AN EXPLORATION OF HOW PRE-SERVICE EARLY CHILDHOOD TEACHERS USE EDUCATIVE CURRICULUM MATERIALS TO SUPPORT THEIR SCIENCE TEACHING PRACTICES

by
DEIRDRE ENGLEHART
B.S. University of Central Florida, 1986
M.A. University of Central Florida, 1996

A dissertation submitted in partial fulfillment of the requirement
for the degree of Doctor of Education
in the Department of Educational Studies
in the College of Education
at the University of Central Florida
Orlando, Florida

Spring Term
2008

Major Professor: David N. Boote

ABSTRACT

Research indicates that a proportion of elementary teachers are not comfortable teaching science to young children. These teachers are unaware of the best methods of approaching science and don't have the science background knowledge to support teaching through inquiry methods. This case study explores the role educative curriculum materials play in supporting pre-service early childhood education teachers' knowledge with science content and teaching practices. Specifically, I examine how educative materials impact pre-service teacher's content knowledge in science and their pedagogical content knowledge related to inquiry methods.

Three pre-service early childhood teachers participated in this research. The teachers were initially interviewed about teaching science based upon three instruments: Views of Science Inquiry, Views of the Nature of Science and the Science Teachers Efficacy Beliefs Inventory. Each subject was observed teaching science in their internship site: the first lessons taught were guided or approved by their teachers and the next lessons were conducted using the support of educative curriculum materials. Finally, the initial instruments were once again administered along with an interview to obtain changes in teacher's knowledge, beliefs and understandings of science and science teaching.

Results from this research indicate that educative curriculum was supportive of teachers in a variety of ways. Most importantly, this curriculum helped teachers to target more aspects of scientific inquiry during their science lessons than lessons without the use of educative curriculum. The important considerations regarding the effectiveness of the educative curriculum for these pre-service teachers were their underlying beliefs about how science should be taught, their uses of the curriculum materials and reflective practices regarding their own teaching.

Results specifically related to early childhood educators include the level of inquiry implemented with young children and how children communicate their findings. Young children need support in their participation of inquiry learning. Successful implementation of guided inquiry practices occurred in this research. Also, the teachers in this research found insightful ways that directly supported young children in their communication of ideas. Implications for further research are also discussed. Educative materials could further support pre-service early childhood teachers if additional supports were used including accessible curricular rationales, support in classroom management and the specific use of guided inquiry.

To my mother and father who taught me how to walk and run but most importantly how to love.

To Pat who helped me to reach beyond my limits and to Leigh who taught me to climb mountains.

ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. David Boote, for his support and guidance throughout the dissertation process. He has continually provided guidance and direction for me and believed in my abilities. I would also like to thank my dissertation committee: Dean Sandra Robinson, Dr. Michael Hynes, Dr. Michael O'Malley and Dr. Robert Everett. Their expertise and feedback helped to make this dissertation possible.

I would also like to thank a number of friends and colleagues. Roz Velentaar and Elizabeth Hatley dedicated their time to providing thoughtful feedback on drafts of this dissertation, which helped me to know I was on the right track. I would also like to thank Dr. Judith Levin, who was always willing to listen and provide guidance for me when I was unclear of how to proceed and Dr. Lynn Hartle who continually supported me during my doctoral program.

This dissertation would not have been possible without the support and love of my family. My family's patience, understanding and support helped me to achieve this goal. I would especially like to thank Leigh, Rebecca and Ian for supporting me through the many hours of work and my sometimes difficult disposition.

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION 1
Definitions 3
Educative Curriculum Materials 6
Study Overview 6
Structure of Dissertation 7
CHAPTER 2 LITERATURE REVIEW 9
Expectations for Teachers of Science 10
Standards for Teacher Preparation 10
Research Related to Elementary and Early Childhood Teachers 12
Elementary Science Teachers 12
Educating Young Children 16
Influences That Impact Science Teaching 18
Self-Efficacy Beliefs 18
Teacher's Science Content Knowledge 19
Pedagogical Strategies 21
Pedagogical Content Knowledge 22
Teaching Inquiry 26
The Nature of Science 30
Influence of Teaching Materials 32
The Uses of Curriculum Materials 33
Educative Curriculum 35
Research Questions 37
Study Contributions 38
CHAPTER 3 METHODS 40
Study Overview 40
Case Study Design 41
Research Participants 42
Educative Curriculum Materials/CASES 45
CASES Curriculum Units 49
Data Sources 51

Data Analysis 54
Composing the Case Study Reports 57
CHAPTER 4 CASE STUDY: PIPPA 59
Teacher Profile 59
Initial Interview and Instruments 61
STEBI-B Instrument 61
Views of Nature of Science 62
Views of Scientific Inquiry Elementary School Version (VOSI-E) 64
Overview of Pre-CASES and CASES Units 66
Pre-CASES Lessons 66
Summary of Pre-CASES Lessons and Reflections 68
CASES Lessons 71
Summary of CASES Lessons and Reflections 77
Use of the CASES Curriculum Materials 80
Final Interview and Instruments 83
STEBI- B Instrument 83
Views of Nature of Science (VNOS-E) 85
Views of Scientific Inquiry Elementary School Version (VOSI-E) 88
Overall Summary 90
CHAPTER 5 CASE STUDY: ALEXIS 96
Teacher Profile 96
Initial Interview and Instruments 98
STEBI-B Instrument 98
Views of Nature of Science 99
Views of Scientific Inquiry Elementary School Version (VOSI-E) 101
Overview of Pre-CASES and CASES Units 103
Pre-CASES Lessons 103
Summary of Pre-CASES Lessons and Reflections 105
CASES Lessons 111
Summary of CASES Lessons and Reflections 113
Use of the CASES Curriculum Materials 117
Final Interview and Instruments 118

STEBI B Instrument 119
Views of Nature of Science (VNOS-E) 120
Views of Scientific Inquiry Elementary School Version (VOSI-E) 122
Overall Summary 122
CHAPTER 6 CASE STUDY: DENICE 129
Teacher Profile 129
Initial Interview and Instruments 130
STEBI-B Instrument 130
Views of Nature of Science 131
Views of Scientific Inquiry Elementary School Version (VOSI-E) 133
Overview of Pre-CASES and CASES Units 134
Pre-CASES Lessons 135
Summary of Pre-CASES Lessons and Reflections 139
CASES Lessons 142
Summary of CASES Lessons and Reflections 147
Use of the CASES Curriculum Materials 150
Final Interview and Instruments 152
STEBI B Instrument 152
Views of Nature of Science (VNOS-E) 154
Views of Scientific Inquiry Elementary School Version (VOSI-E) 156
Overall Summary 157
CHAPTER 7 DISCUSSIONS AND IMPLICATIONS 162
Significant Findings 162
Educative Curriculum Materials Support Scientific Inquiry Practices 163
Influences on Teacher Practice 164
Educative Materials Refinements 166
Research Question One 168
Impact and Uses of Educative Curriculum Materials 168
Science Content Knowledge 170
Influences on The Nature of Science 171
Research Question Two 174
Pedagogical Content Knowledge 174

Scientific Inquiry ... 180
Additional Findings ... 189
Use of Curriculum Materials ... 190
Classroom Management ... 191
Significance of Science Teaching ... 192
Study Limitations ... 192
Implications for Future Research ... 193
Conclusions ... 195
APPENDIX A: PROTOCOL FOR SCIENCE TEACHING INTERVIEWS (PRE-INTERVIEW) ... 198
APPENDIX B: VNOS – FORM D ... 200
APPENDIX C: VIEWS OF SCIENTIFIC INQUIRY ELEMENT SCHOOL VERSION (VOSI-E) ... 203
APPENDIX D: SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT: STEBI – B FORM ... 206
APPENDIX E: TEACHER OBSERVATION FORM ... 212
APPENDIX F: FIELD SUPERVISOR OBSERVATION INSTRUMENT ... 214
APPENDIX G: GUIDELINES FOR PRE-SERVICE TEACHING REFLECTIONS OF SCIENCE TEACHING ... 217
APPENDIX H: INTRODUCTION TO THE CASES WEBSITE ... 220
APPENDIX I: CASES IMPLEMENTATION INTERVIEW ... 223
APPENDIX J: PROTOCOL FOR POST SCIENCE TEACHING INTERVIEWS ... 225
APPENDIX K: CODING CHART FOR CASE STUDY WRITE-UPS ... 228
APPENDIX L: IRB APPROVAL LETTER ... 230
REFERENCES ... 234

LIST OF TABLES

Table 1 - Teaching Context of Research Participants 44

Table 2 - Educative Support Features in CASES Curriculum 48

Table 3 - CASES Curriculum Units Used 50

Table 4 - Data Collection Tools 53

Table 5 - Pippa's Pre-CASES Lessons 67

Table 6 - Pippa's CASES Lessons 73

Table 7 - Pippa's STEBI-B Results 85

Table 8 - Alexis's Pre CASES Lessons 104

Table 9 - Alexis CASES Lessons 113

Table 10 - Alexis' STEBI-B Results 120

Table 11 - Denice's Pre-CASES Lessons 136

Table 12 - Denice's CASES Lessons 143

Table 13 - Denice's STEBI-B Results 153

CHAPTER 1
INTRODUCTION

Teaching is a complex endeavor: it involves a person's individual philosophy and beliefs about teaching and the ability to implement those beliefs in their practice. Numerous factors influence a teacher's ability to teach including internal and external factors. Internal influences can include personal beliefs and experiences in school and in specific content as well as the teacher's own confidence, and knowledge of teaching. External factors also influence teaching and can include such things as curriculum standards, teaching guides, school climate, available resources, student population, etc.

Beyond the issues outlined above, elementary and early childhood teachers face additional challenges because they are considered curriculum generalists. They teach all aspects of the curriculum and usually do not have a strong focus in one particular content area such as science. When specifically looking at the teaching of science, research indicates that most teachers do not have the background or experiences grounded in inquiry to teach with that method (Davis, Petish, and Smithey, 2006). Inquiry is the method for teaching science advocated by the National Research Council and is described as the activities of students in which they develop knowledge and understanding of scientific ideas. Specifically, scientific inquiry is defined as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (National Research Council [NRC], 1996, p. 23). This is accomplished through the process of observing, posing questions, examining background information, planning investigations, reviewing, analyzing and interpreting data to propose answers and explanations and communicating results. Many teachers do not have a strong content knowledge in teaching science and so their approach to teaching is not one that emphasizes a constructivist perspective that is aligned with inquiry (Ekborg, 2005; Harlen and Holroyd, 1995; Weiss, Banilower, McMahon, and Smith, 2001).

Other factors influence the teaching of science. Appleton (1999) found that a teacher's ability to integrate science into the classroom was affected by collegial support, self-confidence in science, and the priority science is given, along with available resources to teach science. Weiss et al. (2001) indicated that teachers' perceptions concerning their qualifications for teaching science directly relate to the amount of time that they spend teaching science. Enochs and Riggs (1990) argue that teacher beliefs are a part of the foundation of behaviors: "Behavior is enacted when people not only expect specific behavior to result in desirable outcomes (outcome expectancy) but they also believe in their own ability to perform the behavior (self-efficacy)" (p. 2). Lastly, many teachers do not have a strong understanding of the nature of science and therefore, may have difficulty understanding the process of inquiry and teaching science through inquiry (Abd-El-Khalick, Lederman, Bell and Schwartz. 2001).

Teachers need to have general pedagogical knowledge or ability to teach effectively as well as content knowledge on the topic and specific pedagogical content knowledge or the ability to help students understand content in different subjects, to successfully teach science as outlined by the National Science Education Standards (NRC, 1996). Weiss, et al. (2001) indicates that 80 percent of current teachers felt they had a number of general instructional strategies that support them in teaching. These strategies, considered to be general pedagogical strategies are not always present for pre-service teachers (Mulholland and Wallace, 2005). More specific pedagogical content knowledge in teaching science requires that teachers have specific skills and understandings of inquiry as well as science content knowledge, to teach science in that way.

Lastly, although many teachers face challenges in the struggle to meet the goals of teaching science, pre-service teachers and beginning teachers challenges may be compounded because they may feel alienated from the study of science, the differences in teaching science versus other content areas and the impact of their novice status on their teaching (Mulholland and Wallace, 2003). This study will focus on how educative curriculum materials can potentially support pre-service early childhood teachers in meeting some of the challenges of teaching science in the primary grades.

Definitions

The following terms are definitions associated with this study. Terms are defined here to clarify specific meanings of terminology addressed in this dissertation.

Constructivism refers to a specific epistemology or theory of learning that involves the construction of meaning from experiences. This theory believes that children construct their understandings of content through experiences and through the processing of those experiences. “Each of us makes sense of our world by synthesizing new experiences into what we have previously come to understand” (Brooks and Brooks, 1999, p. 4).

Educative Curriculum is curriculum developed to support teachers in their content knowledge and in their teaching of science. This curriculum has features that educate and support teachers throughout the curriculum and enhances teacher knowledge while being used to teach young children. Davis and Krajcik (2005) define educative curriculum materials as “materials that help to increase teachers’ knowledge in specific instances of instructional decision making but also help them develop more general knowledge that they can apply flexibly in new situations"(p. 3).

Nature of Science refers to the beliefs and understandings of science. Although difficult to get all concerned parties to agree on a definition, many aspects of the nature of science are considered apparent.

Scientific knowledge is tentative and subject to change

Scientific knowledge is empirically based or based on observations of the natural world

Scientific knowledge is theory laden

Scientific knowledge is partly the product of human inference, creativity and creativity as it involves the creation of models and explanations

Scientific knowledge is socially and culturally embedded

Additionally, scientific knowledge distinguishes between observations and inference, considers the relationship between theories and laws and does not include a single recipe-like method. (Abd-El-Khalick, 2004)

Pedagogical Content Knowledge (PCK) includes the various ways teachers make the specific content of a subject comprehensible to students. Teachers must have an understanding of the content they are teaching and they must have appropriate teaching strategies to teach so students understand. Shulman (1996) refers to PCK as the ways of representing and formulating the subject so it is understandable.

Pedagogical Knowledge generally refers to general strategies of instruction used by teachers. Pedagogy is the art of being a teacher and pedagogical knowledge includes the style or methods of teaching. Gee, Boberg, and Gabel (1996) emphasize the use of social interaction in learning, building instruction on prior knowledge, problem solving and higher level learning as important components of pedagogical knowledge.

Scientific Inquiry refers to the many different ways that scientists study the natural world and propose explanations based on evidence in their work. In the classroom, inquiry refers to the activities that students do to develop knowledge and understandings of scientific ideas and how scientists study the world. Inquiry involves making observations, posing questions, examining books and other sources of information, planning investigations, reviewing what is already known, using tools to gather, analyze and interpret data, proposing answers and communicating results. (NRC, 1996, p. 23).

Science Content Knowledge refers to the knowledge and understanding of science content. The content areas identified by the National Science Education Standards (NRC, 1996) include: Science as Inquiry, Earth and Space Science, Physical Science, Life Science, Science and Technology, Science in Personal and Social Perspectives and History and Nature of Science. Ekborg (2005) believes a conceptual understanding is necessary for teachers in science. This belief moves beyond memorization of facts to include the knowledge necessary to discuss debate and make decisions related to issues in society.

Self –Efficacy is defined as a person's beliefs about their abilities to perform tasks or activities. Self-efficacy beliefs influence behavior and willingness to persist in activities (Bandura, 1994). Bandura believes teachers with a high self-efficacy will persist longer in teaching science and will provide a better approach to developing conceptual understanding in students.

Educative Curriculum Materials

Curriculum is one avenue being explored to support teacher learning in the area of science. Ball and Cohen (1996) believe that if curriculum materials paid closer attention to the process of curriculum enactment, they could contribute to professional practice. Educative curriculum materials could, therefore, support teachers in teaching science in ways that are aligned with teaching standards in science. Davis and Krajcik (2005) explain teacher learning in light of educative curriculum which involves an integration of content, teaching and learning. Teacher learning supports teachers in applying their knowledge to make instructional decisions, in understanding the discourse of teaching and becoming engaged in a variety of teaching practices. Educative curriculum has the potential to support teachers in developing their content knowledge and in supporting their efforts to teach through inquiry.

Study Overview

This case study investigation explores the role educative curriculum materials play in supporting pre-service early childhood education teachers' knowledge with science content and teaching practices. Specifically, I examine how educative materials impact pre-service teachers' content knowledge in science and their pedagogical content knowledge related to inquiry methods of teaching.

The research regarding the use of educative curriculum is small but has shown some impact on teaching. Educative curriculum materials have been used with teachers in previous research but not specifically with early childhood teachers nor have pre-service teachers been the targets of research. This research will look specifically at early childhood pre-service teachers.

Three pre-service early childhood education teachers participated in this study. Each pre-service teacher taught a science unit from the Curriculum Access System for Elementary Science

(CASES) web site. Data were collected over the course of a number of months to develop case studies of each pre-service teacher's science knowledge and practice.

Structure of Dissertation

This dissertation is divided into seven chapters. Chapter One introduces the study and defines related terminology in an effort to relate to how this research addresses issues related to the teaching of science.

Chapter Two looks at the related literature on the topics of science teaching, current efforts to support elementary teachers in teaching science and how scientific inquiry is related to the topic. This chapter includes the related research on educative curriculum and how this previous research relates to the research in this dissertation. These areas are reviewed to situate this dissertation research within the context of science education today.

The third chapter in this research addresses the methodology used to guide the research. This chapter includes the design, analysis and results of the study. The dissertation uses a case study methodology including some research instruments to achieve an overall view of the teaching beliefs and practices of science teaching for three pre-service teachers.

The next three chapters, Chapters Four, Five and Six share the results of three pre-service teachers who participated in this study in the form of individual cases. The purpose of these chapters is to take an in-depth look at each individual teacher to understand their background and feelings toward the teaching of science and to understand how educative curriculum supported their efforts to learn pedagogical knowledge and pedagogical content knowledge. These chapters include specific information regarding how each individual teacher used the CASES educative curriculum supporting them in their teaching of science.

The last chapter summarizes notable findings from the dissertation and discusses the findings in light of previous research. This chapter considers the value of educative curriculum in supporting pre-service teachers in developing their ability to teach science using inquiry methods. This chapter also considers the implications of educative curriculum for pre-service teachers.

CHAPTER 2
LITERATURE REVIEW

The purpose of this study is to explore how educative curriculum materials support pre-service early childhood teachers in meeting some of the challenges inherent in all teaching and specific to the teaching of science. This section provides the framework that situates this work within the broader context of science education. Initially, I will look at the standards for teaching preparation in teaching science. This section discusses the expectations that are outlined for science teachers.

The next section considers the research related to elementary and early childhood educators in general and in regards to teaching science. Elementary and early childhood teachers do not have a strong focus on science in their education and therefore may not have strong content knowledge compared to middle and high school educators that specifically focus on science. Other factors related to teaching are also discussed in this section.

The third section of the literature review involves the influences that impact teaching and specifically science teaching. Self-efficacy will be explored in consideration of each teacher's own beliefs and actions related to teaching science and the influence of the efficacy beliefs and their persistence in teaching science. Science teachers content knowledge will explain how content knowledge is needed to be successful in teaching science. General pedagogical skills will be considered as many new teachers are developing strategies to support their classroom practices. Pedagogical content knowledge will also be explored to understand the teaching strategies employed that are specific to teaching science. Next, the focus will be scientific inquiry and its importance in reform efforts for teaching science including the nature of science.

The foundation of this research considers teachers and the influences on their teaching practices. This foundation will lead us to the next focus which concerns how teachers use curriculum to support their teaching and the specific use of educative curriculum materials. It is significant in understanding how teachers use curriculum materials and the role that educative curriculum materials can play in developing teacher's content knowledge and use of inquiry in the classroom. Educative curriculum materials have the potential to support pre-service teachers in meeting the goals outlined in the science standards for teachers.

Expectations for Teachers of Science

The national organizations for science teachers have outlined important criteria that teachers should know and be able to do regarding the teaching of science. This is the first area that we examine in this literature review. It allows us to consider what the standards are for teacher preparation.

Standards for Teacher Preparation

Teachers play a key role in science education. The National Science Education Standards, developed from the National Research Council, emphasize this fact when they say, "Science teaching is a complex activity that lays at the heart of the vision of science education presented in the standards" (NRC, 1996, p. 27). They further state, "Students are greatly influenced by how they are taught" (NRC, 1996, p, 28) and that the actions of teachers are influenced by their perceptions of science, and how it should be taught. The National Science Teachers Association (NSTA, 2003) has also developed standards for Science Teacher Preparation. These standards have been developed to form the foundation which teacher candidates should demonstrate in science teacher preparation programs. The National Science Education Standards also include their own Science Teaching Standards to describe what teachers of science should understand

and do regarding teaching science. Together, these standards are instrumental in guiding teacher education programs in supporting pre-service teachers as they move towards becoming teachers.

The National Science Teachers Association (NSTA, 2003) has identified ten standards for Science Teacher Preparation. They include: content, nature of science, inquiry, issues, general skills of teaching, curriculum, science in the community, assessment, safety and welfare and professional growth. The National Research Council (NRC, 1996) National Science Education Standards include:

Standard A: Teachers of science plan an inquiry-based science program for their students.

Standard B: Teachers of science guide and facilitate learning.

Standard C: Teachers of science engage in ongoing assessment of their teaching and of student learning.

Standard D: Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

Standard E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

Standard F: Teachers of science actively participate in the ongoing planning and development of the school science program. (NRC, 1996, p. 29-52)

The standards from the NRC and the NSTA demonstrate some overlap in what is considered important for teachers to know and be able to do to impact students learning in science. Both standards for teachers indicate the importance of teaching using inquiry. They also stress the importance of curriculum and in teaching as related to planning, implementing and assessing science.

The Science Teaching Standards are aligned with the reform movement in science education. They advocate for a new emphasis in teaching science, involving focus on individuals, their strengths and needs. Selecting and adapting curriculum to meet the needs of individual and small groups and using inquiry to enhance children's scientific understandings (NRC, 1996, p. 32). Scientific inquiry, being the heart of the reform efforts, is emphasized in both standards documents.

Of particular importance is that teacher preparation programs influence future teacher's ideas about teaching science and how teachers will teach in their future classrooms. Appleton and Kindt (2002) researched beginning teacher's ability to teach science and factors that influenced their teaching. Their findings indicate that beginning teachers need collegial support to enhance their science teaching. They also emphasized that if schools and districts advocate for the importance of teaching science, the teachers themselves are more likely to recognize its importance. Other factors they identified include: teachers should begin with safe and familiar science activities that they have experienced previously and that teachers need to have available resources to teach science effectively.

Research Related to Elementary and Early Childhood Teachers

Elementary and Early Childhood teachers are unique in that they teach all curriculum areas instead of focusing on one specific content area. This is one consideration in looking at the unique challenges in teaching science at this level. This section takes a broad look at elementary and early childhood teachers and issues related to teaching at this level.

Elementary Science Teachers

Teachers tend to teach in ways that are comfortable to them, which generally involves a replay of their past experiences. Everett, Luera and Otto (2006) indicate that teaching is the only profession where people have been involved in observations for years prior to their professional studies in the field. Plevyak (2007) explains that most experiences the pre-service PreK-3 teachers have had in science involved direct instruction. More specifically these previous experiences did not involve the learner in science and did not promote higher-order thinking skills.

Porlan and del Pozo (2004) found that teachers view their responsibilities of teaching in different ways. They identified three specific tendencies in the teacher's conception of teaching and learning science including a traditional model, a technical model and an alternative model. Their findings indicate that "a traditional conception of science teaching and a theory of learning by appropriation of meanings (blank mind) predominate" (p. 42). The traditional model of teaching is not aligned with the teaching practices of inquiry as the standards advocate, and seeks to replace erroneous understandings with correct meanings through a direct transmission of knowledge. This view is in opposition of inquiry and the alternative model of teaching, which recognizes the complexities of teaching, the importance of student participation, and the process of learning. The technical model emphasizes a procedural approach to teaching. Objectives are outlined along with procedures to follow, and if they are followed, learning occurs. The alternative model identified by Porlan and del Pozo is most closely aligned with inquiry and construction of knowledge. This model recognizes the importance of student involvement in learning, with an emphasis on conceptual change and the process of construction.

Regarding teaching practices, Appleton (1999) found that a teacher's confidence level in teaching science related to the frequency of teaching science and the science teaching practices. Confidence level can influence the science topics selected and whether science is taught at all. Teacher efficacy refers to teacher's beliefs about their abilities to promote student learning.

Teachers' self-efficacy beliefs influence the amount of time that teachers spend teaching science. Enochs and Riggs (1990) indicate that teachers may not believe they have the ability to teach science or they may believe that external variables influence a teacher's ability to teach science effectively.

Additional research by Lotter, Harwood and Bonner (2006) explores core teaching conceptions which influence teachers' beliefs and practices in science. Their findings indicate that teachers with different levels of the core teaching conceptions will teach in different ways including the level of inquiry teaching. The first core conception is science and the beliefs that science is a process versus a collection of facts. Teachers, whose core teaching conceptions are more aligned with inquiry, believe in science as a process. The second core belief involves teachers' beliefs about the purpose of education. The inquiry end of the spectrum shows teachers who believe the purpose of education is to develop problem solving skills while the contrary believes the purpose is to amass information. The third core conception has to do with students and teacher's beliefs about them. More inquiry based beliefs include that students have an expanded ability to learn as opposed to a limited ability to learn. The last core conception identified by Lotter, et al. is effective teaching. In the inquiry end of the spectrum, teachers believe that we should encourage independent thought while at the opposite end, teachers believe that effective teaching involves the transmission of knowledge.

Generally speaking, elementary teachers are not only responsible for teaching science, but also language arts, mathematics and social studies and therefore are often considered generalists instead of specialists. Weiss, et al. (2001) indicated that less than one-third of elementary teachers felt well-qualified to teach science. Mulholland and Wallace (2005) followed an elementary teacher through her undergraduate teacher education program and into her teaching career. They concluded that teaching practices were developed in the ten years of the study but they also felt that elementary teachers' expertise in teaching science is not the same as it is for a secondary teacher whose sole focus of teaching is on science. Cobern and Loving (2002) also emphasized that elementary teachers are more like the lay public regarding their scientific understandings than they are like secondary science teachers or scientists.

Teachers initially develop general strategies that help them in teaching which are considered pedagogical skills. Weiss et al. (2001), in a survey of practicing teachers, indicates that the majority of the teachers felt they had a number of general instructional strategies that support them in teaching. These strategies include teaching heterogeneous groups, listening and asking questions that gauge understanding, facilitating cooperative learning groups and engaging students in hands-on work. Gee, et al. (1996) identified pedagogical teaching strategies that included facilitating social interactions in learning science, building instruction on children's prior conceptions, problem solving and higher level learning, and allowing children to structure their own learning.

These strategies along with other general pedagogical strategies are not always present for pre-service teachers (Mulholland and Wallace, 2003; 2005). Davis and Petish (2005) state that most prospective elementary teachers, because they are novice teachers, do not have the general pedagogical knowledge that veteran teachers have acquired through years of experience. These strategies directly affect how they teach science in their classroom. Mulholland and Wallace (2005) indicated that in the early years of teaching, beginning teachers often experience conflicts in their beliefs about teaching compared to actual classroom practices. Even teachers, who held strong beliefs about how to teach science, may have difficulty implementing strategies they viewed as important. The emerging pattern indicated that when teachers held to their beliefs about inquiry-based teaching, they became more successful in teaching science when science pedagogical content knowledge, or knowledge of how to teach science, became more established.

Educating Young Children

While most of the same challenges are present for Early Childhood Educators as they are for Elementary teachers, the field of early childhood education is separate. Teachers who earn a degree in early childhood education earn their degree with a specific focus on child development and how it influences teaching practices. The National Association for the Education of Young Children has developed a position statement specifically for educators of children from birth through age eight. In the book; Developmentally Appropriate Practice in Early Childhood Programs, NAEYC has outlined guidelines to consider regarding the education of young children (Bredekamp and Copple, 1997). “Education practices are most effective when they are attuned to the way children develop and learn - that is, when they are developmentally appropriate” (Bredekamp and Copple, p. 5). The position statement from NAEYC argues that developmentally appropriate practices (DAP) are based on three kinds of information: “what is known about child development and learning; what is known about the strengths, interests, and needs of each individual child in the group; and knowledge of the social and cultural contexts in which children live” (Bredekamp and Copple, p. 9). Yoon and Onchwari (2007) see the connection between DAP and constructivism. They emphasize the basic premise of constructivism is how each child interacts with their environment in a unique way and therefore constructs his or her unique understandings of the world. As educators, we need to consider the individual needs of students and this can be accomplished through constructivist practices such as scientific inquiry.

Even when developmentally appropriate practices were first introduced many teachers had a difficult time implementing them based upon their own beliefs and other factors. Now, in an era of extreme accountability, teachers may have even more difficulties implementing them. Gado (2005) believes that early childhood teachers need more training and professional development in order to implement inquiry. Buchanan, Bidner, White, and Charlesworth (1998) find that teacher characteristics including their perceived beliefs about their influence and control in the classroom and their area of certification impacted their beliefs and practices. “Teachers who believe they have more influence on their practice than others do (e.g., parents or principals) are more likely to use developmentally appropriate practices” p. 463. Buchanan, et al. found that classroom characteristics; such as class size, grade level, number of children with free/reduced lunch predicted teacher beliefs and practices regarding DAP.

Educational accountability is an influencing factor in teachers’ developmentally appropriate practices. Goldstein (2007) mentions the ‘accountability shovedown’ in which the student mastery and accountability have affected classrooms all the way into kindergarten. Goldstein further identified a number of factors directly related to accountability that influence teacher’s DAP. The first area is the changing climate of classrooms. An overall intensification driven by higher standards and expectations has caused daily schedules to be fuller and instructional pace to be quicker in order to cover the standards. This has limited teacher’s freedom to choose what to teach. Expectations of achievements from upper grades have caused many teachers to use direct instruction and to emphasize academic skills instead of approaches considered more appropriate. “The implementation of state-mandated learning standards has intensified their teaching day, constrained their use of professional judgment, and limited their choice, flexibility and freedom” (Goldstein, p. 51).

Regarding the teaching of science, Bredekamp and Copple (1997) believe that science is a major part of the early childhood curriculum because it is based on children's natural interest. Science also affords opportunities for children to develop thinking skills. "Science projects are experimental and exploratory and encourage every child's active engagement in the scientific process." (Bredekamp and Copple, p. 174). Therefore, scientific inquiry is aligned with developmentally appropriate practices. Gado (2005) found that many early childhood teachers did not agree with a traditional approach to teaching science, nor did they advocate scientific inquiry. They suggest these findings indicate that teachers need more training on the processes and strategies of inquiry. This training could potentially support early childhood teachers in the use of scientific inquiry in classrooms.

Influences That Impact Science Teaching

There are a wide range of factors that influence individual teachers in their teaching of science. Self-efficacy is a concept based upon a teacher's personal beliefs about their ability to teach science and can be influential in classroom practice. Other related factors include: teachers content knowledge, pedagogical content knowledge, understanding of inquiry, and the nature of science. This section explores these concepts and how they impact the teaching of science.

Self-Efficacy Beliefs

Teachers' self-efficacy beliefs influence what they teach and how they teach in the classroom. Weiss, et al. (2001) indicated that teachers' perceptions concerning their qualifications for teaching science directly relate to the amount of time that they spend teaching science. Enochs and Riggs (1990) indicate that teacher beliefs are a part of the foundation of behaviors. "Behavior is enacted when people not only expect specific behavior to result in desirable outcomes (outcome expectancy) but they also believe in their own ability to perform the behavior (self-efficacy)" (p. 2). Bandura (1994) indicated four main sources of influence on self-efficacy. The first source of influence on self-efficacy is mastery experiences. When teachers or students feel success, they build their efficacy beliefs. Perseverance is part of mastery experiences because the challenges along the way help them to continue in their efforts and build successes. A second source of influence is observation of social models. When it is apparent that others can succeed, teachers can believe in their own ability. Observing proficient models can support teachers through the demonstration of needed skills. The third source of self-efficacy belief is based upon social persuasion or ways that teachers are verbally persuaded that they have the abilities needed to accomplish a task. Here it is important to provide situations that bring success. The last source of self-efficacy beliefs is based on a person's emotional states and his/her influence. Overall, teachers need to have realistic self-efficacy in teaching science. They should have support in teaching as they build their own confidence in their abilities. Ginns and Watters (1999) made a number of assertions based on their research that followed pre-service teachers into their classroom experiences. These assertions are similar to Bandura's (1994) sources of self-efficacy beliefs. They found that teachers should have successful experiences in their teacher education program, that science coursework must provide authentic practices and experiences and that experienced teachers and other educators must provide positive feedback to reinforce beginning teacher's beliefs about their ability to teach science.

Teacher's Science Content Knowledge

Pre-service elementary teachers may not have a strong background in the content to teach science effectively. Davis and Petish (2005) indicate that elementary teachers have less science subject matter knowledge than secondary teachers. Pre-service teachers need strong science content knowledge to teach for conceptual understanding. "It is argued that knowledge of science is necessary in order to be able to participate in discussion, debate, and decision-making about science related issues in society, such as environmental issues" (Ekborg, 2005, p. 1671). Ekborg further emphasizes that having conceptual understanding of science topics is more important than algorithms or formulas. In the study conducted by Ekborg, it was determined that teachers did not develop the content knowledge to make decisions based upon sound science and that they may not be able to help future students develop conceptual understandings in science.

Science content knowledge, as defined by Gee, et al. (1996) includes: science as interdisciplinary in nature, science as inquiry and the subjects' scientific conceptions. Regarding integration, Gee et al. refers to the integration of science content with other content areas but also includes the emphasis on the integration of different science content. Science inquiry is related to content and considers that science is doing and not just a collection of facts. Lastly, science content includes an understanding of specific science content. Petish (2004) further explains that content knowledge is the knowledge needed to teach a science curriculum unit effectively.

Davis, et al. (2006) found that most teachers have unsophisticated understandings of science. Harlen and Holroyd (1995) found that teachers felt more confident in their ability to help students develop science skills and processes than in helping them develop an understanding of specific science content. About 1/3 of the teachers in their study indicated they would need a significant amount of help to teach Living Things and the Processes of Life and Earth and Space topics and even fewer teachers were confident in teaching Energy and Forces. This confidence level directly related to how teachers taught in the classroom. The study also reinforced the idea that teachers who are uncomfortable with the content of science often make up for it by teaching less science or by teaching science topics within their comfort zone, often relying on prescriptive texts and kits and an emphasis on expository teaching with less discussion.

Content knowledge is needed in order for teachers to implement inquiry practices. The National Research Council [NRC] (2000) indicates that for teachers to teach using inquiry, they need to understand the important content ideas in science. The content standards for science should be understood along with evidence for the content, “how we know what we know” (NRC, p. 92). Jarvis, McKeon and Taylor (2005) worked with pre-service teachers to address misconceptions and incorrect scientific ideas. They found the pre-service teachers to have a number of common misunderstandings along with incomplete or confused terms. One emphasis for pre-service teachers should be the development of strong background knowledge in science content to support more conceptually based science and scientific inquiry in the classroom.

Pedagogical Strategies

Pedagogical knowledge refers to general strategies for teaching. Pedagogy is the art of being a teacher and pedagogical knowledge includes the style or methods of teaching. Gee et al. (1996) emphasize the use of social interaction in learning, building instruction on prior knowledge, problem solving and higher level learning as important components of pedagogical knowledge. Hudson (2004) has also identified different aspects of pedagogical knowledge that support new teachers in teaching science. Some skills include planning, timetabling, preparation, implementation, classroom management strategies and questioning skills.

