time. My name and the names of all participants will be replaced by a pseudonym and all measures regarding confidentiality will be followed to the extent allowed by law. It is possible that Kathleen R. Foley will write the results of this research in narrative form with all individuals in the narrative fictionalized.

I understand there are benefits for participating in this research project. First, my own awareness of inquiry-based science teaching, secondary science methods, my teaching practice (if applicable) and learning may be increased. Also, I will be providing other teachers and college students with valuable insight into knowledge, feelings, and behaviors regarding inquiry-based science teaching. This knowledge can assist others in developing interest in inquiry-based science methods courses for secondary science teachers and to improve science teaching and learning.

I understand that I may contact Kathleen R. Foley by email at kfoley@bellsouth.net or Dr. Nancy Davis, Florida State University at (850) 644-7804 for answers to questions about this research or my rights. If I have additional questions regarding this research project I may also call the IRB at Florida State University (850) 644-8533.

I understand that this consent may be withdrawn at any time without prejudice, penalties, 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 Kathleen R. Foley for answers to questions about this research or my rights.

I have read and understand this consent form.

(Subject)  
(Date)
REFERENCES


Constructivism: Theory, perspectives, and practice. (pp. 3-7). New York:
Teachers College Press.

Bacon.


MT: MindFlight Publishing.
Kathleen R. Foley is in her fourteenth year in teaching middle school science in St. Johns School District, St. Johns County, Florida. She is currently serving in her second year as an 8th grade science teacher at Switzerland Point Middle School. Her educational background includes a Bachelor’s Degree from Flagler College, St. Augustine, Florida and a Master’s Degree in Science Education from Florida State University (1995).

Kathleen has published several professional documents including:


In addition she was a team member for Science Tobacco and You – a multidisciplinary, multi-sensory curriculum resource package designed by teachers, students, science and health educators, scientists, and researchers.

Originally from Darlington, Maryland, Kathleen is a graduate of the Maryland public school system. Kathleen is the proud owner of Tucky Lee and Sconsey, her two dogs. Kathleen enjoys spending time outdoors, being with people, and working with her students and colleagues ... she will remain forever a life-long learner.