One challenge for teachers is to create a classroom learning environment that is productive and manageable. Davis, et al. (2006) states that although new teachers want their classrooms to be student-centered, the concerns they have about classroom management may work against that goal and lead them into engaging in less reform-oriented practices. Additional information from the same research showed that even teachers who began with a student-centered environment to support science teaching may maintain less hands-on activities over time because of management issues. Peers, Diezmann and Watters (2003) also find that classroom management was a concern for seasoned teachers who are trying to implement inquiry and science reform practices. They find that the noise level during group work increased and that management of behavioral problems was more difficult during the science time.

Teachers need support in the development of their pedagogical skills in order to implement scientific inquiry in the classroom. The active nature of science requires skillful teaching practices to maintain focus and control in the classroom. These pedagogical strategies are not always present for pre-service teachers and develop through time and experience in the classroom (Mulholland and Wallace, 2003; 2005). Davis and Petish (2005) state that most prospective elementary teachers, because they are novice teachers, do not have the general pedagogical knowledge, that veteran teachers have acquired through years of experience. These strategies directly affect how they teach science in their classroom.

Pedagogical Content Knowledge

Research on teaching abilities has expanded to include more than just general teaching practices to support classroom learning. Shulman (1996) identifies three categories of content knowledge including subject matter content knowledge, pedagogical content knowledge and curricular knowledge. Content knowledge refers to the amount and organization of knowledge, which goes beyond knowledge of facts and concepts into an understanding of the structures of the subject matter. Pedagogical content knowledge deals with the subject matter knowledge for teaching. PCK includes the ways of representing and formulating the subject so it is understandable. Curricular knowledge has to do with the curriculum and the range of programs designed for teaching different subjects or topics at various grade levels. In this area, teachers must consider the curricular alternatives that are appropriate for instruction when teaching specific subjects of the curriculum. These types of knowledge affect teacher practice and their ability to implement inquiry. Gee et al. (1996) also adds the use of appropriate technology in teaching a given concept as a part of pedagogical content knowledge.

When we look at the overall goals for the teaching of science, they are more than knowing science content and teaching strategies. Science teachers make decisions related to classroom instruction regularly and often unconsciously in the classroom. Lee, Brown, Luft and Roehrig (2007) believe these decisions are based upon a teacher's pedagogical content knowledge. "This type of knowledge allows teachers to reason pedagogically and to make decisions pertaining to practice that ensures students will develop an understanding of science" (p. 52). As such, teachers, who are able to integrate a deep understanding of the content of science while they use their understandings of how to teach the science content through science specific teaching strategies, develop their abilities related to pedagogical content knowledge. The combination of factors and the teachers' ability to integrate his/her personal knowledge of the different aspects together create PCK (Dickerson, Dawkins and Len, 2007).

"Pedagogical Content Knowledge (PCK) is teachers' understanding and enactment of how to help a group of students understand specific subject matter using multiple instructional strategies, representations, and assessments while working within the contextual, cultural, and social limitations in the learning environment" (Park and Oliver, 2007, p.3). Park and Oliver also identify five components for PCK for science teaching from previous work on the topic. The components include: orientation to science teaching, knowledge of students' understanding in science, knowledge of science curriculum, knowledge of instructional strategies and representations for teaching science and knowledge of assessments of science learning.

The first component of PCK identified by Park and Oliver (2007) is orientations to teaching science address the teachers' beliefs about the purpose and goals for teaching science and include nine orientations: process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry and guided inquiry. When considering knowledge of students' understanding in science, the second component of PCK, teachers need to know and understand students' conceptions of science topics, learning difficulties, motivation, learning style and developmental level. The next area is knowledge of science curriculum, which includes how teachers identify core concepts of the curriculum, modify activities and eliminate aspects not deemed central to the understanding of the concept. The fourth aspect from Park and Oliver is knowledge of instructional strategies and representations for learning. This component consists of subject and topic specific strategies. The subject specific strategies are approaches to instruction including the learning cycle, conceptual change strategies and inquiry instruction. Topic specific strategies include specific strategies that correlate with the science topic at hand. The last domain identified as part of PCK is knowledge of assessment of science learning. This domain considers how we assess students including the activities, approaches and specific instruments we use (Park and Oliver).

Further development of two of the five domains of pedagogical content knowledge was conducted by Lee et al. (2007). They took two categories of the five domains and created a rubric for each that would allow researchers to distinguish a level of pedagogical content knowledge. The two aspects were: knowledge of student learning in science and knowledge of instructional strategies. The proficient level for knowledge of student learning in science included prior knowledge, variations in student approaches to learning and student difficulties with specific science concepts. At the proficient level, the teacher draws upon student prior knowledge and constructs lessons to build on the knowledge; the teacher acknowledges various approaches to learning and provides students opportunities to learn in different ways; and the teacher considers learning difficulties during the process of planning lessons and addresses the difficulties in the lessons. For pedagogical content knowledge related to knowledge of instructional strategies two elements were considered: scientific inquiry (science-specific strategies) and representations. The proficient level for these areas of knowledge of instructional strategies include that the teacher adopts scientific inquiry for teaching lessons and incorporates most (four or five) of the essential features of inquiry into lessons, and the teacher's uses representations that are pedagogically effective, scientifically accurate and linked to student's prior knowledge.

The idea of pedagogical content knowledge has continued to be explored in the field of science education. Davis and Krajcik (2004; 2005) have related the idea of pedagogical content knowledge to inquiry because of the reform efforts and the focus on inquiry. They refer to this as *pedagogical content knowledge for scientific inquiry*. They have expanded the definition of pedagogical content knowledge to include: knowledge of the orientations to scientific inquiry; understanding of the instructional strategies and tools for supporting inquiry; knowledge of children's understandings and misunderstandings associated with inquiry; knowledge of appropriate curriculum for inquiry and knowledge of assessment techniques for inquiry. The PCK for scientific inquiry is similar with the identified domains from Park and Oliver (2007), the difference being the specific focus on scientific inquiry instead of general science teaching.

These ideas regarding pedagogical content knowledge for inquiry are aligned with research from Petish (2004). Petish looked at how lesson plans were organized to include features of inquiry and how instructional strategies specifically supported different inquiry practices. She also looked at pedagogical content knowledge in light of curricular rationales or reasons for engaging students in inquiry practices. Lastly, she emphasized that a teacher's pedagogical content knowledge was increased when they were aware of students' alternative ideas in science topics. Petish used the CASES educative curriculum materials as a model curriculum that had the supports for teachers and for teaching inquiry.

Pedagogical content knowledge learning occurs over time and through experiences in teaching science. Lee et al. (2007) emphasize that the development of PCK is acquired through years of teaching experience. They also believe that experiences such as professional development support a growing understanding of PCK. "The development of pedagogical content knowledge by teachers mirrors what we know about learning by students; it can be fully developed only through continuous experience. But experience is not sufficient. Teachers must also have opportunities to engage in analysis of the individual components of pedagogical content knowledge- science, learning and pedagogy - and make connections between them" (NRC, 1996, p. 63).

Teaching Inquiry

Inquiry is a teaching method aligned with research that focuses on how children learn, and is a central component of the Content Standards for Science. According to the National Research Council [NRC] (2000) inquiry "encompasses not only an ability to engage in inquiry but an understanding of inquiry and of how inquiry results in scientific knowledge" (p. 13). Inquiry is advocated as an important practice in teaching science. It has benefits for children because it is aligned with how people learn. Inquiry learning is a dynamic and interactive process where children bring their current ideas, and through interactions with the environment, with teachers and other students, they can reorganize, redefine or replace their initial explanations. The National Research Council (1996; 2000) has identified five essential features of inquiry. These features include: engaging in scientifically oriented questions, gathering evidence, developing explanations based on evidence, evaluating explanations in light of alternative explanations and communicating and justifying proposed explanations. Additionally, NRC (2000) has identified levels of inquiry regarding the essential features. These levels take into account the amount of learner self-direction and the amount of direction from the teacher or materials. “Sometimes inquiries are labeled as either ‘full’ or ‘partial’. These labels refer to the proportion of a sequence of learning experiences that is inquiry based” (NRC, 2000, p. 28). Some inquiry activities will not be considered full inquiry because they will be missing some of the essential features of inquiry and will, therefore, be considered partial inquiries. “The degree to which teachers structure what students do is sometimes referred to as ‘guided’ versus ‘open’ inquiry (NRC, 2000, p. 29). These distinctions are made according to the degree of control or responsibility the students have in regard to asking questions, developing investigations and communicating their findings. Guided inquiry indicates that the teacher has more control in the structure of the lessons and in open inquiry the students gain more control in the overall inquiries.

Many early childhood educators are not equipped to teach through inquiry, as suggested by the National Science Education Standards. Davis et al. (2006) discuss that to teach inquiry-oriented science, teachers must have strong understandings of inquiry and abilities to teach inquiry. Their analysis of findings emphasized that many pre-service teachers have unsophisticated understandings of inquiry which would not facilitate teaching with this approach. The National Research Council emphasizes the need to prepare teachers for inquiry-based teaching. “For students to understand inquiry and use it to learn science, their teachers need to be well-versed in inquiry and inquiry based methods (2000, p. 87). They further emphasize that most teachers have not experienced science through inquiry or conducted scientific inquiry themselves.

Weiss et al.(2001), indicates that from survey results of elementary teachers, 65 percent of teachers reported a moderate or substantial need to learn more regarding how to use inquiry-oriented teaching strategies and 63 percent of teachers surveyed indicated they need support in understanding students’ thinking in science. These pedagogical gaps relate to areas specific to the teaching of science.

Previous experiences with inquiry supported teachers in implementing inquiry. Windschitl (2003) found that when pre-service teachers participated in inquiry activities, their conceptions of inquiry changed, but the decisive factor for implementing inquiry in the classroom was related to previous undergraduate or professional experiences with science research. The inquiry experiences alone did not impact a teacher’s classroom practice. These findings are similar to Plevyak (2007), who indicates that even with inquiry experiences, pre-service teachers need support and guidance to teach through inquiry. Windschitl emphasizes that a teacher’s conceptual understanding of inquiry relates to their perceptions of potential problems related to inquiry. Teachers who viewed inquiry as a procedural exercise viewed it as unproblematic but teachers, who saw inquiry as a complex process, had a more realistic view of the issues and complications involved in inquiry.

Teachers may believe that inquiry is synonymous with hands-on activities, believing that if children are actively involved in using and manipulating materials, they are involved in inquiry. Crawford (1999b) explores the further construction of knowledge in inquiry by emphasizing that the “Interactions of the students and teacher are the foci of the tugging and pushing of ideas students bring to each lesson” (p. 6). She emphasized the socially construction of knowledge through interactions and through the thinking and discussing of ideas. The NRC (2000) has identified the idea that hands-on activities guarantees inquiry teaching and learning are occurring as a myth about inquiry. It explains that interactions with materials in hands on activities are beneficial, but do not guarantee the mental engagement in the features of inquiry (p. 36).

Another factor akin to teachers abilities related to inquiry is that without strong experiences with inquiry, teachers are unsure who is in control of the learning process. Plevyak (2007) finds that even after pre-service early childhood teachers had experienced inquiry methods they were unsure how to make the shift from a more traditional teaching approach where the instructor was in control to a more student centered approach. Plevyak also includes the following three areas of concern that pre-service teachers indicated regarding the use of inquiry. The first concern is the time factor and a teacher’s ability to cover the science content that is required in a limited amount of time. A second concern of the pre-service teachers is classroom management. Student teachers felt that they may lose control of children in inquiry situations. The last area of concern was that young children would not be developmentally ready for inquiry. Students felt that “inquiry-based education would be over the heads of primary students” (Plevyak, p. 9).

Research from Crawford (2007), indicates that even when teachers may hold beliefs that inquiry-based approaches support thinking and conceptual understanding in science, they may still have other beliefs regarding the transmission of knowledge and the coverage of content that are at odds with inquiry. “Evidence from this study strongly suggests the most critical factor influencing a prospective teacher’s intentions and abilities to teach science as inquiry, is the prospective teacher’s complex set of personal beliefs about teaching and views of science” (p. 636).

Crawford (1999b) worked with one pre-service teacher to learn about her ability to implement inquiry in her classroom. She found that the pre-service teacher was able to implement inquiry but Crawford recommended support in the process including the following: examining pre-service teachers’ beliefs about science and teaching science, engaging pre-service teachers in authentic investigations, and providing models of teaching about scientific inquiry.

The National Research Council [NRC] (2000) further indicates that teachers must understand content in science to teach through inquiry. “Teachers need to understand the important content ideas in science – as outlined, for example, in the standards” (p. 92). This includes how the facts, principles, laws and formulas from their own science content courses are linked to the standards. Lastly, they need to know the evidence behind the content they teach such as how we know what we know. So teachers need to understand scientific inquiry, experience it and have a strong background in science content to be able to implement inquiry practices.

The Nature of Science

One goal of the National Science Education Standards is scientific literacy. An important aspect of this goal is to understand the nature of science. “Science is a way of knowing that is characterized by empirical criteria, logical argument, and skeptical review. Students should develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture" (NRC, 1996, p. 2). For students to develop an understanding of the nature of science, teachers also must attain the same understandings.

Research indicates that most students and teachers do not have the desired understandings regarding the nature of science (Abd-El-Khalick, et al., 2001). The Nature of Science is described as the epistemology of science or science as a way of knowing. Abd-El-Khalick et al. explain that although the nature of science is related to science processes, it goes beyond activities related to the collection and interpretation of data that lead to conclusions. The nature of science moves beyond the science processes and inquiry to a deeper understanding of how science works. There are six aspects of the nature of science that are relevant to elementary aged students. Those ideas show that scientific knowledge is: durable and tentative; empirically based; subjective or theory laden; partly the product of human inference, imagination and creativity; socially and culturally embedded; and utilizes observation and inference (Akerson and Hanuscin, 2007). The six areas emphasize that science is more than just a body of knowledge. The nature of science is intertwined with the science inquiry and should support teacher's understandings of how and why we teach through the process of inquiry. By assessing teachers' nature of science understandings and increasing them, student views can potentially be impacted (Abd-El-Khalick et al., 2001).

In research with college students, Abd-El-Khalick (2004) found that most participants held naïve views or demonstrated inaccurate understandings of the nature of science. A variety of views regarding specific terminology became apparent such as "theory", "creativity" and "prove". The multiplicity of meanings gave insight into perceptions of how scientists are involved in science. A second finding from this research indicated that the majority of participants had a fragmented framework of the nature of science. Participants may not have been able to provide examples to support their ideas or may have provided inaccurate ones in their explanations of how scientists do their work. The scientific method was one misconception that may have developed in early years and persisted in this study. Textbooks may contribute to the emphasis on one method of conducting science by the emphasis of this method and its use in science projects and fairs. Another understanding that seemed to be persistently inaccurate was the absolute status of scientific knowledge. Again, the use of textbooks and textbook assessments are indicative of the belief in the one correct answer or the right conclusion that can be found in 'cookbook' type activities (Abd-El-Khalick, 2005).

Researchers have questioned how teachers and students come to understand the nature of science. Schwartz and Crawford (2005) indicate that naïve views of the nature of science and related misconceptions can be attributed to the learners' lack of experiences with scientific inquiry and authentic scientific contexts for learning. Recommendations emphasize the need for students and teachers to engage in scientific inquiry investigations and activities during science instruction. Further, it is also imperative to process those experiences through reflections and discussions to support the construction of ideas related to the nature of science. Akerson, Hanson and Cullen (2007) support these findings but further emphasize the need for explicit instruction on the nature of science through the same formats rather than believing that involvement alone in scientific inquiry is sufficient to change views.

Influence of Teaching Materials

Curriculum materials are an important factor in how science is taught. Teacher's access to curriculum materials and how they use them are key factors in their teaching of science. This section explores current research on the uses of curriculum materials and educative curriculum materials.

The Uses of Curriculum Materials

The term curriculum has multiple meanings. It can refer to the frameworks that specify what should be taught or specific teaching guides or materials that teachers use in creating instruction or in their enactment of classroom instruction (Remillard, 2005). Broader still, we consider categories that can be used to describe types of curriculum, such as a formal curriculum that is outlined in school standards, intended curriculum which refers to the teacher's aims and lastly, the enacted curriculum which refers to what actually takes place in the classroom. (Gehrke, Knapp, & Sirotnik, 1992)

Curriculum materials are a driving force regarding what happens in the classroom. Their continual usage in daily class activities makes them an important aspect of teaching. Beginning teachers may depend on curriculum materials to help them facilitate classroom instruction (Forbes and Davis, 2007a). Remillard (2005), in her review of previous research, indicates that studies of how teachers use curriculum materials have changed over time. In the past, curriculum was viewed as fixed and the teacher was the person who delivered the curriculum rather than a user or designer. This is aligned with the 'teacher proof" curriculum movement. A second view of curriculum was that curriculum guides were one influencing force on classroom practice. More recently, research has focused on the teacher as an "active interpreter of curricular offerings" (Remillard, p. 216). A last category has emerged which overlaps the third category where the focus is the relationship that is developed with curriculum resources, the factors that affect the relationship and the effect the relationship has on the teacher and the curriculum as it is enacted in the classroom.

Based on Remillard's (2005) ideas, curriculum use encompasses how teachers interact with, draw upon or are influenced by material resources designed to support instruction. Ball and Cohen (1996) suggest that "the enacted curriculum is actually jointly constructed by teachers, students and materials in particular contexts" (p. 7). Forbes and Davis (2007a) find that beginning teachers rely heavily on materials that are readily available to them. Their use of materials was a function of and influenced by their own orientations of science teaching. One specific aspect related to this was the tensions between text-based science and inquiry or activity based science orientations. Teachers may struggle with how to use curriculum so that students got the information they needed to learn (textbooks) but were still able to experience and interact with materials. The curriculum materials that are available can influence the balance that teachers strive for regarding their science orientations. Most teachers in this research believed that the materials provided by the school were not sufficient to teach science.

Teachers may change and adapt curriculum for various reasons. Squire, Makinsler, Luehmann and Barab (2003) find that teachers may adapt content inappropriately to align with a more traditional approach, but good teachers will transform the curriculum to be consistent with their individual pedagogical beliefs. Davis (2005) worked with pre-service teachers to begin to understand the process of critiquing science lesson plans. Her research indicates that if teachers do not understand the rationales behind the curriculum, they make unproductive changes. She emphasizes the importance of curriculum materials that provide rationales for teachers so that the decisions they make regarding enacting the curriculum do not deviate from the intention of the lessons.

Additional findings (Forbes and Davis, 2007a; Appleton, 2003) indicate that teachers will often use 'activities that work' in their curriculum because they have been proven to be effective in the classroom. These activities may not provide a well rounded science program or the development of conceptual understandings for students in specific content areas of science. Another related issue regarding the use of curriculum materials is how they are aligned with learning goals and the standards outlined for teachers. Teachers must adhere to prescribed learning goals, usually in the form of standards and curriculum materials and must match the learning goals to fit within the curriculum needs of the classroom.

Lastly, the use of curriculum materials was influenced by the teaching contexts (Forbes and Davis, 2007a; 2007b). The teaching context for science in many schools today indicates that as a subject, it is not as important as other curricular areas such as mathematics and literacy (Weiss et al., 2001). Science may have less time devoted to it in the schedules. Associated with the relative lack of importance of science were the curricular materials and other resources available to teach science. Many teachers face teaching contexts that are not supportive of teaching science which may create conflicts and issues related to their use of curriculum materials and their overall abilities to teach science.

Educative Curriculum

"Teachers are expected to teach meaningful content that helps students to meet learning goals in the context of authentic activities, while addressing the needs of diverse learners and ensuring that all students are successful" Davis and Krajcik (2005). Often times teachers are not prepared to meet this goal and to facilitate the reform efforts that encourage the use of scientific inquiry.

Educative curriculum is a new approach to curriculum development and is designed to support teacher's knowledge in science content and pedagogy while they teach a science topic. Ball and Cohen (1996) first suggested the idea that curriculum materials could be designed to support teacher learning along with student learning. They emphasized that when teachers enact curriculum with students, the curriculum guides could help teachers understand and interpret student responses to activities, and develop a deeper understanding of content including how ideas and representations are connected regarding content. Davis and Krajcik (2005) define educative curriculum materials as “materials that help to increase teachers’ knowledge in specific instances of instructional decision making but also help them develop more general knowledge that they can apply flexibly in new situations”(p. 3).

Educative curriculum can impact teachers’ ideas in a number of areas or domains. Ball and Cohen (1996) identified five intersecting domains that can be included in curriculum materials to support teachers in the enacted curriculum. These include 1) the specific and potential content 2) pedagogy 3) the development of content 4) students and the environment and 5) the broader community. Educative curriculum materials, therefore, move beyond a focus of students to include the teacher and the factors involved in the enactment of curriculum in classrooms.

More specific factors related to educative curriculum materials were discussed by Davis and Krajcik (2005). They identified five guidelines for consideration in the development of educative curriculum materials. The first guideline is that educative materials could help teachers learn to anticipate what students may think and do in response to science activities. This anticipation would be supportive of teachers’ pedagogical content knowledge related to specific science content and understandings of how to deal with classroom interactions. A second guideline for these types of materials is focused on support for teachers’ background knowledge. Teachers can learn subject matter when it is addressed for student learning in curriculum and also when teachers are provided information regarding student alternative ideas and thinking.

Schneider and Krajcik (2002) emphasize that content explanations should be at a level beyond that which would be suggested for students. Thirdly, teachers benefit when they see how ideas and content connect to provide a broader curricular picture and overarching goals. The fourth area addressed to share the curriculum developers' pedagogical reasoning related to the curriculum rather than merely guiding teachers. Curriculum materials should communicate reasons for curricular decisions; this reasoning leads to the fifth guideline to ensure that when the teacher understands the reasoning associated with curricular decisions, they will understand the possible implications of changing the curriculum. Davis and Krajcik (2005) consider the fifth guideline to support teachers' pedagogical design capacity. The pedagogical design capacity is the teachers' ability to adapt curriculum and still achieve the curricular and learning goals.

Educative curriculum has been used in research and has shown progress in impacting elementary and secondary teachers. Schneider, Krajcik, and Marx (2000) find that "educative curriculum materials appear to be a promising approach to facilitate teacher learning that is necessary for improved practice" (p. 60). Beyer and Davis (2007) find that the educative curriculum was supportive in moving towards more explanations and science inquiry in the classroom. Petish (2004) finds that educative materials fostered certain aspects of inquiry including using scientifically oriented questions in lessons, providing activities that allow for evidence gathering and sense making activities.

Research Questions

The research strongly indicates that pre-service and in-service teachers have hurdles to overcome when trying to implement inquiry science effectively in the classroom. Specific hurdles that have been identified in the literature include teacher beliefs regarding their ability to teach science, teacher's content knowledge in science, minimal understandings of and experiences with scientific inquiry and the nature of science. Pre-service teachers are often at the beginning stages in the development of pedagogical skills and pedagogical content knowledge which create additional hurdles for them. One possible avenue of support for teachers is an educative curriculum which provides content knowledge support and support for the nature of science and inquiry practices with students. Although a growing body of research has shown the use of educative curriculum is effective, the focus of the research has not been specifically on early childhood teachers or pre-service teachers. Looking into the practices and abilities of pre-service teachers will add new information to the existing research. This research will provide information to help establish practices that will support pre-service teachers in their efforts to learn and grow as educators. This investigation will examine the role educative curriculum materials play regarding pre-service teacher's science content knowledge, pedagogical content knowledge and the impact and specific uses of educative materials to support the teaching through inquiry. Therefore, the questions that guide this research are:

How will educative materials impact pre-service early childhood education students' content knowledge including their understandings of specific science concepts and the nature of science?

How will educative curriculum materials impact pre-service early childhood education student's pedagogical content knowledge related to inquiry methods?

Study Contributions

The review of the research on science teaching in elementary schools clearly indicates that we need to support elementary teachers in teaching science and scientific inquiry. In supporting teachers, one consideration will be how educative curriculum materials can enhance their content knowledge and knowledge of teaching science. Further, working with pre-service teachers taps an area that has not previously been investigated using educative curriculum materials. Along the same lines, this research will contribute to the knowledge base because it addresses early childhood educators and much of the previous research has addressed elementary teachers. This study can broaden the field of research directed at the benefits of educative curriculum and how the specific CASES curriculum supports the teachers in this study. This information could be used with other research in this field of study to revise and refine educative materials in the future.

CHAPTER 3
METHODS

This chapter describes the methodology used for this study to collect and analyze data investigating how educative curriculum materials, developed by the University of Michigan CASES research group, supported pre-service early childhood teacher's teaching of science in their internship experiences. This chapter begins with an overview of the methodology for the study, the characteristics of participants, and the educative curriculum materials that will support teachers' development in teaching science. Then, a discussion will follow on the data collection and analysis procedures that were used to answer the research questions, providing an explanation of how each case study report developed.

Study Overview

Three pre-service early childhood teachers participated in this research. The teachers were initially interviewed regarding their ideas about teaching science based upon three instruments: Views of Science Inquiry, Views of the Nature of Science and the Science Teachers Efficacy Beliefs Inventory. Each teacher was observed teaching science in their internship site. They were initially observed teaching lessons of their choice guided by their internship teacher; next they taught a science unit based upon the CASES educative curriculum materials. The Curriculum Access System for Elementary Science (CASES) curriculum was developed by the CASES research group at the University of Michigan. During the science teaching, the participating teachers reflected upon their teaching. While teachers were using the CASES curriculum, they were interviewed to ascertain their use of the materials and how they were supportive in their teaching. At the conclusion of the research, the initial instruments were once again administered along with an interview to obtain changes in teachers' knowledge, beliefs and understandings of science and science teaching.

Case Study Design

The methodology for this research involves a case study approach. Yin (2003) defines case study research as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13). The case study will allow consideration and observation of the various influences that occur in the process of pre-service teachers learning how to teach science. Merriam (1988) suggests that case studies look at "real life situations and provide a rich and holistic account of phenomenon" (p. 32). This approach considers various influences such as confidence in teaching science, teacher background regarding science, previous experiences in science, use of educative curriculum, match between beliefs and practices, impact of supervising teacher, teaching orientation and other factors. Three instruments will support the development of a teacher profile for each participant regarding their understandings of the nature of science, scientific inquiry and self-efficacy beliefs in teaching science. These baseline data will be used with observations, interviews and reflections to develop an understanding of each teacher's growth and development of teaching science.

The case study offers an approach to research that is different from other types of research in a number of ways. Case study research is more concrete, more contextual, and is developed by the reader and based on reference populations determined by the reader (Merriam, 1988). Using this approach will allow the exploration of many salient factors associated with pre-service teachers' development as teachers of science.

Research Participants

Purposeful sampling was used to obtain participants for this study. This type of sampling is recommended for case studies allowing researchers to select a sample in which to learn the most (Merriam, p 48). The pool of participants included students who had taken or were currently taking the SCE 4304 course in the Fall term of 2007 (Teaching Science and Technology to Young Children) and who were participating in an internship experience in the Early Childhood program during the time frame of the study. Participants in the study were selected according to their willingness to participate, their inclinations towards science, their ability to teach the science unit selected from the CASES web site and their willingness to devote time and effort to the project. Three early childhood student teachers participated in the project during their internship experiences. The first two pre-service teachers began the research in the fall term of 2007 in their junior internship experience. These student teachers participated in the initial instruments and interview along with teaching science lessons. The third student teacher began the interview and instruments at the end of the fall 2007 term and began her science teaching in the spring 2008 term.

All three participants in the study were female. They were all eager to participate in the study and had a general willingness to learn more about teaching science. All three participants were in their internship experiences during the research. Students in the Early Childhood program at the University of Central Florida participate in one junior internship experience where they spend two days a week in a classroom setting. Students also have a senior internship experience where they spend a full semester, five days a week in a classroom setting. The senior internship experience also allows these student teachers to take over the teaching of their internship classroom setting for a four to six week time period.

A review each of the study participants and a brief overview of their characteristics follows. A more detailed review of the participants will occur in the specific case study chapters. Pippa, Alexis and Denice[1] are all students in the Early Childhood Education program at the University of Central Florida. Pippa and Alexis are regional campus students who did not attend the central university campus. Denice was a main campus student and would also be considered a traditional student. Pippa and Alexis were older than Denice and did not earn their degrees in a traditional fashion. They both attended a community college to earn their associates degree before transferring to the university to complete their bachelors' degree. Denice began her college work right after high school and continued straight through until graduation. See Table 1 for an overview of the participants teaching contexts.

[1] Pseudonyms are used throughout the study.

Table 1 - Teaching Context of Research Participants

Participant Name	School Location	School Type	Percentage of Minority Students	Percentage of Economically Disadvantage
Pippa	Volusia County		First Placement 34% 6.1ELL	First Placement 53.1%
			Second Placement 44% 9.1ELL	Second Placement 45%
Alexis	Volusia County	Public	First Placement 44.5% 10.7 ELL	First Placement 48.7%
			Second Placement 32% 7.1ELL	Second Placement 46.4%
Denice	Seminole County	Public	First Placement 40% 6.4%ELL	First Placement 36.3%

All three teachers were in relatively similar situations related to the number of minority students and the number of disadvantaged students. Pippa and Alexis were in two schools during the time of the study: their junior internship shown as first placement and their senior internship indicated as their second placement. Since I was not able to observe Denice during her junior internship, the information shown represents her school placement in her senior internship experience.

Each of the participants in the research took the science methods course at the University of Central Florida. Although they did have different instructors for the course, the general goals for the course remained the same. The goals for the course were to provide the knowledge and skills needed to implement an integrated discovery science program for young children. The regional campus science methods course directly addressed scientific inquiry as one important method to teach science.

Educative Curriculum Materials/CASES

The CASES science units, which have previously been developed through the University of Michigan's Education program, will be used with these pre-service teachers in the science topics of plants and electricity/magnetism. CASES (Curriculum Access System for Elementary Science) has a web site developed through the University of Michigan Education Department. It was developed through a grant from the National Science Foundation and includes units and lessons designed in an educative format using science inquiry as well as other resources and discussion areas for teachers. The web site for CASES is http://cases.soe.umich.edu/index.html.

The CASES learning environment provides a broad range of resources for teachers to support them in teaching and to support them in their understandings of science content and inquiry practices. When you log in to the website, there are six specific areas accessible. The first area is the Inquiry Oriented Unit Plan Library. This area contains the fully developed science units that have been created by the CASES research team. A second area is the Lesson Plan Library. This area has lesson plans from the units including some lessons that are not a part of complete units. Since the lessons are designed using inquiry features, they can be used individually. The next area is the Teacher Communities area, which allows for discussions of the CASES materials. This area is restricted to graduates of the University of Michigan education program. Those teachers can participate in discussion groups to share ideas about teaching and to discuss the science units and lessons. A Personal Online Journal allows teachers to write reflections of lessons and to consider their understandings of teaching science. The Science Teaching Resource Library has resources for science content, science standards, lesson plans, etc. This resource library is designed to provide additional resources for teachers who are implementing science. The last section of the CASES website is Images of Inquiry. In this area, teachers can read about other teachers who have used the curriculum and who teach science through inquiry. These images provide a look at the experiences of other teachers who are implementing inquiry and who are sharing their experiences.

The CASES website has two early childhood science units that have been developed with educative features in the Inquiry Oriented Unit Plan Library. There are also eight units/lessons that have been developed for grades three to five. The plants unit was developed as a K-2 unit, while the electricity/magnetism unit was intended for grades three to five. The educative features of these curriculum units include an introduction, driving questions, standards, science background, students' alternative ideas, unit lessons, assessment and ideas and resources. The CASES curriculum units have outlined educative supports including Use of Inquiry Practices, PCK Instructional Strategies, PCK Curricular Rationales, PCK Alternative Ideas and Subject Matter Knowledge. *Use of Inquiry Practices* is embedded into the lesson plans as curricular suggestions. All of the lessons are organized around the features of inquiry including questioning, evidence gathering, making sense of science, justifying and communicating explanations. *PCK – Instructional Strategies* are embedded into lesson plans as curricular suggestions and in pop-up boxes. The CASES web site provides a list of instructional strategies associated with each inquiry practice. *PCK- Curricular Rationales* provide teachers rationales in pop up boxes and list the rationales for engaging students in specific inquiry practices. *PCK – Alternative Ideas* provide teachers with possible alternative ideas that students may have on the topic and are embedded into the lessons and on the Alternative Ideas page. *Subject Matter Knowledge* provides an explanation of subject matter knowledge for teachers. This information is embedded into the lessons and can also be found on the Science Background section. See Table 2 for an overview of the CASES curricular supports.

Table 2 - Educative Support Features in CASES Curriculum

Educative Support	Location in CASES Curriculum	Coverage
Use of Inquiry	Embedded into lesson plans	The units and lessons emphasize the use of inquiry practices including the use of questions, evidence, formulation and justification of explanations and communication. All lessons use driving questions to organize content Lessons use one or more aspects of inquiry Some lessons allow more learner self direction Images of Inquiry show cases of teachers using lessons
Subject Matter	Science Background Page and also embedded into lessons	Covers background knowledge related to the content of the lessons
Pedagogical Content Knowledge (PCK)-Instructional Strategies	Embedded into lessons	Pedagogical content knowledge of instructional strategies is supported by lessons that have been developed to support inquiry. Instructional strategies are listed in lessons.
Pedagogical Content Knowledge (PCK)-Curricular Rationales	Pop-up boxes embedded in lessons	Provides reasoning for inquiry practices and explanations of the practices
Pedagogical Content Knowledge (PCK)-Alternative Ideas	Embedded into lesson plans and on Alternative Ideas page	Related to background knowledge, here teachers can see alternative ideas that are commonly held by students

Petish (2004)

CASES Curriculum Units

Each participating teacher engaged in at least one of the CASES curriculum units. The pre-service teachers were provided information about the different units that were available for them in their teaching. The teachers then worked with their supervising teachers to decide what units correlated with the specific science focus that occurred during the internship experience. In this way, the pre-service teachers selected the unit they would be teaching for this research. See Table 3 for the curriculum units including the driving question and the topics.

Table 3 - CASES Curriculum Units Used

Teacher	Unit Topic and Driving Questions	Topics covered within the Unit
Pippa	Plants: Where did the trees in our playground come from?	• Location of seeds in plants • Characteristics of Seeds • How seeds Move • Seed Parts • What plants need • Uses of plants
Alexis	Plants: Where did the trees in our playground come from?	• Location of seeds in plants • Characteristics of Seeds • How seeds Move • Seed Parts • What plants need • Uses of plants
Denice	Plants: Where did the trees in our playground come from?	• Location of seeds in plants • Characteristics of Seeds • How seeds Move • Seed Parts • What plants need • Uses of plants
	Electricity/Magnetism: How does electricity make things work?	• Circuits • Static electricity • Current electricity • Electromagnets • Energy transformations

Data Sources

A whole host of data sources were used throughout this study. Data collection in this stage will included a pre and post interview in conjunction with the Views of the Nature of Science (VNOS-D) instrument (Abd-El-Khalick et al., 2001), the Views of Scientific Inquiry (VOSI-E) instrument (Lederman and Ko, 2003) and the Science Teaching Efficacy Belief Instrument (STEBI-B) instrument (Enochs and Riggs, 1990). Data collection will also include observations of science teaching, lesson reflections in the form of online communications that include comments about their science teaching experiences. The Pre-Interview in conjunction with the VNOS-D, VOSI-E and STEBI-B will seek to ascertain participant's feelings towards teaching science along with their underlying philosophy of science education, understandings of the nature of science, scientific inquiry and self-efficacy beliefs regarding teaching science. After the initial interview, pre-service will be observed teaching two science units. They will first be observed while teaching a science unit of their choice using the Field Supervisor Observation Instrument developed by Windschitl (2004) (See Appendix F). This instrument looks at the type of instruction employed and their approach to teaching using inquiry. Field notes will also be gathered during the observations using the Teacher Observation form. (See Appendix E) Next, the teachers will become familiar with the CASES web site and the associated educative curriculum. They will select a unit of study that has been specifically designed for early childhood teachers and that implements educative features to support teacher and student learning. Pre-service teachers will then implement the curriculum in their internship site. The Field Supervisor Observation Instrument will again be used along with field notes. This data will be collected during a period of two to five weeks. The focus of observations will be to see what educative features are being used in the lessons, and to see if inquiry practices are being implemented. During this time, participants will also submit weekly reflections to share how they are using the CASES materials and to glean their feelings about teaching science. An interview will take place during the implementation of the CASES curriculum to ascertain how participants are using the features of the curriculum (See Appendix I – CASES Implementation Interview). After the observation period, the VNOS-D, VOSI-E and STEBI-C instruments will be used again to see if the pre-service teachers have developed further understandings of the nature of science, scientific inquiry and to evaluate their efficacy beliefs in science. Post interviews will also be conducted to coincide with the instruments and will aim to clarify terminology and understandings from the instruments. See Table 4 for an overview of the data collection tools.

Table 4 - Data Collection Tools

Data Source	Purpose	Timing
VNOS-D	To establish pre-service teachers' understandings of the Nature of Science	Beginning of Research
VOSI-E	To establish pre-service teachers' understandings of Scientific Inquiry	Beginning of Research
STEBI-B	To establish pre-service teachers' self-efficacy in teaching science.	Beginning of Research
Interview	Clarify an understanding of teacher's beliefs regarding the Nature of Science and Scientific Inquiry along with feelings of teaching science	Beginning of Research
Observational Data – Field Notes	Describe the teacher's Nature of Science and inquiry practices used during pre-CASES and CASES science lessons	Pre-CASES Science Lessons CASES Science Lessons
Reflections	Captures the pre-service teacher's use of the curriculum and lesson enactment	Pre-CASES Science Lessons CASES science Lessons
CASES Implementation Interview	Understand how each teacher interacts with the CASES web site and Curriculum materials.	Middle of CASES Teaching
VNOS-D	To elicit how pre-service teachers' understandings of the Nature of Science have changed through the use of CASES curriculum and reflection	End of Research
VOSI-E	To understand how pre-service teacher's understandings of Scientific Inquiry have developed through the use of the CASES curriculum and their own reflections	End of Research
STEBI-B	To ascertain if changes have occurred in pre-service teachers' self-efficacy beliefs after the support of the CASES curriculum	End of Research
Interview	Clarify an understanding of teacher's beliefs regarding the Nature of Science and Scientific Inquiry along with feelings of teaching science	End of Research

Data Analysis

Multiple Sources of data will be analyzed in this research. The Views of Nature of Science (VNOS-D) instrument is designed to assess views of the nature of science. This document will help to assess how aligned the pre-service teacher's views are with current reform documents regarding the nature of science. The evaluation of this instrument provides a description showing if the participant has views consistent with reform efforts. Responses will show how the respondent understands the nature of science including science as tentative, how it involves creativity and subjectivity, that it involves observation and inference and is not limited to a single approach and is empirically based. Akerson et al. (2007) categorize teacher responses to the VNOS and VOSI as having "no understanding", an "emerging understanding" and an "informed view". Their research shows teachers moving along the continuum towards a more informed view of the Nature of Science.

The Views of Scientific Inquiry Elementary School Version E (VOSI-E) is an instrument designed to assess views of scientific inquiry. The VOSI targets various aspects of scientific inquiry including that investigations have multiple methods and purposes, the importance of consistency of evidence and conclusions, multiple interpretations of data, the difference between data and evidence and that data analysis involves the development of patterns and explanations that are logical and consistent (Lederman and Lederman, 2005). Data collected from the VOSI will be used to develop a teacher profile that indicates "no understanding", an "emerging understanding" and an "informed view" of scientific inquiry.

The Science Teaching Efficacy Belief Instrument (STEBI-B) is designed to investigate pre-service elementary teachers' beliefs in science teaching. Enochs and Riggs (1990) modeled this instrument on the idea that teacher behavior is based upon beliefs. If a teacher has increased self-efficacy and high outcome expectancy towards teaching science, he/she will be willing to devote time and energy to science teaching. If a teacher has low self-efficacy toward teaching science, he/she may devote less time to teaching science and might believe it impossible to teach science effectively. This instrument can give a baseline of the pre-service teacher's beliefs regarding teaching science at the beginning of the research. The post-test will show changes in ideas and perceptions regarding the self-efficacy beliefs of the teaching of science.

Data analysis for this research will involve an evaluation of the VNOS-D, VOSI-E and STEBI-C instruments as outlined above. Analysis will also include examining, categorizing and tabulating the data from the Field Supervisor Observation instrument, the Teacher Observation form along with the Reflections to address the initial questions of the study (Yin, 2003). Specific techniques will include pattern matching and explanation building. Data will be organized topically and sorted to look for patterns. Categories will be developed based upon the patterns. Merriam indicates that "in addition to the participants' own categories, classification schemes can be borrowed from sources outside the study at hand" (p. 137). Categories will also be established that are connected to the nature of science and scientific inquiry to ascertain how the pre-service teacher is integrating these into teaching practices. Specifically, the five essential features of inquiry will be identified in lessons to indicate that teachers are able to implement inquiry with students: engaging in scientifically oriented questions, gathering evidence, and developing explanations based on evidence, evaluating explanations in light of alternative explanations and communicating and justifying proposed explanations. Research on scientific inquiry also shows various levels of the five areas or features of inquiry. These levels will be considered when analyzing data collected from classroom science lessons. Also, the observations will show implementation of the Nature of Science features including that scientific knowledge is: durable and tentative; empirically based; subjective or theory laden; partly the product of human inference, imagination and creativity; socially and culturally embedded; and able to utilize observation and inference. The reflections support explicit thinking of the nature of science and inquiry practices so these documents can provide data regarding how the pre-service teachers are considering the teaching practice of inquiry and how they view the nature of science during the research. Additionally the CASES Implementation interview will connect the practices that are being implemented in the science lessons back to how the CASES curriculum is being used. A coding chart was created for the case studies to identify the source of information. (See Appendix K – Coding Chart for Case Study Write-ups)

Overall, the data will provide a picture of how the CASES curriculum is supportive of pre-service teacher's beliefs and ability to implement reform practices in science education. The data will be assessed to create the picture and to learn how educative curriculum can support pre-service teacher's content knowledge of teaching specific content, his/her ideas regarding the nature of science and their pedagogical content knowledge in regards to teaching through inquiry. See Table 3.5 Research Question Alignment.

Table 3.5
Research Question Alignment

Research Question	Data Collection Used	Supports in Educative Curriculum (CASES)
How will educative materials impact pre-service early childhood education students' content knowledge including their understandings of specific science concepts and the nature of science?	Pre/Post Test - VNOS-D, VOSI-E and STEBI Pre and Post Interviews, Field Supervisor Observation Instrument, Teacher Observation Form Reflections	*Subject Matter* is embedded into the lessons and can also be found on the Science Background page *PCK – Instructional Strategies* are embedded into lesson plans as curricular suggestions and in pop-up boxes. Pedagogical Content Knowledge for *Curricular Rationales* is also identified in the lessons as well as *Alternate ideas*.
How will educative curriculum materials impact pre-service early childhood education student's pedagogical content knowledge related to inquiry methods?	Pre/Post Test Views of Scientific Inquiry Questionnaire (VNOS-D, VOSI-E and STEBI) Teacher Observation Form Reflections Post-Interview	*Use of Inquiry Practices* is embedded into the lesson plans as curricular suggestions

Composing the Case Study Reports

The case studies are shared in the following chapters. The data collected in association with each case represents an extensive amount of data. In developing the case studies, it was important to sift through the data and make decisions about which results to include in the narrative. These decisions were based upon the goal of creating a narrative that carefully portrays the important features of each case and that supported a developing understanding of how these teachers were learning to teach science in the processes associated with this study. In each case, descriptions of instructional practices are shared. One consideration to note: this research was conducted with pre-service teachers in classrooms that were not their own. This influenced the lessons taught, especially in the pre-CASES situation as most lessons were developed in conjunction with the supervising teacher.

The case study reports address five different areas with a final summary and discussion. The first section provides a teacher profile. The profile is designed to provide background information regarding each teacher and how this may impact the teacher's teaching. The second section addresses the initial instruments used with each teacher and the associated interview. These instruments focus on how the teacher understands the nature of science, science inquiry and their beliefs about their own ability to teach science. Third, the science teaching is analyzed during the Pre-CASES science lessons and the CASES science units. This includes field notes from observations, reflections of lessons, CASES interview and other worksheets associated with lessons and a summary of practices related to pre-CASES and CASES lessons. Each of these sections include a reflection of the instruction and teacher practices. The fourth aspect of the case study reports includes the Uses of the CASES curriculum followed by the Final Interview and Instruments.

Each case study ends with a summary and discussion section. This section addresses how the different sections relate back to the initial questions of the study. The focus will be changes in classroom practices and explores ways in which the CASES curriculum supported teachers in their content knowledge and their inquiry teaching practices. A second focus of the summary section for each case will be the changes in teacher understandings regarding the nature of science, scientific inquiry and their own personal self-efficacy beliefs regarding their science teaching.

CHAPTER 4
CASE STUDY: PIPPA

This chapter presents the case study of Pippa, one pre-service early childhood educator. This case examines the role of educative curriculum materials in Pippa's implementation of science lessons in her internship experiences and her understandings regarding scientific inquiry. Further, this case study examines the salient aspects of inquiry as they are enacted in her science teaching. These aspects include scientifically oriented questions, priority to evidence, and formulation of explanations, evaluation of explanations and communication and justification of explanations. Additional aspects associated with Pippa's science teaching will be considered including her use of the CASES materials and how they support her content knowledge and her pedagogical content knowledge. The chapter will conclude with a summary and discussion of the critical elements related to Pippa's science teaching and her overall development in her ability to implement scientific inquiry.

Teacher Profile

Pippa is a Caucasian female in her early forties. She is not a traditional student but is earning her degree over an extended period of time. She is expected to graduate from the Early Childhood Education Bachelor's degree program at the University of Central Florida in the spring term of 2008. At the beginning of the study, Pippa was in her junior internship experience in a third grade self-contained classroom in a Central Florida public school. In the second part of the study, Pippa was participating in her senior internship experience in a kindergarten classroom. Pippa had prior experiences with teaching in the school system. These prior experiences appeared to be supportive of her teaching practices and her ability to teach in this study. She worked as a teacher's assistant for over two years in the school system and also did substitute teaching throughout her college experiences.

Pippa worked with her supervising teacher to develop plans for the initial teaching of science for her third grade class. Since she only attended the school setting two days a week during the junior internship experience, there was no continuity in lessons. The lessons that were taught included one lesson on matter, one lesson on turkeys and one lesson on energy. Most lesson plans were based upon science concepts to be covered in preparation for the FCAT science test that occurs in fifth grade, except for the lesson on turkeys which coincided with Thanksgiving.

In the initial interview, Pippa indicated that science was not her strong area. She said, "I am a good candidate for this research because I really need to learn how to teach science" (II). In preparation for the lessons she taught, she indicated the need to spend a considerable amount of time reviewing and learning the content in preparation for teaching the students (PCL-2, PCL-3). Her initial lessons were developed with the support of her internship teacher and were guided and influenced by the content expectations for the county and by associated curriculum topics (LR, PCL-1)

In her second internship experience, Pippa's internship teacher identified two science content areas that were to be covered in the spring period, and Pippa selected one unit from the CASES curriculum to teach. This unit aligned with one of the designated curriculum topics. Her supervising teacher did not place a priority on the teaching of science but was willing to allow the teaching of science. She was involved in the implementation of the lessons that were taught by providing support, materials and guidance as necessary (LR).

Pippa also expressed a strong desire, willingness and openness to learn about teaching science (II). This desire and willingness to learn were demonstrated throughout the study in her eagerness to respond to emails, schedule observations and in her thorough reflections of the lessons she taught.

Initial Interview and Instruments

At the beginning of the research, Pippa was given three instruments to assess her understanding of the nature of science, scientific inquiry and her self-efficacy beliefs regarding teaching science. After the researcher reviewed the instruments, an interview was conducted to clarify any areas that were unclear from the instruments. Pippa's overall reaction to the instruments was that "they really made you think" and it made her aware of her knowledge of science and teaching science.

STEBI-B Instrument

The STEBI-B instrument was administered. This instrument has previously suggested that self-efficacy is a construct that can help to understand attitudes about the teaching of science and can show changes in self-efficacy over time (de Laat and Watters, 1995). The STEBI-B instrument is used to find teacher's self-efficacy beliefs regarding their ability to teach science. It is divided into two specific areas: Outcome Expectancy and Personal Science Teaching Efficacy Belief. For the Personal Science Teaching Efficacy Belief portion Pippa received 41 out of 65 possible points, which shows 63 percent of the total points. In previous research by de Laat and Watters, using the STEBI-A instrument with teachers, they found the mean score for the PSTE was 49.6 with a range of 33-62. Pippa's Personal Science Teaching Belief score shows a lower self-efficacy belief in this area. Riggs and Enochs (1990) worked with a population of 288 teachers and found the mean score for the PSTE was 56.54. Again, Pippa's score is lower than average based upon previous research. Research from de Laat & Watters showed that teachers with high PSTE scores expressed their confidence in teaching science and their interest in it. Pippa expressed her interest in the subject but did not express high confidence in her ability to teach science. Previous research also supported the notion that teacher backgrounds were more limited for teachers with a low PSTE score (Ginns and Watters, 1999). Pippa did indicate that her background in science was based upon science experiences she had with her own children and nature experiences they enjoyed together. She reported taking one or two high school science courses and four science courses in her college years. Overall, Pippa did not have a strong self-efficacy belief regarding her own teaching of science.

On the Outcome Expectancy portion of the instrument, Pippa received 34 out of a total of 50 points, which represents 68 percent. Enochs and Riggs (1990) found the mean score for the STOE for pre-service teachers to be 36.19 (when adjusted to eliminate two questions). Pippa's STOE (Science Teaching Outcome Expectancy) score shows that she is in a normal range for her STOE belief. While the Personal Science Teaching Efficacy belief score deals with the teacher's own personal beliefs about their ability the Outcome Expectancy portion is focused on the outcome which some teachers may believe is out of their control. Pippa's score on the STOE was higher and fell within a normal range for teachers. This score would indicate that she has positive outcome expectancy for her teaching.

Views of Nature of Science

The Views of Nature of Science Instrument was also administered. This instrument is open-ended and allows for short answer responses to a variety of questions related to the nature of science. Research on the nature of science indicates that teachers and students have not attained the appropriate views regarding the nature of science (Abd-El-Khalick, et al., 2001).

Pippa's overall responses to this instrument would be classified as general and naïve and coincides with previous research although she does have some insightful responses. The Nature of Science refers to the understandings of the complex and diverse nature of scientific undertakings. Important aspects of the Nature of Science include that science is tentative, empirically based, subjective, the product of human inference and creativity and culturally embedded (Abd-El-Khalick, et al.). In addition, researchers have also distinguished between observation and inference stating that there is not one scientific method and explored the differences between scientific theories and laws.

When discussing how science is different from other subjects, Pippa explained that "science is an ever evolving discipline". This view is aligned with a more informed view of science and its tentative nature. On the other hand, she did not include references to science as a body of knowledge as well as the processes for the development of knowledge but included a more general view that "science is the study of the world around us."

When asked about scientific knowledge changing in the future, Pippa indicated that scientific knowledge could change. She cited the example of the solar system and the current discussions about the planets and Pluto's new dwarf planet status. Her tendency to explain this was based on the fact that scientists have new and more sophisticated methods that reveal different data. When asked about how scientists know that dinosaurs existed, Pippa explained that they know this because of the fossil remains. The aim of this question was to consider the inferences scientists made based upon the data. She appears to have a view consistent with the informed views regarding how evidence is used to create scientific findings, but did not clarify her understandings about the inferences made. When asked why scientists believe different things regarding why dinosaurs became extinct, she indicated that scientists do not have enough information. This answer does not address the subjective nature of science which would indicate that different scientists bring their own backgrounds and biases to the interpretation of data. So the data regarding the extinction of dinosaurs is the same but different scientists interpret the data in many ways.

Pippa indicated that a scientific model is a representation of a scientific concept (II). The ideas that Pippa seemed to have are aligned with common notions of models. Pippa agreed that a model is not a ‘real’ or exact copy but just a representation. More in-depth ideas related to this question include that creating a model involves subjectivity and creativity and also relies on the fact that models are tentative. Models are also based on inference.

Lastly, Pippa felt confident that in the planning and hypothesizing stages of an experiment, creativity is involved. However, she indicated beyond these stages scientists must remain objective. In Pippa’s mind, objectivity is at odds with creativity. Here also, she provided an example of using creativity and imagination during an inquiry she pursued for the Early Childhood Education Science course. “Hypothesizing involves ones imagination as one is imagining what may occur based on what one already knows” (IInst).

Pippa’s views regarding the nature of science are more naïve than informed. She shows understanding of the tentative nature of science but does not demonstrate an understanding of the empirically based nature of science including the differences between observations and inferences in science. She has some understanding of the creative nature of science but does not show understandings of the cultural influences in science.

Views of Scientific Inquiry Elementary School Version (VOSI-E)

The heart of the Views of Scientific Inquiry Instrument (VOSI) assessment seeks to ascertain views about scientific inquiry. On the one hand, many people believe that there is just one “scientific” method that is followed in conducting science experiments instead of a broader view of multiple ways to experiment. This instrument also looks at the difference between a general scientific activity versus a specific scientific procedure. Regarding what kind of work scientists do, Pippa indicated that they, “attempt to explain, to understand, and to discover events and phenomena that occur in nature.”

On the Views of Science Inquiry instrument, Pippa responded in a general way to the question, “What types of activities do scientists do to learn about the natural world? She explained that scientists attempt to explain and discover events that occur in nature. She further explained that scientists are guided by the science process skills in doing their work, but in the interview she added that this could follow a scientific method format or could be broader. She was not aware of how this method might change; only that it may not be a strict lock-step method. The VOSI instrument provided an example of a scientist that observed birds and made decisions based upon her observations, asking if this work was scientific. Here, Pippa indicated the work was not truly scientific because she did not investigate the birds’ beaks. Her response shows a more limited view of scientific inquiry because she believes that in an experiment you would need identification and manipulation of variables and controls (Schwartz, 2004). Pippa believed that it was not an experiment, only explained an observation. She didn’t have an understanding that even though it was not an experiment, it can and is still scientific in terms of a broader view of scientific inquiry.

Pippa seems to be considering scientific inquiry and the possibilities it presents. Some of her answers show a more informed view of scientific inquiry, but at the same time, she did not follow through with the reasons or justifications that contribute to her ideas. This response may be due to limited experiences using the processes of inquiry. She did not show a clear understanding of multiple methods of science and did not fully demonstrate the link between data, evidence and conclusions.

Overview of Pre-CASES and CASES Units

Pippa taught a total of eight science lessons during her junior and senior internship experiences that were observed for this research. The first three lessons took place in a third grade classroom and were not actual science lessons but were review of science content and other activities that used science content. The time frame for the lessons was 30-35 minutes in length. Pippa taught five lessons from the CASES curriculum unit on plants during her senior internship in a kindergarten class. She followed the lessons as they were outlined in the unit and spent between 30 and 85 minutes on each lesson.

Pre-CASES Lessons

Pippa taught three lessons in her internship site prior to her use of the CASES curriculum. Her lessons were developed in conjunction with her supervising teacher and, in some cases, she followed a curriculum provided by her teacher. The lessons were not correlated into one specific science unit due to the fact that Pippa was only at the school two days a week and did not have the continuity to continue lessons. See Table 5 for an overview of Pippa's pre-CASES lessons.

Table 5 - Pippa's Pre-CASES Lessons

Lesson Number	Name of Lesson	Amount of Time	Lesson Overview
PCL-1	Matter Review	32 minutes	Review of matter, computer questions were discussed
PCL-2	Turkeys/Animals	35 minutes	Students created a science fact book on turkeys
PCL-3	Energy	30 minutes	Used a science text selection on light and created a KWL chart.

The first lesson observed was a review of the topic matter. Pippa used an overhead projector to review questions that would support students' readiness for a test on the topic. Pippa interacted with students to review the information and worked to include definitions. She also continually checked for understanding with the students (PCL-1). As students were reviewing information on matter, Pippa asked them to examine their books and use them as a resource to find the answer. After she read a question, she asked the students, "What information do we need to look for?" (PCL-1).

The second lesson observed was enacted prior to the Thanksgiving holiday. Pippa was given a fact sheet and pictures about turkeys. She worked with students to review the information in the handouts and to help students create a book from the materials. In this situation, the focus was not on science but more of a guided reading activity with a science topic. Pippa again interacted with students and created a game to keep student interest. She would show the students the words that went on each page and they had to select the appropriate picture to go with the words and place it in their book based upon what the words indicated. Pippa did ask the following questions in the lesson to engage students: “Which picture do you think goes here? Why do you think the mother stays on the ground? Did you understand about the country? Are we really eating what they eat (insects)?” At the end of the lesson, the students and Pippa read the book together.

The third lesson taught by Pippa in her internship site involved students reading a science text selection on the topic of light (PCL-3). She worked with a small group of students on this lesson and introduced the book by creating a KWL chart (Know, Want to Know, and Learned). She began by asking, “What is light?” Students answered that light is a form of energy. They discussed what they wanted to know about energy, and then took turns reading from the science text. They read from the book to find out about electric currents, thermal energy, potential energy and kinetic energy. Pippa then asked students to share their ideas regarding what they wanted to know about light. They read additional information from the text to try and answer their questions. This lesson allowed students to share what they knew about the topic and what they wanted to learn. The discussions in the group appeared motivating for students as they considered what they would like to learn and as they shared ideas about light based upon the text and pictures in the book.

Summary of Pre-CASES Lessons and Reflections

Pippa indicated the science content was an issue during her preparation and implementation of the lessons she taught (LR-1, LR-2). She explained that she really had to work and review the information to be able to present it to the students (PCL-1, PCL-2). She reflected on her first lesson, “I obviously don’t feel that the review I did was mine alone. I quickly realized, as I pointed out to you, that I should have taken time to look over the questions to prepare. If I had done so, then I would have made sure I knew the answers to the ones that I was unsure of" (LR-1). She also indicated that she was not familiar with the content of the lesson, "I really did not feel entirely comfortable with the science content of the lesson. In part this [my discomfort] was due to not having adequately prepared. More significantly, however, it was due to not having a solid and broad understanding of the science topics being reviewed (LR-1).

The observations of Pippa's lessons did not show strong components of scientific inquiry (PCL-1, PCL-2, and PCL-3). The five areas identified by the National Research Council (2000) and Windschitl (2004) related to inquiry are: scientifically oriented questions, analysis of data, scientific explanations, connecting explanations and communicating and justifying explanations. In the first two lessons, Pippa only engaged in scientifically oriented questions but did not delve further into inquiry. The questions she asked were also at the lowest variation of questioning, "Learner engages in question provided by teacher, materials, or other source" (Windschitl, p. 509; Appendix F). Also, the questions were not driving questions but were used to interact with students and to ascertain their knowledge of a topic. The focus of the lessons was not inquiry. The last lesson which was based on a science text selection on light did not include any actual science investigations. In this lesson, Pippa used a KWL chart; this did allow her to move from the lower end of the spectrum where the learner engages in questions provided by the teacher to a higher level in which the learner poses the question. This is the first lesson that included the higher level of inquiry which allowed children to consider their own questions. Students developed a number of questions on the topic of light such as: Would a light bulb melt ice? Would a bulb burn out if you kept it on for an hour? Why are stars so bright at night? And, why does light bounce off mirrors?

There was a distinct lack of pedagogical content knowledge displayed in the pre-CASES lessons that Pippa taught. In general, Pippa did not use practices that supported the components of inquiry and she did not include driving questions as the focus of lessons. Since Pippa did not have control over the lessons she taught in this internship site, it is difficult to predict what might have occurred if she had more autonomy in developing science lessons. In her reflections of her third lesson which dealt with light and where students completed a KWL chart, Pippa was asked to reflect on how she might teach the lesson if she could teach it any way she wanted.

> I would rather have either a whole class or small group discussion about this concept (light), using a KWL chart to activate and discover the knowledge that the students already have about this topic. I really feel that this strategy is a great way of encouraging children to think on a deeper level. It also encourages participation and cooperative learning. (If it seemed that the students had very little background knowledge, I would then conduct either whole group or small group reading and discussion of basic literature on the subject).
>
> Using the questions generated by the "Want to know" section of the chart, I would allow students to choose a specific element of the topic to research. (This would require some preplanning on my part, since I would need to consider whether and how each question could be answered. I would then need to provide the appropriate materials and media. These might include the use of a specific computer program or science websites, books and tangible materials that the children could experiment with).
>
> After allowing the students' time to research their questions, I would hold a whole class presentation and/or small group discussions giving the children the opportunity to share what they had learned. (They could share their new knowledge in any ways they chose, such as by demonstrating an experiment, making a poster, reading an essay. This would give each child the freedom of self expression, which I think is important in encouraging particularly timid children). During the presentation, we would fill in the column in the KWL chart under "Learned." (I would display this chart in the room to allow the students to read it). As a follow up and extension, I would read and discuss, and have the children read and discuss books about light/energy in order to generate more questions and to reinforce information previously learned (CLR- 3).

This reflection of how she would ideally teach the lessons does demonstrate an understanding of the processes of scientific inquiry including engaging in questions, formulating explanations and communicating explanations. Depending upon how the lesson was enacted, it could have more essential features of inquiry. Pippa further added in her reflection of the lesson that there were some good points: “What did take place, however, was a stimulating discussion of the topic which generated many interesting questions. This critical thinking phase should have occurred before any or much reading was done, because it [the discussion] helped to engage the students by encouraging them to think about the subject and what they knew. What the students did learn was how to start thinking about light/energy, and what they would like to know about the latter, which is far more important than simply reading a lot of abstract and foreign facts” (LR-3).

Pippa’s reflections on her lessons showed a willingness to learn and to reflect upon her teaching of science. Her answers provided a thoughtful response and she also regularly indicated that the questions “really made me think”. When Pippa reflected upon the turkey lesson she demonstrated understandings of the potential that we can meet in science lessons. “This was not a good science lesson! It was a lesson in following directions, and doing steps in order; it was not a lesson based on inquiry by any means” (PCL-2).

CASES Lessons

Pippa taught five lessons from the CASES plant unit during her senior internship in a kindergarten classroom. The classroom consisted of 16 students. The designated science time was also the time for ESOL students to work with their language teacher. The time conflict meant that during the first lesson only eight students were present and the other eight students returned in the middle of the lesson, creating a unique management issues for the lesson. In the following lessons, the schedule was arranged to allow all students to be present during science. In most of the following lessons, the science time did not interfere with the limited English proficiency students’ language time. See Table 6 for the CASES lessons Pippa taught.

Although Pippa was in her senior internship experience when she taught the CASES lessons, her teacher was present in the classroom during each lesson. Pippa had begun to take over the science lessons but was not in control of the class at the time of the research. Science was not regularly scheduled in the classroom but the teacher and Pippa did have students participate in additional class activities related to seeds related outside of the CASES lessons. The teacher pulled some books to read with children, the students were assigned homework to bring in a display of seeds and the students also watched a related Magic School Bus video after one lesson.

After the fifth lesson from the CASES unit, Pippa changed internship classroom from kindergarten to a third grade class. She was not able to continue to implement the CASES lessons in that classroom and, therefore, unable to teach the full CASES unit on plants.

Table 6 - Pippa's CASES Lessons

Lesson Number	Name of Lesson	Amount of Time	Lesson Overview
CL-1	Finding Seeds in Fruit	35 minutes	Students predicted and examined the seeds found in fruits
CL-2	Grouping Seeds	30 minutes	Students compared and classified seeds
CL-3	How Seeds Travel	43 minutes	Students observed seeds to find out how they move or are moved
CL-4	How Seeds Travel Part II	85 minutes	Students wore socks on school grounds to pick up seeds and observe how they moved
CL-5	What's Inside a Seed?	50 minutes	In this lesson, students observed a lima bean seed that was dry and one that was wet. They made predictions about what they would find inside the seed and investigated

Pippa indicated she was excited to teach the lessons from the CASES curriculum. Her senior internship site was a kindergarten classroom which did not implement very much science. She taught the CASES science lessons one day a week over a five-week period. Her lesson reflections indicated that she was excited about the lessons and enjoyed being part of the research.

Pippa followed the CASES lessons in a very specific manner. She enacted them very closely to the way they were developed. She included a number of the components of inquiry in the lessons. The first lesson from the CASES Plants unit was “Finding Seeds in Fruit”. In this lesson, she was able to engage students by using the driving question: “Where did the trees outside the window come from?” Students made predictions and collected data in a directed manner, but this was appropriate for the lesson and for the age level of the group. “Today I want you all to be scientists with me” was how Pippa introduced the lesson. “Take a look out the window and look at the trees. Where do trees come from?” Students indicated they came from seeds; they then shared ideas about where seeds originated. Pippa recorded these ideas on chart paper. Next, Pippa showed the children the inside of an apple. She asked them to find the seeds and to look at the seeds, then share what they noticed. Pippa explained she had made each child a science journal and she was going to give each group a few varieties of fruit to examine. She directed students to look at their fruits: “Draw a picture of whatever fruit or vegetable you have. Use the best colors to draw it accurately.” Students predicted how many seeds their fruit would have and Pippa asked them to explain why they thought the fruit would have that many seeds. Students then predicted what the seeds would look like before Pippa cut them open. The last part of the lesson, students observed the actual seeds inside the fruit to notice if their predictions were accurate.

Prior to her second lesson, Pippa had gone exploring with her own children to find a variety of seeds to bring in and share with the class (CL-2). She also did research beyond what the CASES curriculum provided regarding the specific types of seeds she found. “Some children came in from the playground with these little things on their pants. How did they get in?” Pippa took advantage of the teachable moment to have children consider that the seeds stuck to some children's pants. "Today you are going to see some new seeds, You can look at them, feel them, and you can smell them. Can you tell me how you would group seeds together?" Students shared ideas that Pippa recorded. She then dismissed groups back to their seats to work on sorting their seeds. She interacted with students while they worked, "Where are we going to put those? Why? How are those seeds the same? Now, I am going to ask you to pick one seed and tell me one thing about your seed." As children shared information about their seeds, Pippa asked other children to look at their seeds and to see if it had the same characteristic. Children then used a handout in their science journal to record how they sorted the seeds. Pippa reminded students to draw accurately: "Remember last week when I talked about how scientists draw accurately so other people can tell what they drew?" Students finished the lesson by drawing the way they sorted seeds in their journal.

"I have a tree in my front yard. How do you think it got there because I did not plant it?" Pippa asked for ideas about how the seed and then the tree could get in her front yard. She explained that seeds can move; they don't have legs but they can move. Pippa reminded the students of the seeds on a classmate's pant leg that they found after recess the previous week. Pippa then showed the children a coconut. "How do you think this coconut traveled? The coconut is a seed, but the tree it is from is far away from here." Pippa explained that seeds can move in different ways. She engaged children in this lesson by showing a coconut. Many children didn't think the coconut would float but Pippa had a tub of water to demonstrate. The third lesson that Pippa taught engaged children in thinking about how seeds move and why plants might be found in our yards or other places where we have not planted them. Pippa then had children observe seeds at their table using a scientist's tool; the magnifying lenses. "I want you to think about how your seed is moved; use your observations to help you decide." Students drew their observations in their science journal, Pippa reminding them to put on their good science thinking hats to decide. Students then had the opportunity to show and describe their seed and comment on how they think it moved.

“Most children wear socks inside their shoes but today, we will be wearing socks over our shoes.” Thus began another exciting adventure in thinking about seeds. Pippa’s fourth lesson from the CASES unit was a continuation of the Seed Dispersal, or how seeds move, topic. In this specific lesson, students wore socks over their shoes and walked around the school grounds collecting seeds. “I am going to give each of you a sock and we are going to act like animals and collect seeds.” Pippa carefully explained how to put on the socks. Each student had a baggie that was used for collecting seeds that may not ‘stick’ to the socks. Pippa reviewed her expectations before they went out to collect seeds. The students were very engaged in the lesson and excitedly indicated what types of seeds ‘stuck’ to them. Students reviewed how seeds travel from a previous lesson and classified the seeds on their socks as ‘sticky’. Students then communicated information about other seeds they collected, sharing observations and beliefs about how the seeds may travel. The students were asked to explain their thinking in light of their observations responding to the question. “Why do you think your seed would be moved that way?” Students also listened to a story called, “How and Why they Travel.” a story about seeds and how they move.

Pippa spoke to me prior to and throughout this lesson to get feedback on procedures and management in the lesson. After reviewing the lesson plan, she was still debating the best approach to having students put on socks and taking them off, indicating the directions were not clear regarding the management of this aspect. She indicated that she had carefully reviewed and enacted how the lesson would unfold to help her prepare (CLR-4).

"Guess what? You get to be scientists again today?" Children were excited about the invitation from Pippa to learn more about seeds as the fifth lesson on seeds began. "Today we are going to think about what is inside a seed. First, we will look at and draw the outside of a seed. Turn to page 15 in your science journal to record your observations of the lima bean. Be sure that you are drawing an accurate picture because we are scientists." Next, Pippa asked students to think about what a wet lima bean would look like, and then observed the wet lima bean and recorded their observations. At this time, students shared their observations of the lima beans explaining why and how the lima beans were different when they were wet versus when they were dry. Before opening the lima bean, students predicted what it would look like inside. They carefully opened the lima bean taking off the seed coat and splitting it open to see what is inside. After children had time to observe and share, Pippa showed the class a diagram of a lima bean which included the three parts: seed coat, food supply and embryo. Students located the parts in their own seed. They drew and labeled them in their science journal.

Summary of CASES Lessons and Reflections

Pippa seemed very comfortable and even excited about the lessons and the student involvement during them. Her own excitement was visible as she introduced each lesson and engaged children in the topic of seeds. The children in the classroom showed their own excitement about the lessons. "Whether I did a good job teaching or not, I really enjoyed doing (science) with those poor science starved children. They seemed to have a good time too, which is even more rewarding. (It really does concern me that this area of the curriculum is so neglected)" (CLR-1).

Several aspects of scientific inquiry were visible in the CASES lessons. "I feel that they were involved with inquiry, but at its most basic level of guided inquiry due to the questions being provided for them. This, I think is an appropriate level for kindergarten students due to their limited exposure to science and consequently limited background knowledge" (CLR-1). When referring to the essential features of inquiry, many aspects were apparent in the CASES lessons taught by Pippa. Each lesson was developed around a central question. These questions came out in each lesson. Questioning is a key feature of scientific inquiry. The CASES lessons used generally provided the question for students to pursue. In the lessons taught by Pippa, students did not engage in any questions they developed themselves.

Communication is also a key feature of inquiry and was persistently visible in the CASES lessons. Two reflection questions addressed the area of communication, the first being the role of communication in the lessons; and, the second being why we want students to communicate their understandings in science. Pippa responded, "Communication took the form of explanations with regard to how the children grouped the seeds and why they grouped them in the ways they did.... I believe it is important for students to communicate their understandings of their learnings for two main reasons: first because in doing so it helps them think critically about what they know and perhaps illuminates for them what they may not understand; [second] it helps us as teachers understand better what they do and don't know. I would expect that in teaching children to communicate their ideas we are also teaching them how to learn and how to formulate their own questions" (CLR-2). Three of the five CASES lessons gave children steps and procedures for communication which is the lowest end of the communication continuum (Appendix F; NRC, 2000; Windschitl, 2004). Two lessons impacted communication at higher levels. In the third and fourth CASES lesson in which children first consider how seeds move, they were coached in the development of communication but were not directly told how to communicate their ideas (CL-3, CL-4). The first CASES lesson on how seeds travel included four out of the five essential features of inquiry. Two of the five lessons included all five of the essential features at different levels; those lessons were seed comparisons and the second seed dispersal lesson (CL-2, CL-4).

Pippa was aware of the benefits of inquiry based instruction. She facilitated the lessons using inquiry as the basis. Scientific inquiry demonstrates one pedagogical strategy that specifically promotes student learning in ways that allow them to construct their knowledge. When asked about science specific strategies that she used in her lessons, she said, “science specific teaching strategies that were used were teaching the children to make careful and detailed drawings of their fruit/vegetable in order to demonstrate accuracy of the data collection through observation. Also asking what and why questions helped the students to form explanations. The students were also asked to make a prediction which is another inquiry skill” (CLR-1).

Content knowledge was an area that Pippa felt that she needed support. One reflection question asked if she felt like she needed support and were there specific content areas that she needed more support with than others. “Yes, yes, and yes some more! I think that unless you have majored in science everyone needs support with content. I definitely feel less comfortable with physical science, mostly due to my lack of knowledge (CLR-3).

Pippa’s reflections of her lessons indicated that she was carefully considering the practices implemented in the CASES curriculum (CLR-2, CLR-3). Regarding pedagogical content knowledge, Pippa was naturally aware of strategies that affected the implementation of the lessons. On a number of occasions, Pippa would ask me questions or bounce ideas off of me before the lesson began or even during the lesson as students worked. This analysis of lessons demonstrates her ability to consider the best approaches to implement the curriculum and to support children’s learning of science which is the heart of pedagogical content knowledge.

Pippa demonstrated specific pedagogical content knowledge when enacting the CASES lessons. Pippa referred to 'scientists' and how they make careful observations in the lesson plan to direct students in doing the same. She used the driving question to focus the students on the lesson. She pursued further information from students to help them justify their thinking. She also spoke of 'scientists tools' when the students used magnifying lenses to make observations in two lessons.

Overall, Pippa implemented the science lessons in ways that facilitated children's thinking and inquiry practices. She proved to be thoughtful regarding the management of lessons and prepared carefully and thoroughly. When asked about adapting the lessons and still keeping the important focus, she said, "I think it is difficult to know, without first teaching the lessons, how it should and if it should be adapted. Thinking through the lesson carefully before teaching it helps, but it does not ensure that it will be completely successful. Careful observations during the lesson are necessary to identify where modifications could be made" (CLR-2).

Use of the CASES Curriculum Materials

Pippa was interviewed regarding her use of the CASES curriculum after her fourth CASES lesson. One of her first comments indicated that she thought this curriculum was a 'thinking' curriculum. "You don't need to bribe kids to get involved because it is engaging". Pippa felt that using the CASES curriculum was her first real experience in teaching science. She did teach the pre-CASES lessons but did not really consider them science lessons. "They were mostly reading or review lessons with some science topics but not actual science" (CI).

When using the CASES curriculum, Pippa printed out the whole unit with all the resources in the unit. She then briefly looked over the materials. A few days prior to teaching a lesson she would look carefully at that specific lesson and review it. The alternative ideas were one area that she found particularly helpful in considering how to approach a lesson or how to address ideas that students may have. She also used the internet as a resource for herself in trying to understand the different concepts related to the topic and to increase her own background knowledge. Pippa indicated that she wanted to answer all her own questions through research and interaction with the materials to be ready to work with the children. “I ask so many questions myself that I want to research and understand. I think it is just me, because I like to know” (CI).

She believed the children seemed to understand the concepts that were taught. “There was one instance when I was not sure if all the children got it. The topic was seed dispersal and we had examples of how a coconut would travel by water, how a sticker would travel by attaching itself to an animal and how some seeds may be blown in the wind, but I didn’t have an example for explosion dispersal so I don’t know if the students got that idea.” Pippa explains that same topic came up again in a later lesson from the unit so the students had another opportunity to learn the information. “I think the ideas came up again later. If I felt like I left something out, I brought it up again the next time” (CI). Pippa provided two specific examples regarding how ideas came up again in lessons. The first topic was about squirrels and that they are an animal that helps to disperse seeds. Squirrels provide a method of transportation for seeds. A second example was the explosion dispersal and in the second lesson on that topic Pippa was able to provide an example of a seed that uses this type of dispersal.

When implementing the CASES curriculum in the classroom, Pippa indicated that she had previously written notes to herself including important points she wanted to make during lessons (CL-3). Pippa explained that she initially printed out the whole unit on plants. She scanned through it and then when she was preparing to teach a lesson, she reviewed the plan and tried to visualize how it would be taught. “I concentrated on how to teach and how to best teach it more than anything else” (CI). This helped her to see what issues may arise and how she would handle different aspects of the lesson. She jotted notes to herself in the columns to keep track of ideas or things she wanted to remember.

In the How Seeds travel lesson, she mentioned she wanted to share about animals that may eat a fruit and then ‘poop’ the seeds out as a way of seed movement. The notes she made to herself in the lessons could be considered strategies that related to the content and that also related to inquiry skills. She did stop her lessons a number of times and reminded students of ‘scientific observations’ or how to use ‘science tools’ as ways to support inquiry and being accurate in collecting data (CL-1, CL-3).

One aspect of the CASES curriculum important to Pippa was the students’ alternative ideas. She felt that this was very important for her to read because it helped her to understand what students might be thinking regarding the topic of plants. It also helped her to know how to respond if the alternative ideas came up in the lesson. Pippa also indicated that she did not always provide the correct answer or information if a child made incorrect observations or shared incorrect information. She felt that in most cases it was alright to let the child explain his/her thinking and that through the lessons the child would continue to construct their understanding. It was more important to Pippa that the child was thinking and explaining his/her ideas based upon an observation or past experiences than it was for the child to have the correct answer. “I want them to be thinking and justifying their ideas and constructing their knowledge over time so all correct information will not be there in one day” (CI).

Pippa indicated she was surprised that she felt successful at implementing the lessons. Her impression of science is that it is abstract for teachers, and she previously did not have a lot of background knowledge. “I don’t feel as intimidated with the background knowledge and now I see that I can learn the content of the different areas of science.” Later in the interview, Pippa said, “If you don’t have an understanding of what most children think on the topic, you can’t really address those ideas in your lessons.” This statement is indicative of Pippa’s understanding of the role her own background knowledge plays in supporting students’ development of science content.

Regarding the integration of inquiry, Pippa felt that the lessons were inquiry lessons. “I think they are inquiry at the bottom level, the guided level and because they (the students) are so young they need that support and guidance. They are bringing up questions but they are not solely pursuing them. They need the guided to move forward with other inquiries” (CI).

Final Interview and Instruments

At the conclusion of the research, the STEBI-B instrument, the Views of the Nature of Science and the Views of Scientific Inquiry were all administered to Pippa. She was also interviewed to provide clarifications on a number of her answers on the instruments and to glean additional insight into her thinking and beliefs regarding science.

STEBI- B Instrument

The STEBI-B instrument was administered at the end of the research with Pippa. This instrument has previously suggested that self-efficacy is a construct that can help to understand attitudes about the teaching of science and can show changes in self-efficacy over time (de Laat and Watters, 1995). The STEBI-B instrument is used to find teacher’s self-efficacy beliefs regarding their ability to teach science. This instrument is divided into two specific areas: Outcome Expectancy and Personal Science Teaching Efficacy Belief. Pippa’s STEBI-B results indicate she is more confident in her beliefs about teaching science.

High outcome expectancy occurs when people (teachers) expect their behaviors to result in desirable outcomes. In other words, teachers believe their teaching will impact what children learn in science and learning can be influenced by effective teaching. The personal self-efficacy beliefs are based on a person's belief in his/her ability to perform the behavior or in this instance, their ability to teach. "Teachers with high self-efficacy should persist longer; provide a greater academic focus in the classroom and exhibit different types of feedback" (Bandura, 1994).

In the final results of the STEBI-B instrument, Pippa scores were at or above the mean score established by Enoch and Riggs (1990) when they developed this instrument. The Personal Science Teaching Efficacy Belief Scale had a mean score of 47.00. Pippa scored 47.00 on the final instrument indicating her efficacy beliefs are average in consideration of previous research on pre-service teachers. Her Science Teaching Outcome Expectancy Scores were above the average score of 36.19 for pre-service teachers. Pippa scored 44 points indicating that she believes her teaching has impacted students understanding of science content. See Table 7 for Pippa's STEBI-B results.

Enochs and Riggs (1990) also indicate that self-efficacy beliefs can be enhanced through modeling and successful mastery experiences. In Pippa's case, she was successful in implementing the CASES curriculum which connected to her higher self-efficacy scores. Research by Ginn and Watters (1999) found two specific areas that supported teachers' self-efficacy beliefs. The first area is successful teaching experiences and the second area is a level of support and reinforcement. It appears that Pippa felt successful with her science teaching efforts. She also indicated that she was supported in her science teaching through the materials, through her internship teacher and through me (CI).

Table 7 - Pippa's STEBI-B Results

	Outcome Expectancy	Personal Science Teaching Efficacy Belief
Initial Instrument Scores	34	41
Final Instrument Scores	44	47

Views of Nature of Science (VNOS-E)

The Views of Nature of Science Instrument was also administered at the end of the research. This instrument is open-ended and allows for short answer responses to a variety of questions related to the nature of science. Research in this area indicates teachers have not reached informed views regarding the nature of science (Abd-El-Khalick, et al., 2001). Pippa's overall responses to this instrument indicate she has refined some of her ideas regarding the nature of science since the initial instrument but still demonstrates some naïve views. She demonstrated in the initial instrument that her ideas were not fully developed. However, some of her views show insight into the nature of science.

Pippa did not feel that her views regarding the nature of science had changed during the study. Related to the nature of science, she talked about her background knowledge in science and she felt that this area had been developed in the project. Her responses to the final VNOS and VOSI instruments do provide evidence of her growing understanding of the field of science and how scientific inquiry fits into these complex ideas. The biggest obstacle appears to be a deep-seated idea that science is objective that came up in her final interview: "It is supposed to be objective, we always aim for that but there is a certain amount of subjectivity in everything we do" (PInt). The idea that science is objective lends itself to the strict scientific method of doing science and to the overall beliefs in one correct answer in science. Pippa is re-evaluating her ideas in light of her experiences in this research.

The Nature of Science refers to the understandings of the complex and diverse nature of scientific undertakings. Important aspects of the Nature of Science include that science is tentative, empirically based, subjective, the product of human inference and creativity and culturally embedded (Abd-El-Khalick, et al., 2001). In addition, researchers who have also distinguished between observation and inference stated that there is not one scientific method and explored the differences between scientific theories and laws.

In considering, "What is science?" Pippa answered, "The study of naturally occurring phenomena" (PI). This answer demonstrates a focus on the processes of science and how we develop knowledge but does not address the second aspect of science which is a body of knowledge. Pippa answered this question in a similar fashion as the initial instrument. This view is aligned with a more informed view of science and its tentative nature. On the other hand, she still did not include references to science as a body of knowledge.

When discussing how science is different from other subjects, Pippa initially explained that "science is an ever evolving discipline". She further explained in her final instrument that "the study of the world around us is an ongoing process which continues, and will always provide mankind with questions (some of which may never be conclusively answered)" (PI). In the final interview, Pippa said

> Science is different from other subjects I am studying because it is based on naturally occurring phenomena (plants, animals, seasons, etc.) rather than on manmade events and occurrences.

The focus of this question was the empirical basis for science-- that science is based on and derived from observations of the natural world (Abd-El-Khalik, 2004). Pippa was right on target regarding phenomena in the natural world but did not address the systematic approach to data collection.

When discussing scientific knowledge and how it might change in the future, Pippa believed that science will change as more sophisticated methods of research arise. “As the ability to answer questions regarding scientific concepts becomes more sophisticated, it is inevitable that scientific knowledge will change” (PInt). This statement is aligned with the views that all scientific knowledge is tentative and subject to change. However, Pippa’s beliefs were based on more sophisticated ways to answer science questions. It is unclear if she is focusing on looking at data in a different way or collecting new data.

The difference between observations and inferences was the focus of the next question, “How do scientists know that dinosaurs really existed?” Pippa answered that evidence from skeletal remains proves their existence. She does not address that scientists have made inferences based upon the remains that have been found. Probing further into the science of dinosaurs, Pippa believed that there is a general consensus on how they look and again spoke of “evidence that exists”. She again did not reference the inferences that scientists must make in going from their observations to developing their ideas about how they looked.

When considering how different scientists can have the same data and not draw the same conclusions regarding dinosaurs, Pippa stated on the instrument that they may not have enough evidence. However, in the interview, she indicated, “they did not come to the same conclusions in the class (internship classroom). No, I don’t think they will come to the same conclusions (scientists)”. She related to her own experiences with the students in teaching the science lessons and decided that prior experiences, beliefs and background could influence how scientists see things.

Overall, Pippa is still developing her understandings of the nature of science. She is still working on the areas of how observations are used in science versus inferences. Here we know that scientists cannot observe all phenomena and therefore must make inferences based upon observations. Also, Pippa talks about new knowledge coming to light as the way that scientific knowledge changes instead of a re-examination of previous knowledge.

Views of Scientific Inquiry Elementary School Version (VOSI-E)

The Views of Scientific Inquiry Instrument (VOSI) seeks to understand views about scientific inquiry. On the one hand, many people believe that there is just one “scientific” method that is followed in conducting science experiments instead of a broader view of multiple ways to experiment. The instrument also looks at the difference between a general scientific activity versus a specific scientific procedure. Pippa appeared to have significant changes in her ideas of scientific inquiry through her experiences with the CASES curriculum and her reflections of inquiry with children. In the beginning, her answers to this instrument seemed quite similar to the initial instrument, but her interview proved insightful into Pippa’s developing beliefs regarding scientific inquiry.

On the written instrument, Pippa indicated that scientists “use the scientific method to answer questions in the areas of the various branches of science” (PInst). She further explained that to do their work, “Scientists must, in order to be objective and accurate use the scientific method to do research” (PInst). These answers are considered general and lack a demonstration of depth of understanding regarding the multiple methods of science. Also, the use of terminology such as' scientific method' and 'objective' show a general lack of understanding of the nature of science and its subjective nature.

Next Pippa was asked to consider if the work of a scientist who observed bird beaks over time was scientific. She indicated, that yes, it was because observations are the "initial stage of the scientific process. Her work had not yet progressed to the experiment stage" (PInst). The response shows a narrow view of scientific inquiry. Although the work of the scientist did not entail an investigation, she did use observations over time and developed patterns based on the observations to develop explanations. Based on this information, the work would be considered scientific.

In the follow up interview, I asked Pippa if there was just one scientific method that should be followed in investigations. "Inquiry is broader. I was thinking about the two and confused them. I don't think it (science inquiry) followed step-by-step method. The scientific method is portrayed that way in science projects." Then referring to her science investigations with students, she said "We were not going in a linear fashion but rather coming around revisiting things. You see connections and you go back to something again and revisit... not step-by-step - more learning takes place. The terminology (scientific method) remains from science projects in the past" (PInt).

Although her initial response was to use the familiar terminology from the past, her understandings as expressed in the interview show more depth and more appropriate ideas. Her responses signify that Pippa is beginning to re-evaluate her own ideas in a more formal way as she has experienced inquiry activities with her students and as she has reflected upon them. The teaching of science through inquiry may be allowing her to reconcile her own past experiences and beliefs with what she is currently experiencing specifically in the orientations of one scientific method versus multiple ways of conducting science and the subjectivity of science as opposed to the belief in its objective nature.

Overall Summary

Overall, Pippa was willing and open to learning how to teach science and, more specifically, how to teach science thorough inquiry. She did indicate that she was a good candidate for this research because, even though she had an interest in science, she did not feel she was a good teacher of science (IInt). Her dispositions and beliefs about teaching made her an ideal candidate for teaching science inquiry. She had a minimal background in science inquiry through the methods course SCE 4023. This course did seem to instill some knowledge of scientific inquiry as Pippa was able to use language such as ‘guided inquiry’ as she reflected on her lessons. She was clear that this type of inquiry was more structured and provided more support for students who were not experienced in doing inquiry. Pippa was also able to provide insight into how she could adapt her pre-CASES lessons to be a more inquiry oriented format. Pippa did have previous experience and interactions with children in the school setting which was apparent in her classroom management. Her management of the class and lessons was not a hindrance to her teaching or implementation of science lessons.

Although Pippa does not demonstrate fully developed views related to the nature of science and to scientific inquiry, it is apparent that her views of science were developing through this research. In the final interview, Pippa was able to understand and articulate some nature of science aspects when she did so through the consideration of her own teaching and her interactions with students. She could relate the ideas of subjectivity and personal influence when she considered her teaching interactions during the CASES lessons. The National Research Council confirms that teachers can extend their learning of science inquiry through their teaching of inquiry (NRC, 2000). She was also surprised to connect the idea that science does have subjectivity because her past experiences lead her to consider science as an objective field. Overall, her self-efficacy beliefs related to her teaching of science improved through this experience. This change may be due to the fact that she was successful in teaching science during her internship experiences.

The extent to which the CASES curriculum materials were supportive in this research was dependent upon "how the opportunity is used by the individual" (Davis and Krajcik, 2005, p. 4). Pippa clearly strived to reach understanding of the materials and how they would be supportive of children in their inquiry and in the content of plants. She further used the materials along with her own research to pursue a true understanding of the content and the lessons (CI, PInt). Schneider and Krajcik (2002) found evidence from classroom enactment that indicated teachers were using the educative features in the lessons. Examples from Pippa's lessons also signify she was using the features provided in the CASES curriculum to support her teaching practice.

"The ability to adapt and mold instruction in response to student-centered inquiry appears a likely stumbling block for novice teachers who have difficulty with improvisation during interactive teaching" (Crawford, 1999b, p. 7). Crawford feels that most teachers would have difficulty with inquiry because they lack the understandings of pedagogical content knowledge and the ability to make the learning of specific science content accessible for students. Pippa seemed to be the exception in this case study. She did use resources available to her in considering inquiry and the teaching of plants to her students but she was able to use the curriculum to meet the needs of her students. She conducted research on the science topics to develop her own understandings, she collected and analyzed seeds to fully experience and understand the lessons prior to her implementation. She also spoke to other educators she considered to be resources to weigh the implications of instruction and how different aspects of the instruction would play out in the enactment of lessons.

Content knowledge was one aspect of teaching science that Pippa had concerns about as expressed in her lesson reflections (LR-1, CLR-3). Previous research has shown that for teachers to teach for conceptual understanding, they must have strong background knowledge. Although, it is unclear if Pippa's background knowledge was sufficient at the beginning of the CASES unit, the development of her content knowledge during teaching was evident. She did, to a certain extent, use the CASES background knowledge but went even further to explore the content and to develop her own understandings. Research by Smith (2007) did find that about half of the participants in her study were able to develop a sufficient background to implement lessons. In the CASES interview she clearly indicated she felt comfortable with this content and that she feels she can learn other content areas. "Now I see that I can learn the content of the different areas of science, as long as I do it in small steps I will take the background knowledge and try to understand" (CI). This belief was also reinforced in her final interview as she indicated she could take small steps to accomplish an understanding of the content.

Lastly, Pippa did seek input and ideas from her teacher and me to help her implement the lessons in the best possible way. Her ability to successfully improvise during her teaching demonstrates her ability to integrate content knowledge with her pedagogical understandings in the context of her teaching. She appeared to be using some strategies related to pedagogical content knowledge such as encouraging children to be scientists as they worked (CL-1, CL-2, and CL-3). She also recognized the importance of emphasizing science processes such as observations throughout the lessons she taught. Davis (2005) explores how teachers adapt instructional materials; she found that they may be adapted during the planning stages or in real time during the enactment of the teaching. Pippa appears to be considering and clarifying her understanding of the materials prior to teaching and adapted and discussed with others the possible changes that could be implemented during her teaching. Although Pippa's internship was not a scientific internship, her use of science inquiry with her students in this field work experience allowed Pippa experiences that were a catalyst for her growth in PCK (Dickerson, et al., 2007).

Looking closely at other areas of Pippa's pedagogical content knowledge, it appears that she has an inquiry or guided inquiry orientation to teaching science as identified by Park and Oliver (2007). Pippa felt comfortable with the guided inquiry format of the CASES lessons, she was able to implement the lessons and use the inquiry format with her internship classroom. Another aspect of PCK identified by Park and Oliver was knowledge of students' understanding in science. In this area, Pippa indicated she used the CASES alternative ideas section to understand students conceptions of plants, she considered children's motivation as indicated in the CASES interview and felt that the lessons were motivating to children because of their interactive nature. One additional aspect of PCK knowledge of students' understandings in science is prior knowledge. In this area, Pippa did, through the CASES curriculum, glean insights into children's understandings of science concepts as she began lessons with questions that allowed children to consider and share their ideas of science content.

One last area of PCK that Pippa demonstrated was knowledge of science curriculum. Pippa did understand important aspects of the topic and was sure that those areas were emphasized in the lessons. She even remarked in the CASES interview that she readdressed important topics as a way to support children learning and understandings. She said this naturally occurred in the CASES curriculum and if she forgot to address something in a lesson, she would add it during the next one (PInt).

Pippa's core conceptions or underlying beliefs regarding teaching and children may have been a factor in her success with implementing inquiry. Lotter, et al. (2006) find that teacher's core conceptions involved four specific areas: beliefs about science, the purpose of education, views of students and ideas of effective teaching. For each of the components listed, teachers can be on either end of a continuum with the highest levels indicating a tendency towards a higher level of inquiry teaching. These conceptions also relate to the constructivist orientation and view the process of learning as one of the construction of knowledge. Pippa's practices in the classroom as well as statements she has made that further indicate her core conceptions aligned with inquiry. Since her overall orientation is aligned with inquiry, adopting and implementing the CASES lessons provided a platform for her to employ her beliefs. The alignment between her conceptions regarding teaching science and the format of the educative curriculum was a prominent consideration in her abilities to implement inquiry.

A final review of Pippa shows that she is still developing her ideas related to the nature of science and scientific inquiry. In this regard she is beginning to question the underlying beliefs she has previously taken for granted. Her implementation of the CASES curriculum has influenced and increased her beliefs in her ability to teach science. In her enactment of lessons, she consistently implemented many features of scientific inquiry (NRC, 2000). Her underlying beliefs regarding teaching and education align with this philosophy. Her previous classroom experiences may have been a factor in her ease in the management of the lessons. She was initially not confident in her abilities to teach science. This lack of confidence may have been a positive factor as she was open and willing to learn through this research. She demonstrated an ability to learn the related content through the curriculum and her own research. She also demonstrated practices that show proficiency in different areas of pedagogical content knowledge. Many of these practices seem to be developed through the use of the CASES curriculum as they were not apparent in the pre-CASES lessons.

CHAPTER 5
CASE STUDY: ALEXIS

This chapter presents the case study of one pre-service early childhood educator, Alexis. This chapter examines the role educative curriculum materials play in Alexis's science lessons during her junior and senior internship experiences. One strong focus was on her understandings regarding scientific inquiry and her abilities to implement inquiry. These aspects include scientifically oriented questions, priority to evidence, and formulation of explanations, evaluation of explanations and communication and justification of explanations. Additional aspects associated with Alexis's science teaching will be considered including her use of the CASES materials and how they support her content knowledge and her pedagogical content knowledge. The chapter will conclude with a summary and discussion of the critical elements related to Alexis's science teaching and her overall development in her ability to implement scientific inquiry.

Teacher Profile

Alexis is a Caucasian female in her late twenties. She is not a traditional student but is earning her degree over an extended period of time. She is expected to graduate from the Early Childhood Education Bachelor's degree program at the University of Central Florida in the spring term of 2008. At the beginning of the study, Alexis was in her junior internship experience in a first grade team teaching classroom in a Central Florida public school.

Alexis's first internship placement was in a first grade classroom. Two teachers co-taught in this room with a total of 28 children. She taught lessons from a scripted curriculum that was used by the school. The lessons included a flip chart with pictures and facts for students to review. In her lesson reflection, she indicated that in the first lesson, she was not prepared to teach and that she needed more information regarding the background of energy. Alexis was also overwhelmed trying to provide hands-on activities to 28 children in the lessons she taught. The science lessons were Alexis' first teaching experiences as she did not have prior experiences in the classroom environment.

For her senior internship experience, Alexis interned in a kindergarten classroom. Science was not a strong focus in this classroom but Alexis had a certain amount of autonomy and flexibility to include science in her whole group activity time or circle time. The inclusion of science in circle time created a more direct instruction approach to science along with center type activities. The direct instruction included Alexis reviewing important concepts with the whole group and then during center time, students were involved in activities related to the concept. The topic covered prior to the CASES curriculum on plants was about insects. This was an integrated unit on insects that included all aspects of the curriculum and not specifically science. A good portion of the activities were art projects related to the topic but Alexis also included observations and explorations of caterpillars. These activities were not observed in this research so it is unclear if they were aligned with inquiry practices.

Alexis taught four lessons from the CASES curriculum unit on plants. She rearranged the class schedule to facilitate the science lessons and to create a specific block of time dedicated to the teaching of science instead of having science integrated into her circle time. Alexis eliminated math on the days that she taught the CASES lessons. Due to the class schedule that was established by her internship teacher, she was not able to dedicate more time to the teaching of the CASES lessons.

Initial Interview and Instruments

At the beginning of the research, Alexis was provided with three instruments to assess her understanding of the nature of science, scientific inquiry and her self-efficacy beliefs regarding teaching science. After the researcher reviewed the instruments, an interview was conducted to clarify any areas that were unclear from the instruments. Overall, Alexis is interested and excited about teaching science.

STEBI-B Instrument

The STEBI-B instrument was administered. Findings from this instrument have previously suggested that self-efficacy is a construct that can help to understand attitudes about the teaching of science and can show changes in self-efficacy over time (de Laat and Watters, 1995). The STEBI-B instrument is used to find teacher's self-efficacy beliefs regarding their ability to teach science. The instrument is divided into two specific areas: Outcome Expectancy and Personal Science Teaching Efficacy Belief. For the Personal Science Teaching Efficacy Belief portion, Alexis received 52 out of 65 possible points, which shows 80 percent of the total points. In previous research by de Laat and Watters using the STEBI-A instrument, they found the mean score for the PSTE was 49.6 with a range of 33-62. Alexis's Personal Science Teaching Belief score shows a high self-efficacy belief in this area. Riggs and Enochs (1990) worked with a population of 288 teachers and found the mean score for the PSTE was 56.54. Finally, Enochs and Riggs (1990) worked specifically with pre-service teachers and found a mean score of 47.00 on the PSTE portion. Compared to this research, Alexis's score is about average based upon previous research. Research from deLaat & Watters showed that teachers with high PSTE scores expressed their confidence in teaching science and their interest in it. Alexis did express interest and excitement in teaching science. She expressed that science allowed children to get involved in their learning but also indicated that some kids may not like science and then even if the teacher was good, they just might not enjoy it (II).

On the Outcome Expectancy portion of the instrument, Alexis received 32 out of a total of 45 points, which represents about 70 percent. Enochs and Riggs (1990) found the mean score for the STOE to be 42.84 but they adjusted the final instrument by eliminating two questions. Therefore, the final mean for their research was 36.19. Alexis's STOE score shows that she is lower than average for her STOE belief. The results of the outcome expectancy indicate Alexis's expectations of specific behaviors to result in certain outcomes. In other words Alexis's expectations of her teaching may result in children learning of science. Since her score is a little lower, it stands to reason that Alexis may believe that, although she tries her best to teach children science, they may not all learn the content. This belief correlates to Riggs and Enochs' (1990) research on teachers' self-efficacy and the outcome expectancy portion addresses external factors associated with teaching science.

Views of Nature of Science

The Views of Nature of Science Instrument was also administered to Alexis. This open-ended instrument provides responses to a variety of questions related to the nature of science. Research on the nature of science indicates that teachers and students have not attained sophisticated views regarding the nature of science and that this influences their overall understanding of science (Abd-El-Khalick, et al., 2001). Alexis's overall responses to this instrument would be classified as general and naive. The Nature of Science refers to the understandings of the complex and diverse nature of scientific undertakings. Several important aspects of the Nature of Science are addressed in the VNOS instrument including that science is tentative, empirically based, and subjective. Science is the product of human inference and creativity and culturally embedded (Abd-El-Khalick, et al.). In addition, researchers have also distinguished between observation and inference, stated there is not one scientific method and explored the differences between scientific theories and laws.

The first area VNOS addresses is the broad definition of science as a body of knowledge as well as the processes for the development of science. Alexis considered science as investigating and conducting experiments to answer questions. This definition fits with the processes of science but does not include the knowledge or content of science. When considering how science was different from other content areas, Alexis indicated you do inquiry and perform experiments in science. The desired response would include reference to the reliance on data from the natural world and science included an organized approach to the collection of data. When asked about how knowledge may change in the future, Alexis explained scientific knowledge could change due to new research. This answer aligns with the idea that science is tentative. A more in-depth answer would also include that knowledge changes because scientists view the same data in a different way than before.

The next series of questions on the VNOS were about dinosaurs with the focus being on the roles of observation and inference in science. Alexis' response to the question about how scientists know that dinosaurs really existed was through investigation and research. The ideal answer would go further here and include the inferences made based upon data. When asked about how dinosaurs looked, Alexis indicated that scientists are very certain about how they looked. In reality, scientists have some data but have inferred from the data to develop ideas about how dinosaurs looked. The next question regarding dinosaurs focused on how the dinosaurs became extinct and how different scientists have different ideas even when they all have the same information. Alexis's response was that this was due to religious beliefs. This answer is somewhat aligned with the ideal that would include different scientists bring different backgrounds and biases to the interpretation of data, but was not as broad and only accounted for religion and not additional cultural variations.

Alexis explained that a scientific model is a result of a scientific experiment. Here she appears to be focusing on the development of a model based upon the results of an experiment. She did not specifically address the concept of a model as a representation of a science concept but the result of an experiment. This proposal does not account for science ideas that are not within our grasp to observe or manipulate where a model can provide a representation. Also, deeper level thinking for this question addresses subjectivity and creativity in science when all things are not visible. Alexis also explained scientists use creativity and imagination during planning and experiments. She used the example of a chemist who must think outside of the box to create new medicines.

Alexis displays some understanding of the nature of science but does not show an in-depth knowledge about the overall structure of science. Some of her ideas are not complete or well developed.

Views of Scientific Inquiry Elementary School Version (VOSI-E)

The heart of the VOSI assessment seeks to ascertain views about scientific inquiry. Many educators and students believe that there is just one “scientific” method that is followed in conducting science experiments instead of a broader view of multiple ways to experiment is more closely aligned with definitions of scientific inquiry from the National Science Education Standards. The VOSI instrument also looks at the difference between general scientific activity versus a specific scientific procedure. Alexis’s overall responses on the VOSI instrument showed that she does have some relevant ideas regarding scientific inquiry but is still clarifying the ideas regarding the difference between how scientists and children execute inquiry.

When asked about the kind of work scientists do, Alexis provided a general answer. “They do experiments to find a better way for us to live longer and healthier” (II). When provided with the example of a scientist observing animals, she believed the work was scientific but not an experiment. Here she indicated the scientist only observed. When further asked how the observation could be made an experiment, she said she didn’t know how. She also added that experiments were more fun but that observation was fine also. Here her belief seems to be that experiments were not necessary to gather scientific evidence. This response shows some understandings of a broader view of multiple methods to conduct scientific inquiry but she is not able to clearly articulate additional methods. The comment regarding experiments being more fun does not adequately express that observations are a part of experiments and they can be the basis of scientific information if they are conducted over time and they develop patterns.

Regarding why scientists have different ideas about the extinction of dinosaurs, she emphasized this was due to religious beliefs. She believed some scientists are moving beyond scientific facts and are influenced by their religion. In the interview, she addressed that evidence was needed for drawing conclusions. When regarding the development of new medicine, she said, “Scientists need hard evidence and to be able to back it up” (II). On the one hand she sees the need for hard evidence but indicates that some scientist may not use hard evidence or the facts due to their religious background. These views appear to be contradictory.

Alexis also provided an example of her daughter, who just does experiments without even knowing it, as opposed to what might be done in a classroom or by a scientist. It seems she realizes to some extent that there are different methods to do science but she appears to still be clarifying her own understandings of scientific inquiry.

Overview of Pre-CASES and CASES Units

Alexis taught a series of lessons during her junior and senior internship experiences. The lessons in her junior internship were related to the topic of energy. She taught two lessons with first grade students in her junior internship experience. In her senior internship experience she taught one lesson prior to the CASES curriculum, that lesson was on the topic of insects. The CASES unit consisted of four lessons from the unit on plants. In Alexis's junior internship site, students were involved in science lessons but they were not implemented on a regular basis. In her senior internship kindergarten classroom, science was incorporated into the circle time in the morning along with calendar and other daily routines.

Pre-CASES Lessons

Alexis taught three lessons prior to her use of the CASES science units. The first two lessons were on the topic of energy but, as she participated in internship which was two days a week, she did not have the continuity between the two lessons. Both lessons were on the science topic of energy. Alexis's first two lessons were guided by her teachers and correlated with the topics that were currently being covered in the first grade classrooms at the time. Her supervising teachers took the lessons directly from the science curriculum materials that had been adopted by the school. See Table 8 for an overview of the pre-CASES lessons taught by Alexis.

Table 8 - Alexis's Pre CASES Lessons

Lesson Number	Name of Lesson	Amount of Time	Lesson Overview
PCL-1	Energy and Sunlight	22 minutes	Introductory lesson on energy and the sunlight
PCL-2	Energy - Food	20 minutes	Lesson addressing how food gives humans energy
PCL-3	Insects	25 minutes	Students reviewed what they knew about insects and wrote about their favorite insects

The first lesson taught by Alexis was on energy and sunlight. The lesson would be considered lecture or direct instruction with a demonstration (See Appendix F). Alexis demonstrated that two cups of sand had different temperatures because one had been sitting in the sun. Alexis asked, “Which is warmer?” to get children to consider the energy from the sun. One child was invited to feel the cups. Students were then asked to share ideas for things that make light. Alexis recorded these on chart paper. Next, Alexis used a flip chart to discuss with students what energy can do and where light came from. She invited discussion during the lesson with the large group but was not able to encourage participation of students. Alexis reviewed concepts with children at the end of the lesson through questions, “Where do we get energy from?” and “What is the main natural resources create energy?”

The second lesson taught by Alexis was also on the topic of energy, but focused on food and how it provides energy for humans. Alexis again used a question/answer format for much of her lesson and involved children in a discussion of the topic. This lesson would be considered a discussion that was followed by a worksheet (See Appendix F). “Are you all full of energy since you have been out playing?" was a question used to introduce the topic. She then asked, "Where do we get energy so we can play?" She then explained that foods help us get energy to do things. She read information from the science flip chart and showed the different categories of foods. She then provided a handout that she had made which asked children to draw two pictures of foods they liked in each food group category. Alexis circulated around the room and interacted with students as they completed their worksheet (PCL-2).

The third lesson that Alexis taught prior to the CASES curriculum was on the topic of Insects. She taught this lesson in her senior internship site to kindergarten students. Children were involved in morning work when Alexis turned on the music, "Beautiful Day". When children heard the music, they began to gather on the floor. The calendar was reviewed together and children talked about the day of the week and the date. Next, Alexis explained that they needed to check on the butterflies. "We predicted yesterday that there would be some butterflies from the chrysalis." One student checked on the butterflies for the class. The teacher then asked the students if they thought they would have butterflies the next day. "Let's review the life stages of a butterfly. What is the first stage? What is the second stage?" (CL-3). Alexis explained to students they would be writing a sentence about their favorite insect at a center. She showed students the pictures that were previously drawn and asked students to complete the sentence, My favorite insect is _____ because _______. Alexis reviewed the directions and released students into centers.

Summary of Pre-CASES Lessons and Reflections

One aspect of Alexis's teaching that affected many of her lessons was classroom management. Alexis really worked to use many different strategies to get children's attention during lessons and during the facilitation of moving from one activity to another. In her junior internship site, her supervising teachers would support her efforts in teaching by intervening and drawing children's attention back to the lesson or in correcting misbehavior. While Alexis taught the first lesson in her senior internship experience, she did not have the support of her supervising teacher's presence. She had taken over the classroom and was working out how to maintain control of the classroom and specifically how to manage students during a more active learning experience such as science. After her third pre-CASES lesson Alexis commented, "I have had issues with circle time. So for me the lesson was not easy to manage because of my issues of how circle time is set up with the students singing and dancing first then being expected to sit for a half an hour" (LR-3).

In Alexis' reflections of her lessons, she indicated a higher comfort level in teaching the second lesson. In her first lesson, she indicated in her reflection and in speaking to her after the lesson, she was not prepared to teach the lesson regarding the science content and overall preparation. The planning schedule that was implemented at the school created a situation that she did not know what she would teach prior to the day she was teaching. In the initial interview with Alexis, she also indicated when discussing science background and understandings, "You just forget if you don't use it and don't do it" (IInt). Although overall, she seemed confident in her abilities to teach science. When it came down to her lessons, she felt although she may have the background knowledge, she needed to review or activate that knowledge to be more successful in teaching. When asked after her first lesson if she felt the lesson went well, she commented, "I did not like how the lesson went at all. I felt unprepared and because I was not familiar with the topic of energy. It was real hard to me to teach. I felt like if I would have had the teacher's manual and had some time to prepare for the lesson, I would of felt much more comfortable" (LR-1).

Content knowledge may have been a factor in the way the science lessons were directed. Research from Davis, Petish, and Smithey (2006) found that lack of content knowledge or experiences in science was related to teacher's ability to implement inquiry lessons. Alexis did emphasize her lack of background knowledge but other factors could have influenced her lessons including the text lesson design and the class size.

Another limiting factor regarding the implementation of lessons for Alexis was the class size. Since her first internship was a team teaching situation, she had a group of 28 students. Her supervising teachers usually collaborated when teaching. However, when she taught her pre-CASES lessons, she was managing the whole group of children. The group size made science teaching difficult in ideal circumstances. In her reflections, the class size was an issue and she indicated she would prefer a smaller group that she could allow interacting with materials and doing an experiment as a part of the science lesson.

Based on how her first lesson went, Alexis indicated she would change the lesson in the future. "If I had my own classroom with a smaller class, I would have conducted the lesson outside so the students could feel the sun's energy. As a whole class I would have had each student fill up their own cup with sand and place it in the sun at the beginning of the day. I would have explained to the students that we were doing and experiment and we would look at the results later in the day" (CLR-1).

Scientific inquiry was not a significant aspect of the pre-CASES lessons. Questioning is one of the five essential features of inquiry. At the lowest level, questioning, was a part of each lesson. The learner engages in question provided by teacher, materials or other sources (NRC, 2000; Windschitl, 2004). Most of the questions were used in a question answer format to facilitate discussions. The question and answer format may not truly fit as an inquiry practice, although, the use of driving questions to guide the lessons was used in the first two lessons.

In the last pre-CASES lesson, students communicated their ideas about their favorite insects. The communication would fit into the lowest level of the essential feature of communication, “Learner given steps and procedures for communication” (PCL-3). This lesson was on insects. The class was completing a unit on insects and this was one of the last lessons. Alexis reviewed the parts of an insect and the amount of legs insects have with the class. She asked one student to check on the chrysalis to see if they had become butterflies. Alexis asked the students to predict when they thought the chrysalises would become butterflies. She then asked students to tell about their favorite insect. They had drawn pictures of their favorite insects during a previous lesson and they were going to be writing a sentence about the insects during center time. Communication was one strong aspect of this lesson.

In her lesson reflection, Alexis indicated that she would have preferred to have actual insects for the children to observe.

> I would have time set aside in the day just to focus on the topic and not cover the topic during circle time. I would like to have science centers where the students could examine the insects using magnifying glasses. As a class we could compare and contrast the differences between an insect and a spider, do read-aloud about insects, watch a video on insects. Lastly, I would get caterpillars and have the students predict from day to day which life cycle the caterpillars would be in for the following day. We would have an observation chart posted in the classroom stating our prediction for day one and what happened on day one; this would go on until the caterpillars turned into butterflies (LR-3).

Alexis did not truly implement inquiry into the pre-CASES lessons she taught. These lessons were based upon a curriculum provided for her except for the last lesson. Although the lessons used questions to encourage children to think about the topic, questions were not used in the manner aligned with inquiry. According to the five essential features of inquiry as outlined by the National Research Council (2000) and used by Windschitl (2004), questioning is an important aspect of inquiry. At the lowest level, the “Learner engages in question provided by teacher, materials or other sources” (See Appendix F). Alexis’s use of questions in the group discussion helped to focus children on the topics but did not really engage them in the inquiry process.

Students were involved in a brief demonstration in the first lesson in which Alexis had left a cup of soil in the shade and one cup in the sun. One student came up and felt the soil but all children were not able to interact with the materials. This lesson mainly consisted of the demonstration and a brief lecture on the topic. A flip chart was used to share important information on the topic. In the second lesson on food energy, students held a discussion and then completed a worksheet that allowed them to draw pictures of their favorite foods into food groups.

The lessons did not fully demonstrate an understanding of pedagogical content knowledge related to science teaching. To some extent, Alexis did use driving questions that encouraged the children to think about the content of the lessons. In the first lesson, she showed children a cup of soil that had been in the shade and one that had been in the sun. She then asked, “Which is warmer?” (PCL-1). In the second lesson, she began by asking, “Are you all full of energy since you have been out playing? And “Where do we get energy so we can play?” (PCL-2). These questions did serve to focus the children on the general science topics.

Alexis felt like she used some general teaching strategies in her lessons. “I used direct teaching approach and engaged learning through question and answer session. This day the approach did not work well at all. I feel that my management was off this day, but I do think these strategies work” (LR-3). In the second lesson, Alexis also indicated that her general teaching strategies were question and answer session, visuals and read aloud. She was happy with these strategies in this lesson (LR-2).

Research from Lee et al. (2007) provides rubrics to help look more closely at two main aspects of pedagogical content knowledge. The areas were knowledge of student learning in science and knowledge of instructional strategies. Since the reform documents advocate for teaching practices that include scientific inquiry, this is a big focus of the PCK for instructional strategies. Most of Alexis' lessons only included one or two essential features of inquiry. The features, such as questions, were not used in ways aligned with their purpose but were used to direct discussions and to communicate. A second aspect of PCK for instructional strategies addresses the use of representations in science lessons. These may include illustrations, examples, models, analogies and demonstrations. In Alexis' lessons she did use demonstrations and illustrations, she was pleased with these methods and they did show some variety.

In the PCK area of knowledge of student learning in science, Lee et al. (2007) identified prior knowledge, variations in students' approaches to learning and student difficulties with science concepts. Alexis did not demonstrate the recognition of prior knowledge in the lessons or difficulties that the students may have had with the science topics. This lack of PCK in student learning may have been due to her proclaimed lack of background knowledge herself.

Overall, Alexis' implementation of the pre-CASES lessons did not demonstrate scientific inquiry, strong pedagogical knowledge, or pedagogical content knowledge. A number of factors influenced these lessons including a general lack of support to guide Alexis in these areas. Classroom management was one added factor.

CASES Lessons

Alexis taught four lessons from the plants unit in the CASES curriculum. Alexis did not sequence the lesson plans in a specific order as outlined by the unit but looked for lessons that would 'fit' into the scheduled frame of time and ones that would be appropriate for her classroom. See Table 9 for Alexis' CASES lessons.

The first lesson that Alexis taught to her kindergarten students allowed them to predict and observe seeds in different fruits and vegetables. Alexis began the lesson by reminding children of what they talked about in the morning. "Remember how we talked this morning about seeds and that they have a life cycle? What was the first stage?"(CL-1). Alexis went through the stages of a seed with students, and then asked, "Where do you find seeds?" She recorded student responses on a chart. Next, Alexis showed the students an apple and asked them if it had seeds and if they could see them. She directed the students to return to their seats where there was one fruit per table. Each table recorded their observations of the fruit. They predicted how many fruits would be inside. Next, fruits that had been cut open were passed out to the tables and the students checked to see if their prediction was correct. Students drew their observations on the handout. Lastly, the teacher allowed the students to rotate to different tables and to take a look inside the different fruits.

For the second lesson, Alexis selected a lesson to allow children to explore the parts of a seed. Alexis had the classroom set up prior to children being picked up from lunch. Seeds were set up on the tables and the chart board in the front of the classroom had "Life Cycle of a Seed" and "Parts of a Seed" as headings. "Today we are going to do an experiment. First, I want to review with you the stages of a seed. What is the first stage of a seed?" Alexis reviewed the stages of a seed with students. She reviewed with them the life cycle of a seed which included:

seed, seedling and then plant or tree. She introduced the parts of a seed and explained each part to students: seed coat, embryo and food supply. Alexis explained what the students would be doing in the lesson. She called tables to go back to their seats and begin observations of the dry lima beans. Next, the students received the wet lima beans. After a few minutes of observations, they shared descriptions of the wet and dry seeds which the teacher recorded on the board. Students then predicted what the inside of the seed would be like and then opened the seed to look inside. The teacher concluded the lesson by referring to the art project that students had completed on seeds, Billy the Bean sprout. The children had created lima bean shaped seeds with a green sprout coming out the bottom to show how a seed grows.

The next lesson that Alexis engaged the children in was, “How can you sort the seeds?” In this lesson children were able to observe seeds and explore various ways to sort them. Alexis began this lesson by explaining that they were going to have a fun time looking at seeds. She asked children to explain the three stages of seeds and then began the lesson. “We are going to do a seed sorting, what are some different ways we can sort?” Children responded with different ideas which Alexis recorded. She called tables to head back to their seats and begin sorting the seeds. The seeds were placed on paper plates for each table. After a few minutes of observation, Alexis called the children’s attention back to her, and allowed the children to talk into a microphone to explain how they sorted the seeds. Children sorted the seeds in the following ways: white to white, all the seeds you can eat, the way they feel, color to color, etc.

“We have been talking about seeds and plants. Who can tell me what they remembered from our book this morning?” Alexis begins her fourth lesson from the CASES unit on plants. She read the book, “Seeds Get Around”, asking questions and interacting with students during the story. This story explains that seeds can move by the wind, by water, by animals and by you.

Students were then sent back to their seats to examine some seeds. Students were to use observations of the seeds and decide how they could have traveled. After a few minutes, Alexis had children stand up and speak into the microphone to tell about their seed and to explain how they think it traveled. Alexis often responded, “Why do you think so?” when children shared their ideas.

Table 9 - Alexis CASES Lessons

Lesson Number	Name of Lesson	Amount of Time	Lesson Overview
CL-1	Where do we find seeds?	22 minutes	Lesson to begin the plants unit, introduction to where seeds can be found
CL-2	What’s inside a seed?	25 minutes	This lesson allowed students to observe and investigate seeds to find out what is inside them
CL-3	Comparing and sorting Seeds	25 minutes	Students observe seeds and decide how to group them
CL-4	How do seeds move?	28 minutes	This lesson explored the different ways that seeds travel and allowed children to observe seeds and decide how it moves

Summary of CASES Lessons and Reflections

Based on the comments during and after Alexis’s teaching of the CASES lessons and her reflections, Alexis was feeling more comfortable managing students in her classroom and specifically managing them during the science lessons. The active nature of the lessons and the use of various materials did make some of the lessons more difficult to manage. To better facilitate her management of the lessons Alexis reflected that she should, “Have great classroom management skills; have all of the materials ready for the students; do the activity beforehand so you are familiar with the procedure; and do research on the topic so you have a good understanding of the topic being taught" (CLR-1). Although management was somewhat an issue in the teaching of the CASES curriculum, Alexis felt that she was implementing more effective strategies to support the lessons. "I, first of all, let the students know what my expectations were and I also explained to them before we got into the classroom what we were going to do" (CLR-3).

Alexis continues to consider the inquiry and its impact on the learning of science. In her last CASES lesson she felt that observation and prediction were a part of inquiry and were included in the lesson. Students engaged in inquiry when "the students looked over the different seeds and had to predict how the seeds traveled" (CLR-4). In looking at the five essential features of inquiry, Alexis included a number of the features in each of the CASES lessons. Engaging in scientifically oriented questions was used in each of the four CASES lessons that Alexis taught. The questions remained at the lowest variation, "Learner engages in question provided by teacher, materials, or other source" (Appendix F; NRC, 2000; Windschitl, 2004). When students collected data from the fruit as they predicted and found out how many seeds were in each fruit, they were at the third level of the essential feature of evidence, "learner directed to collect data." The second lesson taught also worked on the same level as they collected data on the lima bean. In this lesson, students were also given a possible connection to the seed parts previously discussed in the lesson and students were given steps for communication. This lesson employed four of the five essential features of inquiry.

The last CASES lesson taught by Alexis explored how seeds move around also used four of the five essential features including engaging in question provided by the teacher, learner directed to collect data, learner given possible ways to use evidence to formulate explanation and learner given steps for communication. Although the lesson used the different aspects of inquiry and required the children to think and explain how seeds might travel, Alexis felt that the literature selection was the support that students needed to develop their understanding of the ways seeds travel. She felt that the "it was a great tool and I do think most of the students comprehended the way seeds move and I know this because we went over this later in the day" (CLR-4).

Alexis was asked about communication and evidence in her lessons, specifically what role they played. She felt that, "we want them to communicate their understandings of their learning so we, as teachers, know they understand the specific lesson being taught" (CLR-2). In the same reflection, Alexis indicated that she used communication to outline her expectations with students. "Then I allowed the students to feel the lima bean before it was wet and then we predicted what it would feel like after being soaked in water. The evidence was necessary so we could prove our prediction to be true. Without the evidence of the soaked lima bean, I don't think this lesson would have gone as well" (CLR-2). Alexis considered evidence to be important so that students could prove their predictions correct. Alexis also had an interesting way of allowing children to communicate. In two of her lessons, she took out a microphone and allowed students to share their observations and their thinking about seeds by speaking into the microphone. The students seemed excited to use the microphone to communicate their ideas to others. In some instances, Alexis did ask the students to provide evidence for their claims in the CASES lessons, facilitating an additional aspect of inquiry formulating explanations. Communication and the development of explanations were two additional aspects of the essential features of inquiry that were used with some consistency in Alexis' lessons.

Alexis commented on the differences between inquiry and hands-on lessons, “With inquiry the students are exploring and making the predictions and they really don’t know the outcome is, where hands-on (which is used a lot in the schools) is when students can touch or feel an object, but they aren’t really inquiring or predicting an outcome. For example, in science lab when the students touch the rocks and feel the rocks, this is hands-on. Where having the children inquire where the rocks are found and going to explore if the rocks are there would be a more inquiry based lesson. Inquiry is a great way to go, but you must be organized and have great classroom management and have students [in] that area [be] able to handle the inquiry method” (CLR-1). These ideas demonstrate a belief that inquiry is a more open-ended approach to science than hands-on learning.

Using scientific inquiry at the different levels was one pedagogical content knowledge strategy that was implemented during the CASES lessons. In two lessons, Alexis used the lesson question when outlining the science lesson for students. Alexis did not use the overarching driving question for the unit. Other pedagogical content knowledge that was demonstrated in these lessons includes consideration of students’ prior knowledge. Alexis did question her students in a number of CASES lessons to ascertain their knowledge on a topic. In the first lesson she asked, “Where do you find seeds?” In another lesson she requested ideas for how to sort seeds. These questions help to assess student’s ideas prior to the exploration of seeds in the lessons. Alexis did also try to support her students’ prior knowledge by providing information at the beginning of a number of CASES lessons.

Some adaptations were made to the curriculum in the CASES lessons. Alexis decided her students needed additional support or background knowledge in her lessons. In most CASES lessons, she added a review of pertinent concepts to support her children’s ideas. She also included a literature selection at the beginning of one lesson. She indicated the book helped children to understand how seeds might move. These adaptations do display Alexis' belief that children need support in their learning and that the scientific activities will not provide sufficient experiences to build their understandings in science. Forbes and Davis (2007a) discussed the tension that many teachers have between textbooks guided lessons and inquiry-based activities. Although Alexis indicates she believes inquiry is important, she still believes the textbook or other sources have vital information that the students should know up front.

Use of the CASES Curriculum Materials

"I really like these lessons" is one clear statement made by Alexis regarding the CASES curriculum materials. Alexis thought the actual materials were great from the CASES unit and that she was successfully able to implement the lessons. When Alexis decided she would be teaching the CASES unit on plants, she printed out the full unit. As she got closer to implementing each lesson she would look at the whole lesson. She did find the information about how other teachers had taught the lessons helpful as she read through the lessons. She indicated that she briefly read over the student alternative ideas, background information and images of inquiry. She also mentioned she contacted another participant in the research who had taught the lessons before her to get general information about the implementation of lessons. Alexis also found the materials information helpful and the directions easy to follow. She did, however, think that this unit would be better if she had more time. Her time slot was around 30 minutes for the lessons. "I think if you have more time, you could go further with them, 45 minutes is needed as the time allotted. I could have implemented them in a better way". Another aspect that was mentioned was the ability of the kindergarten students to complete the handouts. She felt that because of the writing integration, it would be better for first or second grade students. Some of her kindergarten students were not able to write about the science lessons on the handouts.

Beyond the materials that were provided for her, Alexis still found that she used the internet to support her own background knowledge when teaching the lessons. She mentioned that she searched the topic of plants to support her own learning prior to teaching students. Also, Alexis felt that young children do not have a strong background knowledge themselves so she felt that the students needed additional support such as a literature selection on the topic. “I would like a book to start out with; their background knowledge is not as developed as second graders would be so that would support them” (CI).

Regarding the integration of inquiry in the lessons, she indicated that the way the lessons were set up in an inquiry-based fashion. “They (the lessons) can’t give me a concrete outcome, so they told me what they [students] might ask but not definite. The way it is set up is inquiry based. Observations being a part of doing inquiry, [the] brainstorming [of] ideas and what are the different ways to sort” (CI).

Final Interview and Instruments

After Alexis had participated in teaching the CASES lessons, the three initial instruments were once again administered to analyze any change in the self-efficacy beliefs, views of science inquiry beliefs and the views regarding the nature of science. A comparison of the initial and final instruments took place to ascertain any changes in the teacher’s overall ideas related to science and her ability to teach science. A review of the three instruments is shared below with the findings that were noted.

STEBI B Instrument

The STEBI-B instrument was administered a second time at the end of the research. This instrument has previously suggested that self-efficacy is a construct that can help to understand attitudes about the teaching of science and can show changes in self-efficacy over time (de Laat and Watters, 1995). The STEBI-B instrument is used to find teacher's self-efficacy beliefs regarding their ability to teach science. It is divided into two specific areas: Outcome Expectancy and Personal Science Teaching Efficacy Belief.

Alexis's personal self-efficacy beliefs about science increased overall and in both of the specific areas addressed on the STEBI-B Instrument. In the final results of the STEBI-B instrument, Alexis' scores were above the mean score established by Enoch and Riggs (1990) when they developed this instrument. The Personal Science Teaching Efficacy Belief Scale had a mean score of 47.00. Alexis scored 59.00 on the final instrument indicating her efficacy beliefs are above average in consideration of previous research on pre-service teachers. Her Science Teaching Outcome Expectancy Scores were above the average score of 36.19 for pre-service teachers. Alexis scored 39.00 points indicating that she believes her teaching has impacted students understanding of science content. See Table 10 for Alexis' STEBI-B results.

Alexis demonstrates belief in her ability to teach science to her students and believes that she is able to impact their learning through her teaching. Her previous Outcome Expectancy score was below the average for pre-service teachers at the beginning of this research. This score would be indicative of her belief in her inability to impact student learning, but this area had increased to above the mean through her experiences with teaching science in this research. Previous findings have supported the belief when teachers have successful science teaching experiences, their self-efficacy beliefs improve (de Laat & Watters, 1995; Ginns and Watters, 1999).

Table 10 - Alexis' STEBI-B Results

	Outcome Expectancy	Personal Science Teaching Efficacy Belief
Initial Instrument Scores	32	52
Final Instrument Scores	39	59

Views of Nature of Science (VNOS-E)

The Views of the Nature of Science (VNOS) is an instrument used to assess overall understandings related to science. The aspects of the nature of science that are addressed in the VNOS instrument were the following: the tentative nature of science, science is empirically based, it is subjective, creativity is a part of science, and science is a human endeavor that is socially and culturally influenced. Additional aspects include that science is based on observations gathered from the senses or as extensions of the senses and inferences which are interpretations of the observations. The last area of the Nature of Science (NOS) is the difference between theories and laws. Laws in science describe relationships between phenomena in nature and theories which are inferred explanations for phenomena. This area was not directly addressed on the VNOS-E version used in this study (Abd-El-Khalick, 2001).

The first three questions on the VNOS address overall conceptions and beliefs about science. The questions consider beliefs about what is science, how is science different from other subjects and will scientific knowledge change in the future (See Appendix B). Alexis had similar responses on the initial and final instruments, her responses to the first three questions are below:

> Science is the study of all living and nonliving things. Science is a more hands-on and inquiry-based subject. There are more activities that can be done with science. Yes, I feel new research will be done and, therefore, new outcomes will be made.

These responses do not demonstrate sophisticated understandings of science. Her ideas related to what science is address science as the process for the development of knowledge, but does not recognize science as a body of knowledge. For the second question, Alexis focused on what science is like in the classroom as opposed to the larger field of science. Appropriate responses would be that science relies on data collected from the world and the data should be collected in an organized fashion. Lastly, Alexis felt like scientific knowledge would change. This belief demonstrates some understanding of the tentative nature of science. Reasons why knowledge may change is also considered in this response. Most people agree that when new experiments are conducted, it changes understandings in science. But it is important to recognize scientists can re-evaluate the data and glean new insights from existing data.

The next series of questions on the VNOS address dinosaurs, how scientists know they really existed, how certain scientists are about the way they looked and why scientists disagree on how the dinosaurs became extinct. For these questions, Alexis believed scientists know about dinosaurs because, “they have found their bones and pieced them together" (PInst). The bones would be considered a form of data and scientists would examine the data and make inferences based upon them to develop understandings of dinosaurs. In this response, Alexis did not fully explain the process of using data to find patterns and make inferences based upon them.

Views of Scientific Inquiry Elementary School Version (VOSI-E)

The VOSI-E (Views of Scientific Inquiry- Elementary School Version) seeks to understand views about what work scientists do and what entails doing science. The goal is to seek an understanding of perceptions related to science inquiry. Specifically, this instrument assesses the development of the following ideas related to scientific inquiry. One, investigations have multiple methods and purposes. Two, there should be a consistency between evidence and conclusions. Three, data can be interpreted in multiple ways. Four, there is a difference between data and evidence. Five, data analysis involves the development of patterns and explanations.

Alexis' ideas in the pre- and post-assessment of this instrument were similar. Her main belief is that experiments are the main avenue for scientists to do their work but did indicate they could use observations and research. She also indicated that she thought the scientific method was a "more like a procedure and that inquiry is just looking and digging for stuff without an explanation at the end, without knowing the outcome" (PI). So although she does seem to understand science could involve more than just experiments, she could not clarified how observations would be considered research. Also, her definition of inquiry initially may sound like it is just messing around or playing around but she did clarify that in inquiry you don't know the outcome. She had not clarified her stance on data and evidence and why they are significant in inquiry. On the whole, these beliefs demonstrate some understanding of inquiry but not an in-depth knowledge.

Overall Summary

Alexis indicated that she really liked the CASES curriculum and felt that it was supportive in her efforts to teach science inquiry. "I actually like science, I do like it better, and I feel more comfortable with it now that I have some research. The program [CASES] does give you all the facts you don't have to do much digging. To me it was a hard subject to teach because you need to know all the facts; you don't have to do too much digging" (PInt).

Management was a key factor in Alexis's ability to implement the CASES curriculum and may have taken away from her overall ability to implement the lessons to their fullest potential. In some instances, it seemed that Alexis didn't mind teaching the lessons but that she had a lot of things she was dealing with as she had full responsibility of the students and this was just one small aspect of the total curriculum. Her management strategies appeared to develop throughout her teaching, but even during the last lesson she did have some challenges regarding managing students in the class and focusing them on the science activities. The National Research Council (NRC, 2000) indicates that classroom management must be considered and addressed when teaching scientific inquiry. The difficulty with classroom management was quite possibly a factor in Alexis' ability to implement reform efforts such as all the aspects of scientific inquiry in the CASES curriculum. Davis, et al. (2006) found that new teachers tend to have struggles with management and this can lead to less reform-oriented teaching.

Alexis does not demonstrate fully developed views related to the nature of science and scientific inquiry, but her views of science did seem to be developing through this research. In the final interview, Alexis was able to understand and articulate some nature of science aspects although her overall views did not change significantly from the initial to final instruments. She could relate the idea of personal influence as a factor that may influence how scientists look at data. She specifically mentioned religious beliefs in her initial and final interviews, but when questions in the interview she expanded to say that it, "could be broader than religious beliefs but my first thought was religious beliefs" (PInt). Akerson et al. (2007) indicates that without appropriate views of the nature of science, teachers may have difficulties conducting scientific inquiries. To some extend this was the case with Alexis. Overall, her self-efficacy beliefs related to her teaching of science improved through this experience. This increase may be due to the fact that she was successful in teaching science during her internship experiences. Time spent teaching science could have been supportive of this increase (Enochs and Riggs, 1990).

Regarding her understanding of scientific inquiry, Alexis has some ideas related to inquiry but is still struggling with the overall concept and how it is different from hands-on activities and how it compares with the scientific method. “The method is more like a procedure and the inquiry is just looking and digging for stuff without an explanation at the end, without knowing the outcome” (PInt). This response indicates that inquiry is more open-ended and perhaps that the scientific method is following steps but she did not clearly articulate the differences. Alexis also indicated that she had some understanding of inquiry from the science methods class. “I used to think it was the same as hands-on and it is not but now... it is thinking through and you may be coming up with your own conclusions” (PInt). She also felt she understood how to teach inquiry explaining that you don’t have expectations of what the outcome is supposed to be and it involves thinking. Previous research from Davis et al. (2006) discussed the fact that research indicates a mismatch between teachers’ ideas and practices in teaching science. So although Alexis believed in science inquiry her ideas about this type of instruction were more sophisticated than her actual practice. The CASES curriculum did support her development in teaching through scientific inquiry practices. Continued use of the CASES curriculum may also enhance further understandings of scientific inquiry.

Schneider and Krajcik (2002) found evidence from classroom enactment that indicated teachers did use the educative features in the lessons. Examples from Alexis’s lessons also indicate that she was using the features provided in the CASES curriculum to support her teaching practice. She used a number of the strategies to support teachers in her implementation of the lessons. Scientifically oriented questions, data collection and communication of findings were the three essential features of scientific inquiry that were most apparent in Alexis' teaching. She also implemented explanations to some level in her CASES lessons. The extent to which the CASES curriculum materials were supportive in this research was dependent upon "how the opportunity is used by the individual" (Davis and Krajcik, 2005, p. 4). This research appears to indicate Alexis was limited in her full acceptance and implementation of the curriculum materials because of other classroom factors such as the science time during the circle time in the classroom, and the management of students during the science lessons.

Alexis believed in scientific inquiry as a positive way to teach science but was still developing her overall understanding of inquiry and how it is implemented in the classroom. Research from Crawford (1999b) has indicated many beginning teachers would have difficulty with inquiry because of their lack of pedagogical content knowledge. "The ability to adapt and mold instruction in response to student-centered inquiry appears a likely stumbling block for novice teachers who have difficulty with improvisation during interactive teaching" (Crawford, p. 7). In this study, Alexis was focused on general management strategies and, therefore, was not able to really consider the most effective strategies to support children's learning of science. This finding may indicate that teachers must reach a certain level of competency in management prior to moving forward in inquiry practices and the strong consideration of how they support children's learning.

Alexis felt like she implemented some aspects of inquiry in her lessons. She mentioned that she had read the book and changed other aspects of some of the lessons. When asked if this took away from the lessons being inquiry, she said, "At this age level, no, because I think they need some background knowledge. They wouldn't have predicted the way seeds moved." (PInt). Alexis appeared to believe that her students needed more background knowledge to understand the content of the lessons; she did introduce each CASES lesson with a review of important information that was related to the content. She regularly reviewed the life cycle of a seed and the parts of a seed rather than allow children to develop their understandings in the lessons (CL-1, CL-2, CL-3, and CL-4). These additions to the CASES lessons to some extent contradict the processes of constructing knowledge through inquiry and neglect the changing emphasis on science teaching that moves away from learning science by lecture and reading (NRC, 1996).

Lotter, et al. (2006) found that core-teaching conceptions influenced teachers' beliefs and practices. In the areas outlined by Lotter et al., Alexis seems to be wavering in her beliefs between science as a process or as an accumulation of facts. In the area of effective teaching conceptions, she demonstrated a belief in the transmission of information more than encouraging independent thought. These core conceptions may have impeded her full implementation of the CASES lessons.

Another factor involved in Alexis's approach to teaching is based upon her beliefs about children and how they learn. She indicated that children need structure in the classroom, "structure, structure, structure, children thrive on structure, they want to know what is coming next, especially the little guys." (PInt). She also indicated she felt children learned through example and when things are modeled for them for their own inquiry and by actual experiences. These beliefs seem to indicate a mix between traditional and alternative approaches to education which may have been a factor in her implementation of the lessons (Porland and del Pozo, 2004). Mulholland and Wallace (2005) indicated that in the early years of teaching, beginning teachers often experience conflicts about their beliefs about teaching compared to actual classroom practices. Even teachers, who held strong beliefs about how to teach science, may have difficulty implementing strategies they viewed as important. This study appears to indicate that, although Alexis indicates her belief in scientific inquiry, she is not fully able to implement those practices in the classroom setting.

Alexis's content knowledge was a concern she mentioned throughout the research. In her initial teaching of science she felt unprepared to teach the content of energy. This concern was due in part to her lack of understanding and her inability to use the teacher's manual in a timely fashion. In the CASES unit, she also mentioned that she did research on the topic of seeds and also used the information provided in the unit to support her content knowledge. Smith (1997) indicates that many students in her research were able to prepare themselves through their own research to teach specific science content. Alexis did indicate that she used the CASES materials as a support for her content knowledge and also conducted additional research to reach a comfort level with the content of her lessons.

To some extent, Alexis was able to implement scientific inquiry practices during this research. The degree to which she implemented these practices could be based on the apparent disconnect between her beliefs and practices. She did include a number of essential features in the CASES lessons but did not display a high level of pedagogical content knowledge. This lack of pedagogical content knowledge could also be related to her growing use of pedagogical strategies and building content knowledge. She may need to have her pedagogical strategies and content knowledge firmly in place to support best practices of teaching science.

Overall, Alexis was hindered in her teaching of science by a lack of classroom experience and management strategies. The implementation of science lessons, which are more active, was a problem. Alexis proclaims to believe in inquiry but she is not able to implement inquiry practices to the full extend with her students. This may be due to her developing understanding of inquiry. Alexis also is not confident in children’s ability to construct knowledge and therefore wants to provide supports for them in their learning.

CHAPTER 6
CASE STUDY: DENICE

This chapter presents the case study of Denice, a pre-service early childhood educator, and explores the role of educative curriculum materials in her implementation of science lessons in her internship site. The chapter further examines the integration of scientific inquiry in the science lessons with a focus on how different aspects of inquiry were enacted in her science teaching. These aspects include scientifically oriented questions, priority to evidence, and formulation of explanations, evaluation of explanations and communication and justification of explanations. Additional aspects associated with Denice's science teaching will be considered including a comparison of the CASES and non-CASES lessons. Further examination will include how the CASES materials supported her content knowledge and her pedagogical content knowledge. The chapter will conclude with a summary and discussion of the critical elements related to Denice's science teaching and her overall development in her ability to implement scientific inquiry.

Teacher Profile

Denice is a Caucasian female in her early twenties. She is a traditional student and is earning her degree in the typical four-year period. She is expected to graduate from the Early Childhood Education Bachelor's degree program at the University of Central Florida in the spring term of 2008. Denice participated in the initial interview and instruments at the completion of her junior internship period in the fall of 2007. She began teaching science lessons during the first few weeks of her senior internship in the spring term of 2008. Denice taught in a rural school in the central Florida area. She interned in a third grade classroom. In her classroom, she had 15 students. One additional student entered the class during the period of observations which raised the number of students to 16. The school had a school grade of an "A". Science appeared to be relatively important in this school and was taught on a regular basis. After the initial observation period, students were preparing for FCAT testing and, therefore, did not participate in science for a period of three weeks. After that time, they began regular and consistent science lessons again. The initial CASES unit for science was plants. Denice began by creating her own lessons on the topic of plants based upon the science text, Harcourt Trophies. After a number of days teaching her own lessons, she began to use the CASES curriculum materials on the same topic. Denice began a second CASES unit during this research but was not able to be observed throughout the whole unit. A factor for consideration of Denices' implementation of the CASES curriculum is that she integrated it into a unit on plants that she was already developing. Although she had the topics from the CASES unit prior to her implementation of her pre-CASES lessons, she found it difficult to integrate the CASES into her teaching goals.

Initial Interview and Instruments

At the beginning of the research, Denice was provided with three instruments to assess her understanding of the nature of science, scientific inquiry and her self-efficacy beliefs regarding teaching science. A review of the instruments indicated that Denice is confident in her abilities to teach science and feels comfortable with the prospect of teaching science. She believes that she will be Above Average in teaching science.

STEBI-B Instrument

The STEBI-B instrument was administered. This instrument is based on the belief that self-efficacy is helpful in considering how, how often and why teachers teach science (de Laat and Watters, 1995). The STEBI-B instrument is used to find teachers' self-efficacy beliefs regarding their ability to teach science. The instrument is divided into two specific areas: Outcome Expectancy and Personal Science Teaching Efficacy Belief. According to Enoch and Riggs (1990), high outcome expectancy is when “behavior is enacted when people expect specific behavior to result in a desirable outcome” (p. 2). Self-efficacy beliefs are based upon a teachers’ belief in their ability to perform the behavior.

For the Personal Science Teaching Efficacy Belief portion, Denice received 53 out of 65 possible points, which is over 80 percent of the total points. Research from deLaat & Watters, (1995) showed that teachers with high PSTE scores expressed their confidence in teaching science and their interest in it. Denice did express confidence in teaching science. In previous research by de Laat and Watters using the STEBI-A instrument with teachers, they found the mean score for the PSTE was 49.6 with a range of 33-62. Denice’s Personal Science Teaching Belief score shows a high self-efficacy belief in this area. Enochs and Riggs (1990) worked with a population of 212 pre-service teachers and found the mean score for the PSTE was 47.00. Compared to this research, Denice’s score is above average based upon previous research.

Regarding the Outcome Expectancy aspect of the instrument, Denice scored 40 points out of a possible 55. Enochs and Riggs (1990), in working with pre-service teachers, found an average score of 42.84, but statistical results cause them to eliminate two questions from the instrument to give a mean score of 36.19. Therefore, Denice would be above the average pre-service teacher showing high outcome expectancy. In other words, she believes that she can impact the outcomes of science with the students she works with.

Views of Nature of Science

The VNOS instrument provides information on how educators and students view the nature of science. A number of different versions of this instrument have been developed to use with children and adults in different situations. Denice shows some insightful answers and understandings but is still developing a strong understanding of the nature of science.

Denice includes a definition of science based on the world or “our surroundings.” This definition is aligned more with science as content or a body of knowledge and does not recognize that science can also include the processes associated with scientific inquiry. When considering how science is different from other content areas, Denice acknowledges that science is not concrete or fixed. She realizes the tentative nature of science but doesn’t address the use of data or the empirical nature of science in that it must be based on data or observations. Further consideration of the tentative nature of science, Denice believes that scientific knowledge will change. Her ideas appear to be based on the idea of new discoveries in the field of science. This is a common answer but an even more sophisticated view would include that scientists may also look at the data in a different way.

The VNOS asked how scientists know that dinosaurs existed; Denice indicated that they found artifacts and bones. She did not clarify that the observations of these items helped scientists to make inferences based upon the data. Further questioning pursued an understanding of how certain scientists are about how dinosaurs looked; here Denice indicated that she did not know. The focus of this question is again the roles of observation and inference in science. The development of ideas regarding the dinosaurs involves some subjectivity and creativity and Denice did not consider this. However, when asked about the extinction of the dinosaurs, she was on track in her belief that scientists can have the same information but use it or view it differently. Although not specifically stated for science, she used the example of how various people interpret information from a story in a number of ways.

In looking at the definition of a scientific model, Denice indicated "it is the way a procedure is supposed to be done." Here she focused on "model" as a procedure to be followed such as the scientific method, as opposed to a model that scientists create to understand a concept or to create a copy. Lastly, the VNOS asked whether imagination and creativity are a part of investigations. Denice, along with many others who have completed this instrument, answered that, yes, imagination is used in the planning stages of an investigation. More informed views indicate that "imagination and creativity are essential for the formulation of novel ideas... to explain why the results were observed" (Abd-El-Khalick, et al., 2001, p. 37).

Views of Scientific Inquiry Elementary School Version (VOSI-E)

The Views of Nature of Science instrument seeks to ascertain participant's views of scientific inquiry with importance given to the ideas that there are multiple methods of investigations, multiple interpretations of data and that there should be consistency between evidence and conclusions. Overall interpretation of Denice's views indicate that she had developed understandings of multiple interpretation of data but is still developing a deeper understanding of the multiple methods of investigations and the use of evidence to form conclusions in science.

Denice expressed that scientists "find explanations to normality's and find new ways of fixing problems" (II). Her beliefs included that scientists made observations and conducted experiments to do their work. These views are considered typical but without more depth are not considered informed.

When provided with the example of the scientist observing the birds, she felt the observation was scientific because of the observation but that it was not an experiment. Her idea of experiment included "changing the environment" in some way. Denice's response is indicative of one scientific method although she does not specifically use the manipulation of variable and controls terminology. The example of the scientist observing birds used repeated observations, pattern building and inferred correlation to create conclusions. Therefore, the observations and inferences are recognized as scientific when viewed as a part of a broader view of science.

The last area addressed in the VOSI focused on multiple interpretations of data. Denice believes that there can be different interpretations based on data. Further exploration of what information is needed by a scientist to explain their reasons for the extinction of dinosaurs was requested. Here Denice said interpretations are based on artifacts, beliefs and imagination. A more refined answer would focus more on the consistency between evidence and conclusions.

Overview of Pre-CASES and CASES Units

Denice was in a unique situation regarding her participation in this research. Time was an issue in the ability to observe her during her junior internship; therefore, observations of her science teaching began in January, 2008. She was observed over a three-week period where she taught science almost every day. A second distinctive factor involving Denice was her teacher identified one unit of study that Denice would teach for this research. The topic was plants. Denice initially developed some lessons based upon the science text used in her school for her pre-CASES lessons and then she used some of the CASES materials. The CASES curriculum had a unit developed for K-2 on plants and also had a few lessons dispersed in other three to five units. Since Denice was interning in a third grade classroom, she used a combination of different CASES lessons but began the unit with lessons she developed herself.

Pre-CASES Lessons

Denice taught five lessons prior to the implementation of the CASES lessons. The first lesson was not a part of the plants unit but was the end of a unit on living and nonliving things. This lesson used a DVD to guide the students in thinking about living and nonliving things. Denice facilitated the use of the DVD with the students. The other lessons she taught were on the topic of plants. She developed the lessons using the science textbook as a resource. See Table 11 for the Pre-CASES Lessons Denice taught.

The first lesson observed was not developed by Denice but used an interactive DVD called Science Court. This lesson was not on the topic of plants. In this particular lesson, students watch a DVD that used a 'courtroom' where science ideas and beliefs are debated. Students were then instructed to work in groups cooperatively to answer questions presented in the DVD. Then students come back together and again interact with the DVD to share their answers and compare them to the 'scientific' answers. This DVD was very well done and although children did not participate in an actual science experiment, they did cover many aspects of inquiry. Students were engaged in scientific oriented questions. They were given data and told to analyze the data. They were asked to formulate explanations based on evidence presented in the DVD and were provided steps for communicating their explanations. The above skills allowed students to consider science and to use many important critical thinking skills which are identified as a part of scientific inquiry. This lesson was one of the only lessons that was not a CASES lesson that met many criteria for inquiry.

Table 11 - Denice's Pre-CASES Lessons

Lesson Number	Name of Lesson	Amount of Time	Lesson Overview
PCL-1	Science Court	40 minutes	Living, nonliving and dead.
PCL-2	Introduction to Plants	42 minutes	Introduction to plants, plant parts
PCL-3	What Plants Need	42 minutes	Comparison of human and plant needs
PCL-4	Where Plants Live	47 minutes	Briefly observed plants and looked at characteristics that would show where they were from.
PCL-5	A Look at Leaves	47 minutes	Students discussed characteristics of leaves and did leaf rubbings

The next four lessons observed were developed by Denice and used the science text as a general resource and tool. The lessons developed in a progression that Denice found appropriate and that also aligned with the standards outlined in the State of Florida for the topic of plants in third grade. The lessons were: an introduction to plants including plant parts, what plants need that addressed the specific needs of plants, where plants live which focused on the characteristics of plants, how they determine where plants live and lastly, a look at leaves.

The first lesson in the plants unit addressed the parts of plants. “Do you know the different parts of a plant?” is the question Denice used to introduce the lesson. She read the story, “Oh Say Can You Seed?” Next, students opened their science books and one student read from the book in the section called, “Insta-Lab”. This lab provided directions to conduct an experiment using celery to see how water and nutrients flow through plants. Each group was given materials, the teacher put drops of food coloring in a class of water and one student stirred the water. Denice asked the students to share ideas about what they think will happen to the celery. Next, students turned to page 370 in the textbook and took turns reading paragraphs. Students reviewed the information in the text and Denice asked questions. Denice held up a plant and asked students to tell the parts of the plant and point to them. Students were given a worksheet to label the parts of a plant. As they worked on this, Denice called groups back and students placed lima beans wrapped in wet paper towels in baby food jars and placed them on the windowsill.

The second lesson that Denice taught addressed the topic of what plants need. “Who remembers what we talked about yesterday?” Students shared their ideas about what they remembered. Then one student from each group was asked to get the celery from yesterday, groups looked at the celery and considered what happened. Denice asked the students to think about what they thought would happen and what they actually observed. They shared their observations. Next, students took out their science books and read from the text, different students taking turns. Groups of students worked together to create a Venn diagram to think about the differences and similarities between what plants need and what humans need. Denice called the groups back together to share their Venn diagrams; she recorded information shared by students. At the end of the lesson, Denice introduced an experiment. I will plant one of these flower plants in soil; one is sand and one in rocks. Denice showed the materials that she would use to plant the flowers and asked students to raise their hands if they predict the sand will grow best, if they think the rocks will grow the best, or if they think the plant in the soil will grow best.

The third lesson in the plants unit was on the topic of where plants live. Denice began by having students take out their science text and turn to a certain page. She questioned the students: Can someone tell me what we talked about yesterday? Will a plant grow better in dirt, soil or rocks? Where do plants live? Denice directed the students to read and find out where plants live. Students took turns reading out loud to the class. Denice then held up plants from the previous lesson and had students say where they thought the plants lived. She used a PowerPoint presentation that had pictures of plants and students decided where the plant would live, in the desert, water or temperate area. Students introduced a handout that showed the three areas plants live previously discussed and one page that showed different plants. Students were directed to cut out pictures and glue them in the appropriate place that the plant could live. Students worked on the plant handouts at their seats. During this time, Denice called groups to briefly look at the three plants that had been planted in rocks, soil and sand.

The fourth lesson in the plants unit addressed different types of leaves. Denice began this lesson by asking students to get out their science books. She reviewed the material they had previously talked about: Where do different plants live? Are all plants the same or different? What are some of the differences? What can we look at to see where plants are from? Students answered spikes, stem, flowers and leaves. Denice held up plants and asked students to look at them and see if the leaves were the same or different and how they looked. Students shared observations about the leaves as the teacher showed the plants. The teacher walked around to each table and showed two different plants asking students to observe the leaves. Other tables waited while she walked around the room. Then students opened their textbooks and took turns reading. Once they had finished the pages, Denice asked the students if they can tell the difference between deciduous and evergreen leaves, maple and pine leaves, oak and maple leaves, and fern and magnolia leaves. Denice explained that they were going to do a really fun activity. She had found a bunch of leaves by her apartment and the students were going to do crayon rubbings of the leaves. The helpers passed out materials to students and they created crayon rubbings of various leaves.

Summary of Pre-CASES Lessons and Reflections

Denice did attempt to include hands-on activities in the lessons she developed. She kept a strong focus on the text as a source of information for the students. In the lessons that included an ‘experiment’, Denice provided quick activities labeled by Windschitl (2004) as discovery activities. These activities were brief activities to exemplify a scientific principle. In the first lesson, Denice had students put celery in water and discussed what would happen to the celery when they checked the next day. This short activity did not allow children to carefully observe the celery or record their observations and predictions. When the celery was the focus the next day, again, students were asked to look at the celery and note any observations which were quickly discussed in the group before moving on. Students did not work to make careful observations or form conclusions in the activity. Students worked at their tables to observe the celery. In another lesson, Denice had students predict where plants would thrive: in soil, in sand or in rocks. This portion of the lesson took only about three minutes of the 40 minute lesson and did not allow children to record or analyze their thinking. Although Denice was attempting to include ‘experiments’ and hands-on activities, she did not fully develop the active portions of the lessons and allow children to fully explore the events. Most lessons were quick and fun for children but not developed. The thinking aspect, which is supported uniquely in scientific inquiry, was not really present.

Although not really inquiry lessons, some aspects of scientific inquiry like questions were a regular focus of the lessons. Questions were integrated into most of the lessons. Denice would often begin a lesson with a question or use questions to review what had previously been covered on the topic of plants. Scientifically oriented questions are one feature of scientific inquiry (NRC, 2000; Windschitl, 2004). Although questions were integral to the lessons, when children answered, they were rarely asked to explain or justify their thinking. Observation periods associated with hands-on activities were not accompanied by discussions , drawings or writing, so children were not fully recording or communicating their ideas or understandings. The brief interactive sessions did not sufficiently provide opportunities for data collection. Students were not asked to explain or justify their thinking during lesson enactment. Further facilitation of these lessons could have caused them to include more aspects of scientific inquiry and this expansion could have led to higher levels of thinking and interactions with the materials.

Denice indicated that she used several different teaching strategies in her lessons; she used whole group work, individual work and hands-on activities in one lesson. When asked about specific science teaching strategies, she indicated the following strategies: “I used a PowerPoint, hands-on and an assessment form. I also lectured the students and questioned them” (LR-3). For the next lesson, “I used hands-on activities and inquiry by having students examine and compare different leaves. This was extremely successful” (LR-4).

When considering pedagogical content knowledge in the pre-CASES lessons, Denice did use questions as a focus for many of her lessons. In one lesson, Denice introduces the lesson by asking “Where do plants live?” in another she asked, “Do you know the different parts of a plant?” (PCL-1 and PCL-3). These questions served to focus students on the overall topic of the lessons. When asked if the students were engaged in inquiry, Denice answered, “Yes, we did several hands-on activities to see what would happen" (LR-2). This response would indicate that although Denice has some idea of scientific inquiry, her overall understanding is not well developed believing that the lessons were inquiry based.

Content knowledge did not appear to be an issue in Denice's lessons. She did mention her lack of understanding in most areas of science content in her reflection saying, "I do not feel comfortable teaching most science subjects without having resources available to me" (LR-4). In her lesson on classifying plants and trees, Denice had students look at plants to tell if they had flowers or not. One student indicated that he had seen flowers on an aloe plant but Denice dismissed this since there were not visible flowers on this plant. Generally, Denice displayed a strong understanding of the content for this unit but this one incident correlates with her lack of confidence in knowing science and the broad understanding of many concepts related to a science topic.

Technology was prominent in the lessons Denice developed. She included a PowerPoint slide show in one lesson and had two lessons where she showed students pictures of plants or plant parts online and then followed by having students cut and paste similar pictures into categories as a follow up.

Denice's reflection of the lessons indicated that she was generally pleased with them. At the end of each lesson, she would discuss the lesson with me. She was concerned about management in her lessons and requested strategies that would support her in this area. In these discussions, I would provide my thoughts of classroom management and throughout the following lessons; she did implement general classroom management strategies. When asked if she would change or adapt the lessons if she could, she said, "I enjoyed teaching it that way. I had the basis for what to talk about, but I had the freedom to create activities that I knew the students would enjoy" (LR-4).

CASES Lessons

Denice initially taught three lessons from the CASES curriculum in the plants unit. Out of the three lessons, only one was enacted in a manner similar to the CASES materials. The other two lessons used part of the CASES curriculum but were adapted to be more suitable to Denice's objectives and included the use of the textbook to support students' background knowledge of the science content. Denice began a second CASES unit at the end of this research study, I was able to observe two lessons from the unit on electricity and magnets. Denice's implementation of these lessons was close to the plan outlined in the curriculum materials. See Table 12 for CASES Lessons Denice taught.

Table 12 - Denice's CASES Lessons

Lesson Number	Name of Lesson	Amount of Time	Lesson Overview
CL-1	What’s inside a seed?	42 minutes	Student’s observe and open a seed to see what is inside
CL-2	Grouping Seeds	40 minutes	Students observed seeds and sorted them
CL-3	Photosynthesis	37 minutes	Students discussed what would happen to plants with and without sunlight, they then read about and discussed the processes of photosynthesis
CL-4	What is Electricity?	42 minutes	This lesson was an introduction to the topic of electricity. Students considered what they know and wanted to learn about the topic
CL-5	Circuits	52 minutes	This lesson introduced the concept of a circuit, students explored materials and created their own circuits to light a bulb

The first CASES lesson used was on the topic of seeds and was entitled, what’s inside a seed? In looking at this lesson regarding the inquiry aspects, the lesson did have a number of inquiry components. The lesson engaged students in pursuing a question. The lesson would fall closer to guided or teacher directed inquiry because the students pursued a question that was provided for them by the teacher. The National Research Council (2000) identified essential features of classroom inquiry and their variations which show levels of inquiry. Students were also involved in collecting data about seeds through their observations. They discussed evidence of when the embryo can grow based upon their observations of wet and dry seeds. Lastly, in this lesson, they used an open-ended worksheet to communicate their findings. The highest level of inquiry present in this particular lesson was the learner collecting data (CL-1). When reflecting upon this lesson, Denice indicated she felt the students understood the concepts covered regarding seeds. The worksheet was open ended and they made illustrations of their understandings. She also mentioned that “When I asked them questions, they were able to properly answer the questions with a basis of understanding” (CR-1). Denice felt confident the students understood the content of the lesson.

In the following two lessons, Denice did not enact the CASES lessons as designed. She adjusted the lessons to suit the content that was outlined for the topic of plants. Although, Denice covered topics that were aligned with the CASES curriculum, the steps and procedures did not align with the specific lesson. Therefore, some aspects of inquiry were present in these lessons but was not as fully developed as if the lesson followed the curriculum more closely. Denice’s second CASES lesson was an adaption of the comparing/classifying seeds lesson. In this lesson, students reached a higher level of evidence on the science inquiry features chart as they were “directed to collect certain data” (See Appendix F). On the other hand, students were directed to answer the question, “How can seeds be sorted.” They were also provided specific steps to communicate their findings by creating a grid on paper showing four ways to sort seeds. The question and communication aspects of the lesson were at the lowest level of inquiry. So, in essence, three aspects of inquiry were covered in this lesson. In Denice’s lesson reflection, she indicated that communication and evidence were a part of her lesson. “Without communication, they would not have been able to properly classify them [seeds]” (CLR-2). She did not clearly address how evidence played a part in the lesson.

The last lesson that Denice taught on the topic of plants was an adaptation of a lesson on photosynthesis. This lesson was very loosely based on a CASES lesson. Denice introduced the lesson by having students look in their science texts. Next, she reviewed with students, what plants need to grow. Denice did have students consider what would happen to a plant that was in the sunlight compared to one that was kept in a closet and then she had students vote on where to put the plants. Then Denice had students read about photosynthesis from the book by taking turns. She reiterated the information and had students copy a cartoon on photosynthesis. In this lesson, students did consider the question, "What will happen to the plants?" putting one in the closet and one in the sunlight. Out of the five essential features, the question was at the lowest level. Learners also communicated their understandings by copying the cartoon the teacher created which aligns with "learner given steps and procedures for communication" (See Appendix E – Teacher Observation Form; Appendix F).

Denice was able to begin a second unit from the CASES curriculum on electricity. This lesson was called, "What is electricity?" Denice began the first lesson with the driving question from the lesson. She then asked the students why electricity is important and had them share their ideas. "This week we will be learning about electricity, so I made you an electricity journal" (CL-4). Students were initially invited to decorate their science journals on electricity. They answered the two questions in their journal that were previously discussed as a whole group. Students were then organized into groups and were asked to use paper to create a KWL chart (What I KNOW, What I WANT to learn and What I LEARNED). The groups worked together to complete the first two sections of the chart. After groups worked on their chart, they presented their thoughts to the whole class.

Observations of the second lesson in the electricity unit were made. In this lesson Denice gathered the students in a circle to play a game. “Everyone needs to hold hands” she explained to the class. When the students had formed a circle, Denice began by squeezing the students hand next to her, after that each student secretly squeezed the next student’s hand until it got back to the teacher. After the class did this a few times, Denice asked two students to break the circle so it was not longer connected. She began squeezing hands again but the class realized that because the circle was broken, they could not go fully around the circle. Denice also had a doll that was placed in the circle, when the circle was connected, it would light up and play a song, but when the circle was broken, it would stop the music. “We demonstrated a circuit. If we hold both hands we complete the circuit and the doll lights up.” Next, Denice reminds students to think about the words she used and write in their journal to answer the question, “How do bulbs light?” After students completed the writing, they got a baggie that contains a battery with wire taped to both ends and a light bulb on one wire. Denice explains that they will have a few minutes to explore the materials and see what happens, she turns the light out. Children begin to figure out how to light the bulb and the teacher then tells the children they can light the bulb in two different ways. After all the students have been successful in lighting the bulb, the teachers asked, “What was the most important thing to get the bulb to light?” The class discussed the question and shared ideas. One child mentioned that her dad used a paper clip in the circuit and the teacher demonstrated how the circuit still worked with the paper clip. Next, the teacher called the children to the front of the room and read them part of a book called, Electricity. She connected what the students had done with their circuit to the information in the book. Lastly, the students returned to their seats and answered the question, “What is a circuit?” in their electricity journal.

Summary of CASES Lessons and Reflections

Denice was pleased with the lessons she taught from the CASES curriculum. Although she did not align her enactment of the lessons to the CASES curriculum in the first unit of study, she still felt that the curriculum materials were a good resource. She was able to closely align her teaching of the second unit with the lessons designed in the CASES curriculum. Her enactment of these lessons included more inquiry practices.

Reflections of the third CASES lesson requested Denice to consider how inquiry and hands-on activities were similar. Her response was that “Inquiry is the students doing an experiment and finding how it works, why it works and the different outcomes and answering the questions themselves. Hands-on activities are just the students performing the different activities and not answering the questions” (CLR – 3). This response indicates that Denice does see questions as a key component of inquiry but does not consider the other aspects of inquiry.

The five essential features of inquiry (NRC, 2000; Windschitl, 2004) were demonstrated to varying degrees in the CASES lessons. In the What’s Inside a Seed? Lesson, Denice used all five of the components of inquiry. This lesson would be considered a full inquiry lesson as outlined by the National Research Council (2000). The enactment of this lesson was quite similar to the procedures from the CASES curriculum. This lesson was also a guided inquiry lesson as the students did not have as much control over the question they pursued and how the investigation was conducted. The other lessons generally contained two or three features of inquiry at varying levels. The lower amount of inquiry features could have been due, in part, to the adaptations that were used.

Also, pedagogical content knowledge was more clearly demonstrated in the CASES lesson that adhered to the CASES curriculum more so than the other two lessons that were adaptations. PCK- Instructional Strategies were used including the three of the five essential features in the first and second CASES lessons (CL-1, CL-2). In the first CASES lesson, Denice did mention that, “we are going to do a scientific experiment”. She also referred to observations and the use of hand lenses to look at the seeds. This comment may be associated with the CASES curriculum, which provides reasoning for the inquiry approach of the curriculum. Further areas of PCK knowledge of instructional strategies were also visible in Denice’s CASES lessons. She used science journals, presentations, group work and discussions as ways to allow students to share their understandings of science content.

Additionally, Denice demonstrated PCK knowledge of student learning in science in the areas of student prior knowledge, learning approaches and student difficulties in science content. Denice assessed prior knowledge in a number of the CASES lessons. In the unit on electricity, she began by having students discuss ideas of electricity followed by them creating a KWL chart. These activities directly supported their sharing of prior knowledge. Her use of questions at the beginning of many of her lessons provided insight into students’ understandings. To facilitate the differentiation of instruction, Denice implemented science lessons in a variety of formats. She included whole group activities and discussions, small group work, hands-on activities, and games. The variety of methods allowed students to learn in different ways. The last area of PCK for student learning was not directly observed in Denice’s lessons but was brought up in the CASES interview. Denice did use the information in the curriculum about student alternative ideas. “It gave me responses so I knew how kids would respond. Then I knew how to respond” (CI).

In the second unit on electricity that Denice taught from the CASES curriculum, she followed the curriculum as it was outlined. She commented, “I liked it, it was a good introduction to the topic. It was hard to keep quiet and accept all answers because I wanted to tell them. One child said electricity comes from dirt!" (CL-4). In the previous CASES unit, she had adapted most lessons because they did not fit with her content and purposes for teaching. She indicated that she felt the science text was an important part of the lessons as it taught the students valuable information (CL-1). In this lesson, students posed questions which are almost the highest variation of the essential feature for questions in scientific inquiry. Other essential features of inquiry that were a part of this lesson included communication as students shared their KWL charts. Students also made connections to their own lives as they talked about electricity and its importance. It appeared that Denice was struggling with how this curriculum related to her own beliefs about teaching.

Denice's reflections of the lessons indicated that she felt students understood the concepts learned and that whole group teacher questioning was key to knowing if students understood the content covered (CLR-1, and CLR-2). She also indicated that communication was important in lessons because "the teacher knows what they understand and do not yet grasp and so they can learn how to communicate their ideas" (CLR-2).

One major consideration of Denice's teaching of the CASES lessons was her adaptations of the lessons she taught. Denice did teach one lesson as it was designed from the CASES plant curriculum. She also enacted the second unit in a similar fashion to what was designed by the curriculum. Since Denice had specific criteria of what she wanted to accomplish, she did not carefully adhere to the curriculum as it was designed. Rather, she took an idea or an activity from the second two CASES lessons and adapted them to fit with what she considered important and aligned with her goals. Forbes and Davis (2007a) found that beginning teachers use materials as a function of and influenced by their own orientations of science teaching. One specific aspect related to the use of materials was the tensions between text-based science and inquiry or activity-based science orientations. Teachers may struggle with how to use curriculum so that students got the information they needed to learn (textbooks) but were still able to experience and interact with materials. Denice appeared to want students to interact with materials but still felt the textbook was important.

In the second unit that Denice taught, she did adhere more closely to the CASES curriculum in her teaching. Her lessons did include more aspects of inquiry and did demonstrate an approach to learning science aligned with constructivist beliefs where the children construct and build their knowledge through experiences and through the thinking associated with those ideas. The first lesson was enacted in a way that closely matched the curriculum. Denice responded that, “it was difficult to keep my mouth shut and let them have their own (incorrect) ideas” (CL-4). In her fifth lesson, she did add the literature selection to support children in learning factual information regarding electricity and circuits. This again reinforces her traditional approach to teaching that does rely on the imparting of factual information (Porlan & del Pozo, 2004).

Use of the CASES Curriculum Materials

Denice was interviewed regarding how she used the CASES materials. The interview took place after she taught her third CASES lesson. When preparing to teach lessons from the CASES unit, Denice reviewed the full lesson online and then cut and pasted portions of the lesson that she would use. She specifically copied materials needed for the lesson as well as the steps or procedures followed during the lesson (CI, CL-1).

She felt that she was successful overall in planning and implementing a science unit on plants and somewhat successful at implementing the CASES curriculum. “They are excited to see what was happening and they were shocked to see the plants in the sand, soil and rocks" (CI). The inability to implement the CASES lessons was due to the fact that she did not feel the science curriculum met all the criteria she considered to be important regarding science lessons. The CASES lessons did not have nonfiction text that students read to support their understandings of science concepts (PCL3, CL1, and CI). After completing her first CASES lesson, she said, "I didn't like it as well as the book" (CL-1). In a majority of the lessons Denice developed herself, she included the textbook. She had students read from the textbook to gain background information related to the topic.

Another concern that Denice indicated regarding the CASES curriculum was that she felt it was not integrated. She again mentioned the literature selections and also mentioned the integration of mathematics into lessons. She felt that integration was valuable and did not see it in the CASES lessons. In most every lesson Denice developed, she did include either a literature selection or the science text so she demonstrated her belief regarding content area reading for lessons but no evidence was seen of mathematics integration (PCL-2, PCL-3, and PCL-4). Mathematics can be a natural component of science as children collect observational data, but it was not apparent in any lessons observed.

In using the CASES website, Denice reviewed the curriculum for lessons she was going to teach. She did refer to the pop-up boxes that were dispersed throughout the units and stated that she read them. She indicated that she used the background information for the lessons and the student alternative ideas sections. She mentioned that these were helpful in her overall preparation for the topic of plants. "It gave me responses to how kids would respond and they said it so I knew how to respond" (CI). In her reflection of the last CASES lesson, Denice emphasized her need for support with the content, "Because I am not knowledgeable about many science topics. I do not feel comfortable teaching most science subjects without having resources available to me" (CLR-3). In the second CASES unit, Denice shared that she was confident with the science content and felt comfortable with students asking her related questions.

In the end, Denice's response to the CASES curriculum was that it was an additional resource for her to use. She is already implementing hands-on activities and the CASES lessons also provide hands-on lessons for students. "I was able to use it along side with our curriculum but I didn't like using it alone. I liked the hands-on things and they had hands-on activities so it was another resource for me" (CI).

Final Interview and Instruments

The instruments used at the beginning of the research were once again administered to Denice. The instruments included the STEBI-B instrument, the VNOS: views of the nature of science and the VOSI; views of scientific inquiry. The administration of these instruments at the end of the research was done to consider any changed in the teachers ideas regarding scientific inquiry, the nature of science and their self-efficacy beliefs related to inquiry and to compare the results with the initial instruments.

STEBI B Instrument

The STEBI-B instrument was administered to Denice a second time at the end of the research. This instrument has previously suggested that self-efficacy is a construct that can help to understand attitudes about the teaching of science and can show changes in self-efficacy over time (de Laat and Watters, 1995). The STEBI-B instrument is used to find teachers' self-efficacy beliefs regarding their ability to teach science. The instrument is divided into two specific areas: Outcome Expectancy and Personal Science Teaching Efficacy Belief. De Laat and Watters found "high outcome expectancy was related to having personally experienced success in science and with science teaching" (p.454). They also indicate that personal teaching efficacy is related to teacher beliefs regarding their own ability to teach. The overall increase in Denice's self-efficacy beliefs could be related to the time dedicated to teaching science in her internship site. "If elementary science education is to be improved, elementary teachers must be willing to devote more time and energy to this curriculum" (Enochs and Riggs, 1990, p. 4). It seems that the time factor or the amount of time she spent teaching science could be one reason for Denice's increased self-efficacy. See Table 13 for Denice's STEBI-B results.

Table 13 - Denice's STEBI-B Results

	Outcome Expectancy	Personal Science Teaching Efficacy Belief
Initial Instrument Scores	40	53
Final Instrument Scores	42	58

Denice's self-efficacy beliefs did increase during the time of this research. Her outcome expectancy was initially 40 and increased to 42. The Outcome Expectancy aspect of the STEBI-B assesses the pre-service teacher's beliefs regarding her ability to impact student learning of science. Regarding the Personal Science Teaching Efficacy belief, Denice increased from 53 to 58. In the final results of the STEBI-B instrument, Denice's scores were above the mean score established by Enoch and Riggs (1990) when they developed this instrument. The Personal Science Teaching Efficacy Belief Scale had a mean score of 47.00. Denice scored 58.00 on the final instrument indicating her efficacy beliefs are above average in consideration of previous research on pre-service teachers. In fact, Denice's PSTE beliefs were above average at the beginning of the research and increased during the research. Her Science Teaching Outcome Expectancy Scores were above the average score of 36.19 for pre-service teachers. Denice scored 42 points indicating that she believes her teaching has impacted students understanding of science content.

Denice, on the initial STEBI-B instrument, felt that she would use more activity based instruction than text-book based presentation. At the end of the study she felt that she would spend her science instruction time using an equal amount of text-book based presentation and activity-based instruction. This change in thinking was notable in her teaching efforts as she prominently used the textbook.

Views of Nature of Science (VNOS-E)

The Views of the Nature of Science instrument sought to provide insight regarding Denice's ideas of nature of science. Although the nature of science was not a direct focus of this study, many of the ideas are connected with scientific inquiry and, therefore, may be influenced in this research. This instrument targets several important aspects of the Nature of Science including that science is tentative, empirically based, subjective, the product of human inference and creativity and culturally embedded (Abd-El-Khalick, et al., 2001). In addition, researchers have also distinguished between observation and inference, stated that there is not one scientific method and explored the differences between scientific theories and laws.

At the end of the research, Denice still displays a good understanding of the tentative nature of science. In the initial interview she indicated that science was not concrete and the final instrument her response was that it is "ever changing". Her overall beliefs about science, indicate that it is "the study of how and why things happen the way they do". This response appears to express the idea that science is a process for the development of knowledge but does not address science as a body of knowledge. She briefly explained that science is different than other subjects because it is changing. This view does not consider that science relies on data that should be collected in a systematic and organized way but touches on the tentativeness of science. She does not address the methods for doing science. When asked her thoughts on changes in scientific knowledge, Denice responded again that scientific knowledge may change in the future. Here she noted the example of Pluto which she also referred to in the initial instrument. This answer displays some understanding of the tentative nature of science but does not address the possibility that scientists may also look at data in a new way.

Denice explained that scientists understand dinosaurs existed because of fossils. She said scientists make their best guesses but they were not 100 percent sure about how they looked. In reality the fossils would be evidence or data to provide the existence of dinosaurs but the scientists had to make inferences based on the data collected or observations of the fossils. Denice's answer does not adequately address observations and inferences but appears to understand that the fossils would provide evidence.

The questions related to dinosaurs also address how the development of knowledge involves human creativity and subjectivity. Denice does have some understanding of the ways that scientists interpret data and recognizes that different factors can influence their scientific activity. Different scientists "interpret this information using their own experiences which makes each person different" (PInst).

Regarding an understanding of a scientific model, Denice did not clearly connect the terminology. "The concept of a model is "the standard way of questioning and finding results." The aim of the question was to show understanding of inferences and that scientists create a model based upon observations. The model uses observations and goes further with inferences to make a copy of nature. Inferences and models are used when scientists do not have access to all aspects of scientific phenomena and must make educated guesses based upon the available information.

Denice did demonstrate understanding of creativity in science. “They can use their imagination during the questioning, planning and the interpretations” in science (PInst.). In the interview, Denice gave an example of grafting a tree. She explained that creativity was used in questioning and planning because you are thinking and questionings to begin to wonder what might happen in this situation. Creativity is part of the plan because you must decide how to go about the investigation. In the interpretation of data she said, “They might not know all the details because you can’t see everything that happens so they just use their experiences and their best thoughts to figure it out”

<u>Views of Scientific Inquiry Elementary School Version (VOSI-E)</u>

The Views of Scientific Inquiry – Elementary School Version (VOSI-E) instrument looks at a person’s views regarding inquiry. Less developed views regard the scientific method as the one way to conduct science. Denice indicated that scientists “find reasons of why things happen, cures to problems and create new investigations, doing their work through many tests and repeated experiments”. This answer would be considered naïve view as it directly relates experiments to the way of doing science and does not consider the broader ways that science can be conducted.

When provided with an example of a scientist observing birds, Denice thought it was scientific because “part of science is observation”. She further believed that it was not an experiment because “she was not testing anything. She was just making an observation” (Pint). This view indicates a belief that an experiment is scientific but that observations would not be sufficient to qualify as scientific. The example can be considered scientific because it involved repeated observations, the establishment of a pattern and an inference based upon the observations.

In the final interview, Denice was questioned about scientific inquiry. She said that she understands more of what it is and how to lead the students into it, “They learn by doing instead of just teaching [lecturing?].” Regarding the steps or an approach, she said, ”I think it is hands-on activities and then them [students] questioning why it happened.” In regards to her own teaching and how it was scientific inquiry, she responded, “the only thing we have done is the one science unit but we classified, learned about doing an experiment. Scientists do the same thing, classify research and test theories.” In the interview, Denice also explained about doing science, “In a sense they need to go by the scientific method but they have some flexibility depending upon who they are and what they do. With kids they do need to use the scientific method.”

Overall Summary

A review of data collection from Denice indicates that she is excited about teaching science. She had positive attitude about teaching science and generally felt that her science lessons were successful. She also seemed to be pleased that the children enjoyed interacting with the materials in the lessons. Her self-efficacy beliefs as demonstrated in the STEBI-B instrument showed a positive increase indicative of her belief in her own ability to teach science. Enochs and Riggs (1990) believe these high self-efficacy beliefs relate to teacher’s perceived ability to teach science.

In her expectations of scientific inquiry in teaching, she emphasized questions and communication as key but did not consider other aspects of inquiry to a great extent. Many of the lessons she planned did include these inquiry components. On the other hand, she did not really expect or request children to collect data and explain evidence and justify their thinking in most lessons that she planned. The National Research Council has identified five features of inquiry that they recommend to help support students development of science content and their understanding of inquiry practices (2000). More of the features of inquiry were present in her CASES lessons, especially the ones that aligned with the curriculum. Denice specifically used scientifically oriented questions, data collection and communication on a regular basis in her CASES lessons.

Denice emphasized hands-on activities with children but she did not move beyond the hands-on activities to allow children to construct understandings through discussions and explanations of what occurred. Crawford (1999b) emphasized this important aspect of inquiry that moves it beyond hands-on. “The reforms explicitly ask teachers to change their teaching by shifting the emphasis from the textbook to exploring questions that are students centered and can be answered empirically” (Crawford, p. 3). In the lessons Denice created and even in the implementation of the CASES lessons, Denice still kept the textbook as a central focus of information for students. She did not allow for discussions, justifications or gathering of information to allow students to reach this information on their own terms. Denice’s views emphasized in the interviews and in the enactment of lessons focused on the sharing of information with students instead of their own construction of that knowledge. Although using resources to support learning in scientific inquiry, Denice did not appear to be using the textbook and other resources in this way. She appeared to be using them to demonstrate the correct answer associated with science. In the second CASES unit, Denice did appear to lower the amount of textbook usage. The focus on the textbook for learning and gathering scientific knowledge is not aligned with the changing emphasis for science learning through investigations (NRC, 1996).

Denice did not discuss previous involvement with inquiry in her coursework although she indicated she understood the concept. She seemed to equate hands-on activities with inquiry and felt that the lessons that she implemented were sufficient. Crawford (1999b) states, “Inquiry should not be confused with merely providing students with a series of hands-on activities. Instead teachers need to meld inquiry activities with constructivist-oriented discussions to facilitate students building on their current knowledge and revisiting their understandings” (p.6). She did not seem to have a full grasp of the concept of scientific inquiry and expressed the scientific method as important for children to follow when doing science. This narrow view of inquiry may have impacted her teaching, especially as she equated hands-on activities with inquiry and felt that she was sufficiently teaching in this way. Also, her views of the nature of science could impact her implementation of lessons. Her overall understanding of how scientists come to understand phenomena is not recognized in her teaching as she appears to want students to come to one correct conclusion in her lessons. Akerson et al. (2007) emphasized that teachers need strong views of the nature of science in order to teach through scientific inquiry. She does not emphasize the process of coming to understand science and allow children to grapple with ideas to develop understandings.

She was developing her abilities to manage students in the classroom and in the science classroom. Her general pedagogical skills were developing along with her pedagogical content knowledge in teaching science. Denice focused on her own teaching skills and requested feedback after each of the lessons regarding what strategies might support her development of classroom management. She did not pursue feedback regarding the content of what she did or the actual implementation of the science aspects of the lessons. Denice shared that this project allowed her to teach science and to gain experience in teaching. She also emphasized that her teacher and I were supportive in her development of general teaching strategies (CI).

Denice indicated on the STEBI-B instrument that she thought a combination of hands-on activities plus textbook instruction with more hand-on would be appropriate for her teaching. In the lessons that she taught, she emphasized the use of the textbook as a support for students and as a way of providing information to them. In each of the lessons Denice developed herself to teach, she used the textbook. Generally, in these lessons, students would read round robin from selected text pages (PCL-2, PCL-3, and PCL-4). The focus of her lessons demonstrate the presentation of scientific knowledge through the text instead of providing opportunities for scientific inquiry and discussions to develop science understandings as promoted through the standards (NRC, 1996).

Overall, Denice was able to implement a number of inquiry strategies in her CASES lessons. She was confident at the beginning of the research in her abilities to teach science. Therefore, she may not be looking for additional support in her science teaching. She is struggling to find a balance between textbook instruction and activity- based learning. If she resolves her ideas about how inquiry practices versus textbook orientations impact her teaching, she will increase her use of the five essential features in her lessons. She also does not sufficiently understand scientific inquiry to have confidence in the process. This may be based in her lack of understanding of how children construct their scientific understandings of content, leading to her use of external support in the form of the textbook to develop understandings. Her pedagogical content knowledge was demonstrated in her ability to include various approaches to learning, her understandings of student misconceptions and her use of numerous representations that were effective in teaching. It did appear that Denice was moving towards more inquiry methods in the second CASES unit. This additional teaching experience using inquiry may support additional understandings of inquiry.

CHAPTER 7
DISCUSSIONS AND IMPLICATIONS

This chapter includes an integration of previous research with the findings of this study to provide a view of how three early childhood teachers developed in their ability to teach science. The expectations for teachers outlined in the standards include that teachers will teach science through inquiry methods (NRC, 1996; NRC, 2000; NSTA, 2003). Numerous influences that impact a teacher's ability to teach scientific inquiry are considered in light of the research questions. The specific focus in this research was to explore the extent to which pre-service teachers overcome issues related to content knowledge, pedagogical skills, pedagogical content knowledge, and the nature of science in order to teach science inquiry. Each individual case study was unique and provided a rich source of data on how pre-service teachers teach science in the beginning stages of their teaching careers.

This chapter begins with an overview of significant findings from this research. Next, the research is summarized according to the research questions. Based upon the summary of findings, important factors emerged regarding pre-service teachers' abilities to teach inquiry science when using educative curriculum supports. Additional findings are also discussed. Next, will be a discussion of the limitations of this study and implications for future research. The chapter will end with concluding remarks.

Significant Findings

This study contributes to the growing research on the use of educative materials to support teachers in science instruction. This research had three significant findings that impact our understanding of how pre-service early childhood teachers use educative curriculum materials to support their science teaching. First, educative curriculum materials supported all three pre-service early childhood educators in this study to use scientifically oriented questions, evidence gathering and communication. Second, the pre-service teachers in this case study were impacted in their ability to enact the educative curriculum materials by their own perceptions and conceptions regarding science and science teaching. The teachers with naïve conceptions about scientific inquiry and the nature of science lacked an understanding of the rationales behind the curriculum and were less likely to enact the materials as intended. These teachers adapted the materials to align with their own teaching style. Thirdly, the study suggests several specific changes that should be made to educative curriculum materials that would make them more supportive of early childhood teachers and subsequently; young children.

Educative Curriculum Materials Support Scientific Inquiry Practices

The CASES educative curriculum materials supported these pre-service early childhood educators to use scientific inquiry in their internship locations. The National Research Council (1996; 2000) has identified five essential features of inquiry. These features include: engaging in scientifically oriented questions, gathering evidence, developing explanations based on evidence, evaluating explanations in light of alternative explanations and communicating and justifying proposed explanations. Out of these five features, three were regularly implemented into the CASES lessons taught by the pre-service teachers: scientifically oriented questions, gathering evidence and communicating explanations.

Previous research about teacher’s ability to teach science inquiry showed that it was difficult for many teachers to make the transition toward a more inquiry-oriented approach (Plevyak, 2007; Weiss, et al. 2001; Windschitl, 2003). Davis, et al. (2006) indicated that because pre-service teachers had unsophisticated understandings of scientific inquiry they may have difficulties moving toward inquiry practices. Since past research has confirmed the difficulty for teachers in their abilities to teach inquiry and the CASES lessons included numerous features of inquiry, we can conclude that the educative curriculum materials were a factor in the support of these teachers ability to move towards more inquiry oriented practices.

Influences on Teacher Practice

Teacher beliefs and understandings about science and science teaching impact their classroom practices. These underlying beliefs develop through past experiences with science in society, in the K-12 classroom, in college and in any other related experiences. These beliefs will impact the curriculum materials teachers select and how they enact curriculum (Forbes and Davis, 2007a; Remillard, 2005). Additionally related to teacher beliefs are the teacher's understandings of the nature of science. The perspectives of the nature of science are associated with the broad picture of how science is done and specifically science inquiry. Teachers with more informed views of the nature of science will more likely implement scientific inquiry.

Lotter, Harwood and Bonner (2006) explored core teaching conceptions which influence teachers' beliefs and practices in science. Their findings indicate that teachers with different levels of the core teaching conceptions will teach in different ways including the level of inquiry teaching. The four core conceptions outline by Lotter et al. include science processes vs. collection of facts, purpose of education, beliefs about students and beliefs about effective teaching. Within these four areas, teachers with a more traditional view believe that students learn science facts delivered by the teacher as opposed to a view of students involved in thinking processes and inquiry to gain science knowledge. The core conceptions outlined by Lotter et al. also correlate with research by Porlan and del Pozo (2004). Porlan and del Pozo indicate that teachers fall into one of three categories for teaching: traditional, technical or alternative. Again they emphasize that teaching practices are aligned with these underlying beliefs. Two of the teachers in this study adhered more closely with a traditional approach and therefore found it more difficult to implement practices different from those beliefs such as inquiry. Therefore, it would be beneficial to support teachers in the development of teaching orientations that align with scientific inquiry as recommended by Petish (2004).

Since teachers do bring their own set of beliefs to their curriculum enactment in science, curricular materials should also explicitly explain the purpose of design features. Previous research by Davis and Krajcik (2005) and Forbes and Davis (2007a) emphasize the need for the explanation of curricular rationales in curriculum materials. They emphasize that teachers do participate in decision making regarding the enactment of curriculum and therefore the provision of rationales could support teachers' enactment. Two teachers in this study appeared to use the individual lesson plans in planning one lesson at a time instead of the broader perspective of planning the unit. Schneider and Krajcik (2002) had similar findings which indicated teachers used the curricular supports embedded within lessons instead of broader supports included in additional materials.

Teacher's views about the nature of science impact their underlying beliefs about science and science teaching. Akerson, et al. (2007) explains that teachers possess misconceptions regarding the nature of science which "present barriers to effective science teaching" (p. 752). They further explain that improved nature of science can be reached by allowing teachers to experience science through inquiry using an "explicit-reflective NOS approach" (p. 769). Akerson et al. further clarify that explicit-reflective instruction involves making connections clear after different activities to strengthen nature of science understandings. Akerson et al. indicates that without appropriate views of the nature of science, teachers may have difficulties conducting scientific inquiries. More explicit teaching of the nature of science would support an understanding of science and how science is conducted including scientific inquiry and therefore lead to a closer alignment with inquiry practices.

<u>Educative Materials Refinements</u>

While this research did find that the educative curriculum materials supported these teachers in the teaching of scientific inquiry, it was apparent that the materials could have further supported the pre-service teachers. Specific adaptations of the materials could support these teachers and also help young children to be more successful in scientific inquiry. The adaptations that would be beneficial for pre-service early childhood teachers include: a rationale for curriculum methods, classroom management strategies, and a focus on guided inquiry practices.

Research from Petish (2004) emphasized that teachers used the curriculum materials in ways that did not support their interaction with certain educative features including curricular rationales. Therefore, they did not get the benefits of those curricular supports. Davis and Krajcik (2005) have identified the following curricular supports in educative materials: student alternative ideas, background knowledge, broad curricular picture and curriculum goals, pedagogical reasoning behind curriculum and pedagogical design capacity. The CASES curriculum units have outlined educative supports including Use of Inquiry Practices, PCK Instructional Strategies, PCK Curricular Rationales, PCK Alternative Ideas and Subject Matter Knowledge. This research confirms that a revision of materials to include support structures within the lessons would be beneficial to the teachers in this study.

Classroom management was another factor that should be better supported through the curriculum materials. Two teachers in this study struggled with the management of the more active nature of science inquiry. Davis et al. (2006) emphasized that management issues could impact teaching practices. Also, Pippa questioned the management of specific aspects of the lessons and sought guidance from her teacher and myself to consider the best approach since she did not get sufficient information through the curriculum materials. These factors could be directly related to the pedagogical skills of beginning teachers but could still be addressed through educative curriculum materials. Hudson (2004) discussed numerous aspects of pedagogical knowledge that support new teachers in teaching science including planning, timetabling, preparation, implementation, classroom management strategies and questioning skills. These skills directly correlate with issues that the pre-service teachers had in their teaching of science inquiry and could possibly be supported more through the curriculum. Therefore, if educative materials were to be more supportive of pre-service teachers they should include more features that address pedagogical teaching skills to support growth in this area.

Science inquiry curriculum materials designed for young children should be developed using a guided inquiry format. As previously stated, Gado (2005) questions the ability of young children to participate in open inquiry. He believes that open inquiry-based activities may be developmentally inappropriate for first and second grade students. “The degree to which teachers structure what students do is sometimes referred to as ‘guided’ verses ‘open’ inquiry (NRC, 2000, p. 29). These distinctions are made according to the degree of control or responsibility the students have in regard to asking questions, developing investigations and communicating their findings. Guided inquiry indicates that the teacher has more control in the structure of the lessons and in open inquiry the students gain more control in the overall inquiries (NRC, 2000). All of the teachers in this research used guided inquiry in their CASES lessons, they did not move beyond guided inquiry into more open inquiry activities where students have more control. In a review of the research by Keys and Bryan (2001) they indicated that around 11 years of age, children can do experiments similar to how scientists would do them. They also believe that children can be engaged in all aspects of inquiry at a younger age. The question that remains involves young children's ability to participate in guided verses open inquiry activities. Curriculum materials that base units on guided inquiry may be most appropriate for young children.

Research Question One

> Research Question: How will educative materials impact pre-service early childhood education students' content knowledge including their understandings of specific science concepts and the nature of science?

To answer this research question I begin with an overview of how the pre-service teachers used educative curriculum materials and the impact of those materials on their classroom practice. We then move to data related to their content knowledge related to the content they taught and the nature of science. Evidence from this research indicates that teachers are able to overcome a lack of content knowledge to support their science teaching efforts. Teacher's understandings of the nature of science should be addressed explicitly to have a stronger impact on teachers and teaching practices.

Impact and Uses of Educative Curriculum Materials

Teachers' views about the nature of science largely determine how they teach science in their classroom. "The teachers' views of how scientists construct knowledge were consistent with their beliefs about how students should learn science" (Brickhouse, 1990, p. 59). In this research, there were some variations among the pre-service teachers regarding their views about science and their views about how to teach science that had implications for the way that they enacted science lessons. Pippa advocated a constructivist approach to learning and emphasized the thinking aspect as outlined by Brooks and Brooks (1999). Her views of scientific inquiry and the nature of science seemed to be the most developed. Although not considered fully developed, she did begin to uncover and question her own underlying beliefs that are not aligned with the nature of science and inquiry. Based on research from Akerson et al. (2007) Pippa had more informed views which therefore relate to her abilities to conduct science inquiry. Pippa's practices or enactment of the lessons was closest to the curriculum materials. Denice and Alexis had misconceptions related to the nature of science and to scientific inquiry. It appears that their ideas are still developing and thus could be an influencing factor in their overall implementation of the CASES lessons.

The pre-service teachers used the CASES curriculum materials in a variety of ways including using them out without use of the resources on the website and adding additional science content from other sources. The ways materials were used contributed to their enactment of lessons and further to their development as teachers of science in this research. Davis and Forbes (2007) state, "Curriculum materials possibly exert the most direct influence on day-to-day classroom activity in which teachers and students engage" (p. 2). The CASES curriculum materials did prove to be influential in science teaching practices. However, Denice also had other curriculum materials available to her which she used and integrated into her plants unit. The science textbook influenced her teaching of the first unit. Petish (2004) confirms that teachers tend to rely on curriculum materials to guide instruction, since Denice had additional curriculum materials they were also used in her lessons. She enacted the second unit of the CASES curriculum in ways which were more aligned with the actual curriculum. Pippa implemented the CASES curriculum in ways that were aligned with the intention of the materials. She did not appear to experience conflict regarding the implementation. Alexis was constrained in her use of the materials by time and classroom management. Science was not a priority in her class but integrated into the broader learning goals of circle time. She took away from other content areas to accomplish the lessons that she did teach. She also looked to find lessons that would fit into the time frame, which further influenced her enactment of the curriculum. Thus causing her to disregard the overall building of ideas through the curriculum, instead, picking and choosing lessons that fit her criteria.

Science Content Knowledge

Previous research has indicated that science content knowledge is one area of concern for elementary and early childhood teachers resulting in science not being taught or being taught in ways that may not allow children to develop conceptual understandings (Davis et al., 2006; Ekborg, 2005; Harlen and Holroyd, 1995). Content knowledge was an issue to some extent with the pre-service teachers in this research. All teachers mentioned needing more background information and knowledge when preparing and implementing science lessons. This lack of content knowledge was especially apparent in their pre-CASES lessons. Alexis's and Pippa's pre-CASES lessons were developed on physical science topics which could have been an influential factor. Previous research has shown that physical science is one content area that teachers feel they need additional support (Harlen and Holroyd). Denice, in her reflection questions, mentioned that she needs support in all areas of science content because she was not knowledgeable about science content.

The CASES curriculum appeared to be supportive of these pre-service teachers to some extent in their teaching of the CASES lessons. All teachers indicated that they did use the background knowledge developed for each specific lesson in the CASES unit. Pippa and Alexis indicated that they went beyond the information provided in the CASES curriculum to research additional information on their own. In her first teaching unit, Denice explored additional resources to gain content knowledge. She did, however, indicate that the CASES unit on electricity provided her the information she needed and that she felt confident with the content. Research by Smith (2007) found that teachers were able to learn the content needed to implement science lessons.

Although the teachers expressed an understanding of the content related to the topics they taught in the CASES lesson, they did not fully explore the CASES website which did have additional supports for background knowledge development beyond the specific lessons. The most common practice among these teachers was to initially look through the CASES website and then to focus on the particular unit they were going to teach. In most cases, the pre-service teachers printed the full unit and did not use the website beyond that. The use of the curriculum materials influenced the amount of background knowledge that was accessible to each teacher and was limited to the background information shared in lesson plans. Petish (2004) also found that the way teachers used the curriculum materials was a factor related to changes in knowledge and practice.

Although these teachers did indicate a need to improve their science content knowledge in this study, they also felt like they were able to accomplish that. To some extent, the CASES curriculum did support this development of science content knowledge.

<u>Influences on The Nature of Science</u>

Teachers should develop more sophisticated views of the nature of science so that they understand the significance of science as inquiry instead of science as a collection of facts (Schwartz, et al., 2003). The notion of the nature of science regards the underlying assumptions regarding scientific knowledge. Without this underlying knowledge the image of science passed on to students will also be limited. Keys and Bryan (2001) indicate that “teacher’s beliefs about the nature of science as an objective body of knowledge created by a rigid ‘scientific method’ impede their teaching of an accurate view of inquiry" (p. 635). The changes in views of the nature of science for these three teachers were minimal. The interviews with the pre-service teachers at the end of the research, was clearly indicative of their lack of advanced understandings of the nature of science. The conclusion that teachers have many misconceptions regarding the nature of science correlates to previous research (Akerson, et al. 2007). All three teachers felt that the research had not directly influenced these understandings. To some extent they seemed unfamiliar with the terminology and concepts related to the nature of science but other areas seemed to be understood. The teachers did understand the tentative nature of science and the involvement of creativity.

Students learn about the nature of science through the inquiry-oriented instruction (Flick, Lederman and Enochs, 1996). There was a connection between the type of inquiry practices and the understanding of certain areas of the nature of science. In this research, it would seem that specific aspects of science inquiry teaching practices was supportive in some areas of nature of science understanding for the participants. All three participants did grasp the tentative nature of science and realized that creativity could be a component of science. Denice and Alexis were unclear about their understanding of inquiry and their views of one scientific method verse multiple methods of doing science. By the end of the research, Pippa had a clearer vision of scientific inquiry and came to realize that children were involved in inquiry in different ways. She came to believe that there was not one specific way that science teaching should be performed. Research from the National Research Council (NRC, 2000) supported the belief that teachers can develop understandings of scientific inquiry "as they investigate with their students" (p. 137).

Specific experiences can help teachers to gain more mature views of the nature of science (Akerson and Hanuscin, 2007). While this study did not allow for the pre-service teachers to engage in inquiry with scientists, they did have the opportunity to use inquiry during their implementation of the CASES curriculum. Schwartz, et al. (2003) outlined ways to support teachers in improving their nature of science based upon their research. They found that just 'doing' science was not sufficient to improve nature of science beliefs but reflective activities and discussions did contribute to a more informed view of the nature of science. Related to this current research, teachers did reflect upon their teaching of inquiry in the CASES lessons. Reflection questions provided a platform for the pre-service teachers in this study to consider their own thinking and ideas of science and science teaching in a more direct format. The following questions were more specifically related to the nature of science and helped the teachers to consider their own beliefs: What is the difference between hands-on activities and inquiry? What aspects of the lesson involved inquiry? How can you support inquiry in your teaching? These questions were designed to have the teachers consider their beliefs and understandings of scientific inquiry, what it is and if it was occurring in their science teaching. A stronger emphasis on the nature of science and more explicit teaching of the nature of science as advocated by Akerson et al. (2007) would be appropriate for these teachers.

Question one focused on how educative curriculum materials were supportive of teachers' content knowledge and their understandings of the nature of science. Evidence from this research demonstrated that educative materials can support teacher's science content knowledge. Teacher's understandings of the nature of science should be addressed explicitly to have a stronger impact on teachers and teaching practices.

Research Question Two

> Research Question: How will educative curriculum materials impact pre-service early childhood education student's pedagogical content knowledge related to inquiry methods?

In considering the second research question, I looked to the data to provide insight into the pre-service teachers' pedagogical content knowledge and the evidence of scientific inquiry in their teaching practice as well as their reflections and understandings of scientific inquiry to create a picture of how educative materials were supportive in these areas. The teachers in this research were supported in their developing pedagogical content knowledge. At the same time, research shows that PCK develops over time and through experiences (Lee et al., 2007). Scientific inquiry practices were demonstrated more in the CASES lessons than in the pre-CASES lessons. Some aspects of scientific inquiry appeared to be easier to implement for these pre-service early childhood educators.

Pedagogical Content Knowledge

Educative curriculum materials provide supports for teachers in the area of pedagogical content knowledge. The three teachers in this study did show improvements in this area. Pedagogical content knowledge is a combination of a teacher's background and understanding of the science content mixed with his/her teaching strategies for teaching science that result in specific strategies that are supportive of children's learning in science (Dickerson et al. 2007; Park and Oliver, 2007). PCK takes time and teaching experiences to become highly developed (Lee, et al., 2007). The pre-service teachers showed development of PCK in the area of knowledge of student learning and knowledge of instructional strategies during this research.

The teachers also benefited from the support provided on student alternative ideas and their personal efficacy beliefs related to teaching science.

The three teachers in this study all mentioned a need for content knowledge development but also felt they accomplished an understanding of the content necessary to support their teaching practices. Science content knowledge is one aspect of a teacher's pedagogical content knowledge and so it considered in relation to the larger picture of PCK (Dickerson, et al., 2007). Both Pippa and Alexis in their pre-CASES lessons noted that they were learning the curriculum and that it impacted their preparations and lessons. During the CASES implementation, Denice, Pippa and Alexis used the plants unit and the issue of content did not seem to be as significant. This may be due in part to the background information provided in the CASES curriculum as well as the general higher comfort level that has previously been reported by teachers in the life science areas (Harlen & Holroyd, 1995). All of the pre-service teachers did indicate that science content knowledge was an issue for science lessons taught but indicated that they were successful in learning the content related to the CASES science lessons they taught. Therefore, teachers in this research indicated the content knowledge aspect of pedagogical content knowledge was sufficient to support the CASES implementation. The conclusion here is that although science content knowledge is a factor regarding PCK, teachers may overcome a lack of content knowledge in their science teaching. Smith (1999) reinforced the idea that teachers recognized the need for stronger content knowledge to teach science and can develop that knowledge during their teaching internship and experiences.

The five components of pedagogical content knowledge include: orientations to science teaching, knowledge of students' understanding in science, knowledge of science curriculum, knowledge of instructional strategies and representations for teaching science and knowledge of assessments of science learning (Park and Oliver, 2007). Previous research by Lee et al., 2007 showed that beginning science teachers had limited or basic proficiency levels in pedagogical content knowledge. Classroom experiences over time supported the development of a teacher's pedagogical content knowledge. Park and Oliver further clarify that they found two dimensions of PCK including understanding and enactment. Therefore teachers develop their understandings as they enact classroom practices. They also found that pedagogical content knowledge was very complex and is often difficult to categorize because encompasses several different aspects of a teacher's knowledge. While being a difficult concept to capture, it is an important consideration in supporting teachers' efforts to enact curriculum aligned with the science standards. This research finds evidence of the impact of educative materials on these pre-service teachers' pedagogical content knowledge.

Lee et al. (2007) developed rubrics to assess teachers' PCK in the areas of Knowledge of Student learning and Knowledge of Instructional Strategies and Representations. These rubrics were supportive in taking a closer look at the pre-service teachers involved in this study. In the area of knowledge of student learning in science, the goals are for teachers to understand student's prior knowledge, their variations in approaches to learning and their difficulties with specific concepts. The rubric for knowledge of instructional strategies considers a teacher's ability to adopt science-specific strategies for instruction especially scientific inquiry and representations that are effective, accurate and linked to students' prior knowledge (Lee et al.).

Knowledge of Student Learning. For the category of *knowledge of student learning* in science, Lee et al. (2007) identified student prior knowledge, variations in students' approaches to learning and difficulties with specific science concepts. The initial questions from the CASES units provided an avenue for teachers to informally assess prior knowledge. In one lesson, Pippa asked students to think about why she had a plant in her yard that she didn't plant. Student ideas gave some indication of their prior knowledge regarding how seeds move. Alexis and Pippa both recorded ideas from students about how to sort seeds. Denice did begin a number of lessons with the lesson question which served to have students share ideas about the topic. She also included a KWL chart in her initial lesson of the electricity unit. These activities were built into the CASES curriculum; their use indicates the curriculum was supportive in this area of PCK. The demonstration PCK for knowledge of student learning would be in the basic to proficient levels identified by Lee et al.

A second aspect of the PCK category explored by Lee et al. (2007), *knowledge of student learning,* was the variations in how each student approaches learning. This aspect of PCK considers different approaches to how teachers allowed children to investigate and learn in various ways. The CASES curriculum engaged students in a variety of ways, thus allowing the teachers to use a variety of approaches to student learning. Some strategies built into this curriculum include: drawing, writing, discussion, science journals, hands-on activities, kinesthetic activities, use of materials and scientific tools. These strategies were mainly completed in small or large groups. Denice and Pippa created science journals for their students in the units they taught (plants and electricity). The science journal included a place for students to record what they did through writing and drawing. All teachers included discussions and hands-on activities. According to the rubric developed by Lee et al. these teachers were at the basic to proficient level when using the CASES curriculum.

Pippa indicated the CASES curriculum supported students in revisiting ideas from the content and the lessons built on each other as students progressed in the unit. The curriculum also revisited the same concepts in different ways throughout the lessons. She was the only participant to express the building nature of the curriculum associated with this aspect of PCK. This construction of knowledge is aligned with the previous research from Yoon and Onchwari (2007) which recognized that each child interacts with their environment in unique ways and therefore builds understandings over time and through experiences.

The last area of the PCK category, *knowledge of student learning* was students' difficulties with specific science concepts (Lee, et al., 2007).This aspect was more difficult to observe during the CASES implementation but was brought up in the CASES implementation interviews. All teachers indicated that the Alternative ideas support in the CASES curriculum helped them to understand what students responses might be so they would be able to address their ideas. Pippa added that she looked at the perspectives of the children when preparing to teach the lessons. The CASES materials seemed to be supportive in this area for the teachers.

Knowledge of Teaching Strategies. Specific PCK *teaching strategies* associated with the knowledge of instructional strategies are again aligned with scientific inquiry (Lee, et al., 2007). Beginning teachers may lack a collection of instructional strategies to engage students in science and inquiry practices. Davis et al. (2006) emphasized that many pre-service teachers have unsophisticated understandings of inquiry which would not facilitate teaching with this approach. Since some of the teacher orientations for science were inconsistent with inquiry, these practices were not fully implemented by all the pre-service teachers. Beyond scientific inquiry, all teachers implemented various teaching strategies guided by the CASES materials. The teachers had students work in whole group and small groups; they also included discussions that supported understanding in science.

Additionally, PCK *instructional strategies* were used to support children's representations of their science understandings (Lee, et al., 2007). These teachers included class charts, student journals, writing and illustrations, diagrams, class presentations and other avenues that supported multiple representations of science content. These representations allowed students to express their understanding of content. According to the rubric developed by Lee, et al., most teachers were at the proficient level in this area.

Pippa was the teacher who demonstrated the most sophisticated level of PCK in her teaching. She taught through an inquiry and guided inquiry orientation. She appeared to be able to integrate and consider the students' learning and understanding throughout her implementation of teaching. In some cases, adapting or adding additional activities that supported children's learning. These adaptations were aligned with the purposes of the curriculum and fit with what Forbes and Davis referred to as the teachers' "ability to mobilize and requisite resources, including personal resources and external curricular tools, to craft learning environments in light of identified goals or objectives" (2007a, p. 4). She demonstrated high levels of pedagogical content knowledge in this regard.

Park and Oliver (2007) have added to the previous research on pedagogical content knowledge and added a new dimension: teacher efficacy. They explain that efficacy is linked teacher understanding and enactment. Ginn and Watters (1999) has indicated that some factors can contribute to self-efficacy beliefs and that support the development of these beliefs. These include: successful teaching experiences and the level of support and reinforcement from other teachers. This increase is further emphasized by deLatt and Watters (1995) who state, "People are reassured by success, especially if that success is repeated and generalized across similar situations" (p. 461). All pre-service teachers spent time implementing science lessons; they all felt successful in their implementation and their self-efficacy beliefs increased during this research. Related to self-efficacy beliefs is the amount of time spent on teaching science (Enochs and Riggs, 1990). This research allowed the three pre-service teachers to spend a regular amount of time teaching science. In some cases, science was not taught outside this research so the experience promoted the time spent on science and this could be another factor that impacted self-efficacy beliefs. All teachers indicated that they felt supported in various ways through their science teaching efforts. All of these factors together may have contributed to their improved self-efficacy beliefs related to science teaching.

This research shows that educative curriculum can impact pre-service teachers' pedagogical content knowledge. This may be due to the supports placed in the curriculum materials that address the teacher's content understandings along with an awareness of typical students' ideas on the science topic at hand. The specific pedagogical content knowledge areas that were demonstrated in the CASES lessons include knowledge of student learning in science and knowledge of instructional strategies. These areas were demonstrated at different levels by the teachers in their enactment of the CASES unit. The teachers in this study demonstrated more development in the areas of PCK for instructional strategies. They indicated the use of PCK alternative ideas from the CASES curriculum, but did not seem to fully use the PCK curricular rationales. Also, related to PCK is efficacy beliefs which also increased in this study.

Scientific Inquiry

Although previous research has indicated the difficulty teachers face in implementing inquiry, the teachers in this study were able to integrate a number of features of scientific inquiry into their practice. Pre-service teachers do need support in teaching science and in particular teaching through scientific inquiry (Weiss, et al. 2001). Previous research has shown that "pre-service teachers, given certain caveats and adequate support can feasibly create inquiry-based environments similar to those advocated in the standards" (Crawford, 1999b, p.37). Gado (2005) also advocated for support for early childhood teachers to develop their competence and comprehension of teaching inquiry. The CASES curriculum does provide built-in supports for teaching inquiry. Each of the five features of inquiry is explored below with the consideration of how the pre-service teachers integrated the features into their classroom practice and how the features were specifically addressed in individual lesson plans. The teachers in this research were able to implement a number of the aspects of scientific inquiry into their CASES lessons during this research. These findings align with previous research by Petish (2004) regarding the use of educative curriculum materials: “these materials served to expand these teachers’ repertoire of instructional strategies with regard to inquiry-oriented teaching practices” (p. 200).

Scientifically Oriented Questions. The use of *questions and questioning* is one of the five components of scientific inquiry (NRC, 2000). The CASES curriculum used questions in two ways to support teachers in the inclusion of questioning in the lessons; driving questions focused the each curricular unit while lesson questions focused each lesson. Petish (2004) indicates that the “teacher references a scientifically oriented question and students are expected to engage in this question through journaling or discussion” (p. 222). Each of the CASES units was centered on a driving question. This question helps to connect the different lessons in the unit and serves as a starting point for the curriculum. All three teachers taught using the CASES curriculum unit on plants. Pippa was the only one of the pre-service teachers who attempted to use the driving question as a focus for the unit. On the first day of the lesson, she asked students to look out the window and think about where the trees came from. One reason why Pippa may have integrated this aspect while the other teachers did not may be in part due to her use of the CASES curriculum as she indicated a review of the full unit in preparations for teaching. Research has shown that teacher' interactions with curriculum materials influence enactment (Remillard, 2000).

Each lesson similarly had a *scientifically oriented question* that helped to focus the lesson and its content. These questions are a critical feature of scientific inquiry (NRC, 2000). All three teachers were successful in using the lesson questions in their implementation of the CASES lessons. Pippa used the lesson questions as she introduced each lesson; she also referred to it during the lesson and prompted students to respond to the question at the end of the lesson. This was usually done orally since the students were in kindergarten and not able to thoroughly explain their thinking in writing. Denice emphasized the lesson questions in her lessons from the electricity unit but not as much in her plants unit. There was also some evidence of using lesson questions in pre-CASES lessons that Alexis and Denice taught. The pre-CASES lessons that were taught were guided by each school's adopted science curriculum, so this could have impacted their use of questioning, but the questions were not used consistently in the lessons. The focus of questioning in the CASES lessons was offered in each specific lesson which made it easily accessible for these teachers. The use of a central question and questioning in general were used more in the CASES lessons. The use of scientifically oriented questions is an important component of inquiry and was consistently visible in the CASES lessons. Since the teachers provided the scientifically oriented question, this would indicate a guided approach to inquiry (NRC, 2000) with more teacher directedness (Petish, 2004).

Evidence Gathering. Another essential feature of inquiry was promoted in the educative curriculum was *evidence gathering* (NRC, 2000). Observations and interactions with materials were the main ways that facilitated the feature of evidence gathering. All three pre-service teachers implemented evidence gathering practices during the CASES unit. Denice provided some opportunities for students to gather evidence in her pre-CASES lessons but did this inconsistently. Denice would have students look at plants for a brief moment but did not allow the thorough observations or recording of observations in most lessons. Petish (2004) identifies this type of evidence gathering as unstructured since students do not record data (p. 223).

All teachers in the CASES curriculum did have children gather evidence. Most evidence gathered in the CASES lessons was from observations and also included some classification (Petish, 2004, p. 222). Pippa's teaching practices showed she was a strong advocate for gathering evidence. She also explained to students that accuracy was an important factor in observations and thus encouraged them to make detailed drawings, using the correct colors, etc. "so that if someone else looked at your drawing they would know what you had drawn" (CL-2). Alexis and Denice also had students collect data but did not consistently have them record the information from observations in the CASES lessons. Denice did use the science textbook as a source of information for the students. Denice and Alexis provided information to students that were associated with the content of most lessons. These forms of evidence did not support children in the gathering of evidence as was recommended in the curriculum and as a part of inquiry.

Overall, there was indication of students collecting evidence during the CASES lessons; this was mainly in the form of observational data. Some classification was conducted during the seeds unit, classification is another source of evidence as described by Petish (2004). None of the teachers went further to support students further in analyzing information in the following ways: double check information, repeat experiments or verify accuracy as suggested by the NRC (2000). Consequently, there was some improvement in the area of collecting evidence from the Pre-CASES to the CASES lessons. The curricular supports for evidence gathering was integrated into each specific lesson plan which could be a contributing factor regarding their usage.

Formulating Scientific Explanations. Although we have evidence of scientifically oriented questions and data collection in the CASES curriculum, the area of *making sense* of the lesson is even more vital because the process of making sense allows students to construct their understandings of science content. The development of *scientific explanations* is vitally important in helping students make sense of science and as an essential feature of inquiry (NRC, 2000). The third essential feature of inquiry is learner formulates explanations. The CASES curriculum provides specific guidance for the formulating explanations in the descriptions section of the lessons. All three participants in the research copied this portion of the lessons and did have access to it. Most CASES lessons explained that scientific explanations include a claim and then evidence. They further stated that students should make a claim and then use their observations or data to explain why (CASES website). This feature of inquiry was apparent in lessons conducted by Pippa and Denice. They regularly asked the children to explain why they thought something. For example, when the students indicated they thought a seed would travel by water, the teacher asked, "What was it about the seed that made you think that?" This questioning supported children in their development of scientific knowledge as they sought to consider supports they had for their ideas. Although the practice of asking for explanations was consistent with Pippa and Alexis, it is not clear if this was sufficient to help students develop scientific explanations. The educative features were used to some extent in the lesson but I believe the teachers needed additional support to understand how children develop their scientific ideas and for them to know when and if they needed to intervene with additional information. Findings from Petish (2004) reached similar conclusions regarding teachers' ability to support students in developing scientific explanations. "Each of the teachers in this study faced difficulties in assisting their students in understanding important science principles" (p.

185). Petish attributed this difficulty to teacher's orientations toward science teaching and learning, finding that one teacher felt it was her responsibility to share answers with students instead of encouraging them to develop their ideas in the lessons.

Connect Explanations to Scientific Knowledge. The fourth feature of scientific inquiry that was a part of the CASES curriculum was "*learners connect explanations to scientific knowledge*" (NRC, 2000). In the CASES curriculum this aspect of inquiry was incorporated into the formation of scientific knowledge aspect. This aspect was difficult for Denice and Alexis to implement into their lessons, even the CASES lessons. They were consistent in sharing information with students that would commonly be known as the accepted scientific knowledge of the topics at the start of lessons. This was done in the form of textbooks, literature selections or just brief lectures. Both of these teachers explained the correct answer to students. This teacher directedness in the development of explanations correlates with Petish (2004) as she explains teacher dominates the development of explanations. In the cases of Denice and Alexis they did not provide for the observations of patterns but just provided the information to students. This focus on factual information indicates they were not comfortable with allowing children to construct understandings on their own. The National Research Council (1996) explains that changing emphasis from learning science by lecture and reading to a focus on learning through experiences. During the CASES lessons, Denice did lessen her use of the textbook at the beginning of lessons but consistently included instruction in the form of a mini-lecture or the reading of a textbook to reinforce the concepts in the lesson. Alexis emphasized the belief that students in her kindergarten classroom did not have enough background knowledge to support their efforts to understand different concepts. This may be the reason she chose to include factual information at the beginning of the lessons instead of allowing children to process what they had done to develop their own ideas. The NRC (2000) clarifies that investigations provide the context for developing definitions and the associated science understandings. On the other hand, Pippa was comfortable with allowing her students to construct their knowledge on their own. She did bring in scientific knowledge when it was a part of the CASES curriculum such as the inside a seed lesson where she shared a diagram of the seed and its parts with students at the end of the lesson.

The CASES curriculum did not include the five specific features of scientific inquiry but seemed to combine the third and fourth together. In the CASES units, there is some evidence of specific resources that provide scientific knowledge such as the parts of a lima bean link in the plants unit. It is unclear if the CASES curriculum was designed with the understanding the processes of inquiry are sufficient to develop the content knowledge. The National Research Council in the science standards document has changed the emphasis from "knowing scientific facts and information" to understanding scientific concepts and developing abilities of inquiry" (NRC, 1996, p. 113). This change supports the use of a more constructivist approach that is evident in the CASES materials. Although the processes of scientific inquiry advocate that students develop understandings of scientific content, the CASES curriculum did not supply an integration of factual information into most lessons used in this research but rather through the unit lessons and associated discussions felt that these ideas would build in a more natural fashion. Having students explain and justify their thinking would support a stronger development of the content and could to some extent be based on the CASES lessons and the content developed through them.

Communicates and Justifies Explanations. Communication is the last essential feature of inquiry and one that allows children to communicate their scientific knowledge in various ways

(NRC, 2000). This communication can also support clarification of ideas for the students as they share their ideas with others. All three teachers did include a variety of ways that allowed children to communicate their understandings in science. The facilitation of communication was one area that was prominent in the pre-CASES and CASES lessons. Refinements were noticeable in the CASES lessons regarding communication. In the pre-CASES lessons, Alexis used worksheets and question/answer sessions to allow children to communicate their ideas. In the CASES lessons, Alexis allowed students to share their ideas with the class by talking into a microphone. She also allowed children to share in their groups and to record ideas on charts. Denice included a variety of ways to communicate in her pre-CASES lessons and her CASES lessons. Students used a Venn diagram and worksheets in the pre-CASES lessons and during the CASES lessons, they created KWL chart, used discussions and group presentations. Pippa in her pre-CASES lessons used discussions and a book on turkeys to communicate ideas, during the CASES lessons, she included drawings, verbal explanations in class, class charts and seed charts as ways for children to share their ideas and understandings of the content.

The communication of ideas is also closely connected to evidence and justification, when students communicated ideas in the CASES lessons, most teachers requested more explanations than in the pre-CASES lessons. The aspect of justification of explanations could be explored more fully in the CASES lessons taught in this study. Aspects of communicating explanations identified by Petish (2004) include the sharing of explanations with others, sharing strengths and weaknesses of explanations and creating artifacts to share explanations. In this research, the primary focus was the sharing of explanations and not examining the explanations for validity.

Related to the *communication* feature of scientific inquiry is the understanding that young children may not have the ability to communicate their ideas and understandings adequately.

Fleer and Robins (2003) indicated that young children's thinking is more complex and fluid than regular questioning might reveal. Communication is a critical feature of young children's understandings in science. Because of the limits with young children's communication by their development and culture, it would be beneficial to provide more and different opportunities for them to communicate their ideas in science. Providing unique and creative ways to communicate understandings in science is aligned with research by Fleer and Robins. They believed that children had complex ideas but teachers should provide a variety of formats for communicating them.

The level of inquiry that was observed in this research was guided inquiry (NRC, 2000). Here the students received support from their teacher to implement inquiry practices. Although some higher levels of inquiry were apparent, the majority of lessons were guided by the teacher. The lessons build so that if the units were continued, they would have led to more open inquiry that was student directed. Gado (2005) questions the ability of young children to participate in open inquiry. He believes that open inquiry-based activities may be developmentally inappropriate for first and second grade students.

Beyond the ability to include inquiry practices in teaching, other factors related to inquiry were considered. Teachers having a supportive environment and collegial support were key factors in teachers' ability to teach science (Crawford, 1999a). The importance of science was not really emphasized in most of the schools where the pre-service teachers participated in internship. Participating in this project provided the opportunity for Pippa and Alexis to be able to teach science in kindergarten classrooms where science is not the focus. Also, the interactions between the interns and the researcher in the form of emails, debriefings after lessons and reflections allowed the teachers to feel some support in their teaching efforts. This support may have possibly influenced their interest and willingness to teach science in the future.

The teacher participants in this research indicated that they had positive experiences in teaching science in their internship site. Hammer and Polnik (2006/2007) indicate that these types of experiences are important to help to create an excitement for science and science teaching. The positive feelings and attitudes were apparent in conversations with the pre-service teachers and in the final interview.

Pre-service teachers are able to implement scientific inquiry to some extent when provided support in the process. Factors that influence that ability include: the school context, the pre-service teacher's teaching orientation, the importance of science and the time dedicated to teaching science in the school. Although many factors appeared to influence the teaching practices associated with scientific inquiry, it appears that the teacher's beliefs about teaching science as inquiry were critical (Crawford, 1999a). The National Research Council (2000) reinforces this belief when they say that "beliefs and values about students, teaching and the purposes of education can impose obstacles to inquiry-oriented approached" (p. 139).

Additional Findings

Three additional areas appeared to be significant in this research. The use of educative materials including how supports were embedded into the curriculum affected how lessons were enacted. Classroom management and lesson management appeared to be significant in the implementation of lessons. Lastly, the importance of science content in the curriculum was a factor related to this research.

Use of Curriculum Materials

Davis and Krajcik (2005) explained that a teacher's use of curriculum materials and their learning from them is based on a number reasons. The factors include the characteristics of the curriculum materials, the type of teaching activity, the teachers persistence in reading materials over time, what the teachers focuses on in the curriculum materials, the teacher's own beliefs and knowledge about the content, the learners, teaching and curriculum materials and lastly how the beliefs are aligned with the goals of the curriculum. Findings from this research reinforce how differently the pre-service teachers used the materials and to what extent they seemed to be influenced by them. Previous research from Petish (2004) discussed the ways that teachers used the CASES curriculum and website. Since they printed the materials, they "diminished the effectiveness of one of the CASES design principles, Guidance on Demand" (p. 197). The focus of guidance on demand was to support teachers while they used the website by providing access to a wealth of information. Pippa appeared to be most influenced by the materials. Denice, in her initial unit, had other factors like learning goals that interfered with her use of the curriculum materials, but in her second unit seemed more open and willing to enact the curriculum. Alexis was willing to use the curriculum but management and the significance of science in her classroom influenced her ability to implement the curriculum.

The CASES curriculum does provide some support for pre-service teachers in their implementation of scientific inquiry through the use of curricular rationales linked to the curriculum through pop-up boxes. Remillard (2005) provided ways to look at how teachers use curriculum materials. Indications confirm that teachers interact with curriculum materials and based upon those interactions they will then enact the curriculum. The PCK-curricular rationales section was not readily available to the teachers because of their material usage. According to

Petish (2004), teachers tend to use the curricular supports embedded in lesson plans and therefore were more influenced by those aspects of the curriculum. The curricular rationales could have been supportive of Denice and to some extent Alexis, as their orientations towards science were not as closely aligned with scientific inquiry. The curricular rationales were designed to explain the rationales behind the lessons but since the teachers copied the lessons they did not gain access to the pop-up boxes on the CASES website. These rationales may have been most supportive of Denice and Alexis in understanding the reasons for implementing many aspects of the curriculum and could have potentially supported their knowledge in teaching through scientific inquiry.

Classroom Management

Classroom management and the management of specific lessons was one pattern in teaching that emerged in this research. The NRC (2000) recognizes that teachers must maintain control of their classroom during inquiry experiences. They suggest planning and organization are important aspects to be considered in the classroom. Davis, et al. (2006) states that although new teachers want their classrooms to be student-centered the concerns they have about classroom management may make their goals difficult to reach. In this research, Alexis and Denice did have some difficulties with classroom management and the implementation of the CASES lessons.

Since pedagogical skills such as maintaining focus and control in the classroom develop over time (Mulholland and Wallace, 2003; 2005), prior classroom experiences would support teaching practice during this study. Pippa, who appeared to be the most comfortable teaching and had the strongest control of the classroom, managed the science lessons most closely aligned with inquiry. Denice and Alexis developed their management of students through their teaching experiences. Denice appeared to develop the management of students over time and through the support of her internship teacher. On the other hand, Alexis was left in charge of the classroom and did not appear to have additional guidance from the supervising teacher. She indicated that the science lessons, being more active, were more difficult to manage.

Significance of Science Teaching

Overall, it seemed that in the earlier grades, that teaching science was more difficult to accomplish. The big push appears to be in literacy so science was not emphasized in the classrooms. Appleton and Kindt (2001), in their research, found that science was “a second order curriculum priority” behind mathematics and reading (p. 51). In both Pippa’s and Alexis’s case, their kindergarten classrooms did not really teach ‘science’. Pippa had not seen actual science lessons during her senior internship site but did integrate the topic of bears to include some science activities. Alexis also taught a unit on insects. During this unit, the children did have caterpillars that turned to butterflies but again this unit was an integrated unit that contained some science instead of a specific science curriculum. Weiss et al. (2001) found that early childhood classrooms spent an average of 27 minutes a day teaching science.

Study Limitations

There are several factors that limit the generalizability of this study. First, the sample in this research was three pre-service early childhood educators. Although the small group allowed me to explore their science teaching in depth and to form a detailed picture of their science teaching, generalizations from this study to other similar educators needs to be done with caution.

The pre-service teachers in this study were still learning and in some cases, the teaching represented here was their first experience in teaching science and managing the classroom. This factor is bound to influence the overall teaching practices that were observed, including their general pedagogical teaching strategies and pedagogical content knowledge which both develop over time and through experiences.

Two teachers, Pippa and Alexis were in my science methods course as well as a number of other courses in their bachelor's degree program. They were involved in specific scientific inquiry activities during the science methods course that Denice did not experience. This may have influenced their willingness to work with me and their understanding of teaching in general and the teaching of science specifically.

An additional limitation to the study was my ability to associate changes in teaching practices to the CASES curriculum. The pre-service teachers were able to teach science content to students for a two-week to a five-week period. They were involved in their internship experiences for longer periods of time. The time dedicated to teaching and to teaching science could also enhance the teaching practices of the participating interns instead of the CASES curriculum alone.

The pre-service teachers involved in this study, were in different grade levels and in different schools. The emphasis on science at the grade level and school and the general interest of the supervising teacher all impacted the outcomes of this study. The pre-service teacher's ability and support in these areas influenced the overall ability to implement science and the CASES lessons.

Implications for Future Research

The findings of this research bring new questions into light. The use of the CASES curriculum for these three pre-service teachers did in fact, influence their teaching of inquiry. Further research on the use of educative materials with pre-service and in-service teachers would be recommended. The lessons that were guided by the CASES curriculum showed more aspects of inquiry as well as higher levels of each of the essential features. Therefore, the curriculum did support the teachers in using inquiry. Pedagogical content knowledge was also more apparent in teaching practices during the use of the CASES materials. Future research could investigate any affects that the educative curriculum would have over a long period of time on these teachers' science teaching. For instance, if the teachers are not guided by the specific CASES curriculum will they still consider the five aspects of inquiry when they are planning and implementing science in their classrooms? If teachers used the CASES curriculum over time, will they be able to understand and then implement inquiry practices into other curriculum materials that they may have access to?

The CASES curriculum could be more supportive for early childhood educators if it was revised with support features intertwined within the classroom lessons. This integration of support would enable teachers to benefit from the curricular rationales behind the lessons. Additional supports for classroom management and specific management of materials in lessons would also be supportive of the pre-service teachers who may lack the pedagogical skills and experience in these areas. This research confirms what Petish (2004) has previously suggested. Petish advocates for more specific information and guidance in lessons plans to support teachers in more challenging aspects of the curriculum.

Also when looking at the various aspects of scientific inquiry, some aspects were more readily implemented in the curriculum. Further research could explore additional support for teaching inquiry at higher levels of the essential features of inquiry. The essential features of scientific inquiry that were most readily used were scientifically oriented questions, evidence gathering (data collection) and communication. Future research could also investigate the essential features of inquiry that were not as readily used in science lessons.

It would be important to consider if guided inquiry is most appropriate for early childhood children. The inquiry practices demonstrated in this study would fit into the category of inquiry which is more structured and guided by the teacher. It would be important to consider if young children can build their experiences in scientific inquiry that leads to open inquiry or if that would be considered developmentally inappropriate. Also, young children are different in their abilities to communicate their science understandings. It would be beneficial to consider if a broader range of avenues for communication in educative materials would prove to be beneficial for their implementation with young children.

Conclusions

While educative curriculum materials have shown some promise in supporting new teachers in the teaching of science, they have not been explored in relation to pre-service teachers. Also, research has not shown how effective curriculum materials are in developing teachers' understandings of scientific inquiry, content knowledge or the nature of science for this population of incoming teachers. The pre-service teachers in this research were able to implement a number of the features of scientific inquiry when provided support in the process. The features of inquiry that were observed most while the teachers used the educative curriculum were scientifically oriented questions, data collection and communication. The use of evidence was used inconsistently but did show promise as another area of inquiry that can be impacted from the use of educative curriculum. Factors that influence that ability include: the school context, the pre-service teacher's teaching orientation, the importance of science and the time dedicated to teaching science in the school.

The CASES curriculum does provide some support for pre-service teachers in their implementation of scientific inquiry but the extent to which they enacted the scientific inquiry was based on the additional factors. Specifically factors that influenced the teachers in this study were their personal beliefs about teaching science, their learning goals and their understandings of scientific inquiry and the nature of science. These factors could be addressed during education programs and through the curriculum materials which could potentially lead to closer alignment with inquiry practices.

Refinements in educative curriculum materials may benefit early childhood teachers and students. Including supports for pedagogical skills would be important for pre-service teachers who are using educative curriculum materials and at the initial stages of learning to teach science. Also, additional refinements regarding the curricular rationales in the lessons may promote greater understanding of the lessons and lead to enactment closely aligned with the intention of the materials.

The type of inquiry that was demonstrated by the early childhood students in this study was guided inquiry. This type of inquiry supports young children in their investigations and the teacher plays a key role. It appears that this level of inquiry may be beneficial for young children in order to develop their understandings of the processes of inquiry. Also, of significance for young children, would be the broadening of ways to represent and communicate their scientific understandings. Young children may be less adept at communicating in typical ways such as writing. Additional features to support young children within educative curriculum would be beneficial.

The overarching implications of this research are to recognize that educative materials do support pre-service early childhood teachers in teaching science. Educative curriculum materials provided supports for pre-service teachers related to their developing practices in teaching science. They have potential to help pre-service teachers move closer to the reform efforts advocated in the National Science Education Standards.

APPENDIX A: PROTOCOL FOR SCIENCE TEACHING INTERVIEWS (PRE-INTERVIEW)

PROTOCOL FOR SCIENCE TEACHING INTERVIEWS (PRE-INTERVIEW)

This interview is used to clarify and understand responses on the instruments used: VNOS-D, VOSI-E, and STEBI-B

The instruments should be reviewed prior to the interview period. Questions and topics will be guided by the responses provided but the general topics for the interview are outlined below.

General Topics will include:

Terminology used

Explanation of responses

Verbal clarification of ideas

Participants general comments about instruments, teaching science or feelings of science

APPENDIX B: VNOS – FORM D

VNOS - FORM D

Lederman, N.G., Schwartz, R. S., Abd-El-Khalick, F., & Bell, R.L. (2001)

Instructions:

Please answer each of the following questions. You can use all the space provided and the backs of the pages to answer a question.

Some questions may have more than one part. Please make sure you write answers for each part.

There are no ‘right’ or ‘wrong’ answers to the following questions. I am only interested in your ideas about the following questions

- What is science?
- How is science different from the other subjects you are studying?
- Scientists produce scientific knowledge. Some of this knowledge is found in your science books. Do you think this knowledge may change in the future? Explain your answer and give an example.
- How do scientists know that dinosaurs really existed?
- How certain are scientists about the way dinosaurs looked?
- Scientists agree that about 65 million years ago the dinosaurs became extinct (all died away). However, scientists disagree about what had caused this to happen. Why do you think they disagree even though they all have the same information?
- In order to predict the weather, weather persons collect different types of information. Often they produce computer models of different weather patterns. A. Do you think weather persons are certain (sure) about the weather patterns? B. Why or why not?

- What do you think a scientific model is?
- Scientists try to find answers to their questions by doing investigations/experiments. Do you think that scientists use their imagination and creativity in their investigations/experiments?

YES NO

- If NO, explain why
- If YES, in what part of their investigations (planning, experimenting, making observations, analyzing data, interpretation, reporting results, etc) do you think they use their imagination and creativity? Give examples if you can.

APPENDIX C: VIEWS OF SCIENTIFIC INQUIRY ELEMENT SCHOOL VERSION (VOSI-E)

VIEWS OF SCIENTIFIC INQUIRY ELEMENT SCHOOL VERSION (VOSI-E)

Lederman, J.S. and Ko, E. K. (2003)

Instructions:

We want to know what you think about science and how it is done.

Some questions may have more than one part. Please make sure you put answers for each part.

There are no ‘right’ or ‘wrong’ answers to the following questions

If you want, you can draw pictures to help explain your ideas.

- What kind of work do scientists do?
- Explain how scientists do their work.
- A scientist studied many different kinds of birds. She noticed that birds that eat the same types of food usually have the same shaped beaks. For example, many birds that eat hard nuts have short, strong beaks, and many birds that pick worms out of the ground have long, thin beaks. So, the scientist decided that there is a connection between beak shape and the type of food birds eat.
- Do you think her work was scientific? Why or why not?
- Do you think her work was an experiment? Please explain why or why not.
- A long time ago all the dinosaurs died. Many scientists are trying to find out why this happened.
- Do you think they will all come up with the same reasons for why this happened?
- Explain why or why not.
- What information do scientists use to explain their reasons for why this happened?

APPENDIX D: SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT: STEBI – B FORM

SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT: STEBI – B FORM

Questionnaire

Gender ____F _____M Number of College Science Courses_______

Number of Years of High School Science (9th grade or above) _______

If you have your choice, will you choose to be the one to teach science to your elementary students?

Definitely no

Probably no

Not sure

Probably yes

Definitely yes

The major portion of my time in science instruction should be spent in:

Textbook-based presentation only

More textbook-based presentation than anything else

An equal amount of textbook-based presentation and activity-based instruction

More activity-based instruction than textbook-based presentation

Activity-based instruction only

Please rate how you think you will view your own effectiveness as a future teacher of elementary science.

Superior—one of the most outstanding teachers of elementary science in the building: a master teacher of elementary science.

Above average

Average—typical teacher of elementary science

Below average

Low—one of the least effective teachers of elementary science: In need of professional improvement in this area.

Enochs and Riggs (1990)

STEBI Form B Continued

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = Strongly Agree

A = Agree

UN = Uncertain

D = Disagree

SD = Strongly Disagree

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2. I will continually find better ways to teach science.	SA A UN D SD
3. Even if I try very hard, I will not teach science as well as I will most subjects.	SA A UN D SD
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach	SA A UN D SD
5. I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6. I will not be very effective in monitoring science experiments.	SA A UN D SD
7. If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8. I will generally teach science ineffectively.	SA A UN D SD
9. The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD

10. The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12. I understand science concepts well enough to be effective in teaching elementary science.	SA A UN D SD
13. Increased efforts in science teaching produces little change in some students' science achievement.	SA A UN D SD
14. The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17. I will find it difficult to explain to students why science experiments work.	SA A UN D SD
18. I will typically be able to answer students' science questions.	SA A UN D SD
19. I wonder if I will have the necessary skills to teach science.	SA A UN D SD
20. Given a choice, I will not invite the principal to evaluate my science teaching.	SA A UN D SD
21. When a student has difficulty understanding a science concept, I	SA A UN D SD

will usually be at a loss as to how to help the student understand it better.	
22. When teaching science, I will usually welcome student questions.	SA A UN D SD
23. I do not know what to do to turn students on to science.	SA A UN D SD

Enochs and Riggs (1990)

APPENDIX E: TEACHER OBSERVATION FORM

TEACHER OBSERVATION FORM

Name of Teacher:

Date:

Start Time: Stop Time

Lesson Topic (CASES):

Is this a continuation of a previous lesson? If so, date of previous lesson.

Is there a worksheet or other materials associated with lesson? (Attach or provide information.

Summary of the Lesson:

Time	Observations/Comments

Initial comments/interpretation of lesson:

Note evidence of CASES educative features used in lesson including: Use of Inquiry Practices, PCK – Instructional Strategies, PCK- Curricular Rationales, PCK- Alternative Ideas, and Subject Matter Knowledge

APPENDIX F: FIELD SUPERVISOR OBSERVATION INSTRUMENT

FIELD SUPERVISOR OBSERVATION INSTRUMENT

Kind of instruction the TEP student employed—

Inquiry: Inquiry is a multi-faceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already know in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking and consideration of alternative explanations.

Discovery Activity (brief activity to exemplify a scientific principle)

Confirmation Lab

Laboratory skill exercise

Discussion

Lecture/direct instruction

Worksheet/seatwork

Other

If some form of inquiry used, circle **one variation in each of the five rows** that best describes the student teacher's approach for each of the five "essential features." Not all five of the "essential features" will be observable in a given class session, even if they are using inquiry.

Essential Feature	Variations			
1. Learner engages in scientific oriented questions	Learner poses a question	Learner selects among questions, poses new questions	Learner sharpens or clarifies question provided by teacher, materials, or other source	Learner engages in question provided by teacher, materials, or other source
2. Learner gives priority to evidence in responding to questions	Learner determines what constitutes evidence and collects it	Learner directed to collect certain data	Learner given data and asked to analyze	Learner given data and told how to analyze
3. Learner formulates explanations to scientific knowledge	Learner formulates explanation after summarizing evidence	Learner guided in the process of formulating explanations from evidence	Learner given possible ways to use evidence to formulate explanation	Learner provided with evidence
4. Learner connects explanations to scientific knowledge	Learner independently examines other resources and forms the links to explanations	Learner directed towards areas and sources of scientific knowledge	Learner given possible connection	
5. Learner communicates and justifies explanations.	Learner forms reasonable and logical argument to communicate explanation	Learner coached in the development of communication	Learner provided broad guidelines to use to sharpen communication	Learner given steps and procedures for communication

From Windschitl (2004)

APPENDIX G: GUIDELINES FOR PRE-SERVICE TEACHING REFLECTIONS OF SCIENCE TEACHING

GUIDELINES FOR PRE-SERVICE TEACHING REFLECTIONS OF SCIENCE TEACHING

To be completed by Pre-Service Teachers

Participants will be asked to respond to one or two questions each week after they teach a science lesson.

- How do you think the lesson went? Would you change or adapt anything based on how the lesson went?
- What did you plan to teach today? How did the lesson actually reflect what you planned?
- What went well in the unit/lesson? What changes may need to be made if you taught the lesson/unit again?
- Did the lesson meet the objectives set forth? Did you feel the students met the objectives identified during the lesson?
- Were students engaged during the lesson? Were they involved in inquiry?
- Were you able to manage the lesson easily? What environmental factors could be adjusted in the future?
- Was classroom management an issue during the lesson? Explain.
- What general teaching strategies did you use in the lesson? Were they successful or not? Explain.
- What specific science teaching strategies did you use in the lesson? Were they successful or not? Explain.
- Did you feel comfortable with the science content of the lesson/unit? Explain.

- How do you know that students understood the science concepts you were teaching today?
- Did the students communicate their understandings or provide evidence in some way?
- How did the lesson/unit help children understand the process of inquiry and nature of science? Explain.
- Do you feel that your teaching today was key to student understanding of science concepts in the lesson? Explain.
- What is your comfort level with teaching this specific science content? Explain.
- Do you feel that students may ask you something regarding the science content that you would not be able to answer? Explain.
- What role did communication and evidence play in your lesson today? Explain
- Why do we want students to communicate their understandings of their learning?
- How can we adapt lessons (such as the cases) and make sure we still keep the important focus?
- How are inquiry and hands on activities similar and different? Are there times it is best to use one over the other?
- When considering teaching science, do you feel that you need support with the content? Are there some areas that you feel less comfortable with?

APPENDIX H: INTRODUCTION TO THE CASES WEBSITE

INTRODUCTION TO THE CASES WEBSITE

CASES (Curriculum Access System for Elementary Science) is a website developed through the University of Michigan Education Department. It was developed through a grant from the National Science Foundation and includes units and lessons designed in an educative format using science inquiry as well as other resources and discussion areas for teachers. The website for CASES is http://cases.soe.umich.edu/index.html. CASES is an online learning environment that has been designed to support elementary teachers in teaching science using inquiry. You must register to use the CASES resources, but registration is open to all educators.

CASES has a number of features to support your teaching of science and the use of inquiry practices:

Inquiry-oriented unit plan library contains fully developed units using inquiry methods that are geared for different age groups. Units have been developed for K-2, 3-5 and 6-8 grade bands. Full units can be taught over a period of 4-8 weeks. The units and lesson plans are designed around key questions using an inquiry approach. The objectives for each lesson explain what aspects of inquiry is a part of the lesson. The *science background* and *student's alternative ideas* sections provide content knowledge for teachers and an understanding of student's ideas.

Lesson plan library contains lessons that can be taught in isolation without the full unit. A search engine helps to search by topic or grade level. These lessons are also supportive of inquiry methods. The units and lesson plans are designed around key questions using an inquiry approach. The objectives for each lesson explain what aspects of inquiry is a part of the lesson. The *science background* and *student's alternative ideas* sections provide content knowledge for teachers and an understanding of student's ideas.

Teacher Communities are online discussions that are typically used by students in the University of Michigan's education programs. You can review the postings that show topics of interest or relevance to your own teaching.

Personal Online Journal is an online journal that can be used to reflect upon the lessons regarding your own science teaching. Specific prompts help you to consider your own science teaching. (If you chose to use the personal online journal, please cut and paste your thoughts to share as a part of this research.) The personal online journal will be similar to the lesson reflections that are a part of the research.

Science Teaching Resource Library provides wonderful resources and background information that support your teaching of various science concepts. Although all the information is very valuable to explore, two specific areas that provide wonderful information are the *Science Background for Teachers* area and *Science Teaching Tips*.

Images of Inquiry is an area that allows real and fictional teachers to share their ideas and challenges regarding the teaching of inquiry. The images deal specifically with lessons related to the CASES curriculum.

APPENDIX I: CASES IMPLEMENTATION INTERVIEW

CASES IMPLEMENTATION INTERVIEW

- Do you feel that you successfully implemented science lessons in your internship site?
- Do you feel that you were successfully able to implement the CASES curriculum?
- What support was helpful in teaching science in your internship site?
- How did you use the CASES curriculum?
- Can you explain how you used the CASES resources to plan your science unit?
- Can you explain how you used the CASES resources when planning specific lessons?
- Do you think the students learned what you intended them to learn in the CASES science unit? Why or why not?
- Do you think the CASES web site has influenced you thinking about teaching science? Explain.
- How did you use the information on the CASES web site? What aspects did you use? What parts did you choose not to use? Why?
- When you were preparing to teach using the CASES lessons, What did you find helpful?
- How did the CASES curriculum support inquiry?

APPENDIX J: PROTOCOL FOR POST SCIENCE TEACHING INTERVIEWS

PROTOCOL FOR POST SCIENCE TEACHING INTERVIEWS

This interview is used to clarify and understand responses on the instruments used: VNOS-D, VOSI-E, and STEBI-B

The instruments should be reviewed prior to the interview period. Questions and topics will be guided by the responses provided but the general topics for the interview are outlined below.

General Topics will include:

Terminology used

Explanation of responses

Verbal clarification of ideas

Participants general comments about instruments, teaching science or feelings of science

Other General Questions can be added:

- Overall, how have your ideas and feelings regarding the teaching of science changed since the beginning of this project?
- How have your feelings of teaching science changed since beginning this project?
- How has your understanding of inquiry changed since beginning this project? How has your understanding of the Nature of Science changed since the beginning of this project?
- What is your overall philosophy of education and/or science education?
- Do you feel that you will use inquiry activities in your own teaching?
- What are your beliefs related to how children learn?
- What do you believe is the best way for children to learn science?

- Do you feel that you have strategies to help you facilitate instruction in the classroom?
- Do you feel that you have science specific strategies to help you facilitate science instruction in the classroom?
- Would management and teaching strategies be different for another content area than for science?

APPENDIX K: CODING CHART FOR CASE STUDY WRITE-UPS

CODING CHART FOR CASE STUDY WRITE-UPS

Data Collection Tool	Code used in Case Studies
Initial Interview	II
Initial Instruments	Iint
Pre-CASES Lesson	PCL
CASES Lesson	CL
Lesson Reflections	LR
CASES Lesson Reflection	CLR
CASES Interview	CI
Post Interview	PI
Post Instruments	PInt

APPENDIX L: IRB APPROVAL LETTER

IRB Approval Letter

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

From : **UCF Institutional Review Board**
FWA00000351, Exp. 5/07/10, IRB00001138

To : **Dierdre Englehart**

Date : **November 05, 2007**

IRB Number: **SBE-07-05299**

Study Title: **The Impact of Educative Curriculum on Pre-Service Early Childhood Teacher's Science Content Knowledge and Teaching Practices**

Dear Researcher:

Your research protocol noted above was approved by **expedited** review by the UCF IRB Chair on 11/5/2007. **The expiration date is 11/4/2008.** Your study was determined to be minimal risk for human subjects and expeditable per federal regulations, 45 CFR 46.110. The category for which this study qualifies as expeditable research is as follows:

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

The IRB has approved a **consent procedure which requires participants to sign consent forms.** Use of the approved, stamped consent document(s) is required. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Subjects or their representatives must receive a copy of the consent form(s).

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

To continue this research beyond the expiration date, a Continuing Review Form must be submitted 2 – 4 weeks prior to the expiration date. Advise the IRB if you receive a subpoena for the release of this information, or if a breach of confidentiality occurs. Also report any unanticipated problems or serious adverse events (within 5 working days). Do not make changes to the protocol methodology or consent form before obtaining IRB approval. Changes can be submitted for IRB review using the Addendum/Modification Request Form. An Addendum/Modification Request Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at http://iris.research.ucf.edu .

Failure to provide a continuing review report could lead to study suspension, a loss of funding and/or publication possibilities, or reporting of noncompliance to sponsors or funding agencies. The IRB maintains the authority under 45 CFR 46.110(e) to observe or have a third party observe the consent process and the research.

On behalf of Tracy Dietz, Ph.D., UCF IRB Chair, this letter is signed by:

Signature applied by Janice Turchin on 11/05/2007 03:23:55 PM EST

Janice M Turchin

IRB Coordinator

REFERENCES

Abd-El-Khalick, F. (2004). Over and over again: College students' views of nature of science. In Flick, L.B. and Lederman, N. G. (Eds.), *Scientific Inquiry and Nature of Science*, Netherlands: Springer.

Abd-El-Khalick, F., Lederman, N. G., Bell, R. L. & Schwartz, R. S. (2001). Views of Nature of Science Questionnaire (VNOS): Toward valid and meaningful assessment of learners' conceptions of nature of science, ED 472901, 1-48.

Akerson, V. L., Hanson, D. L. & Cullen, T. A. (2007). The influence of guided inquiry and explicit instruction on k-6 teachers' views of nature of science. *Journal of Science Teacher Education*, 18(5), 751-772.

Akerson, V. L. & Hanuscin, D. L. (2007). Teaching nature of science through inquiry: Results of a 3-year professional development program. *Journal of Research in Science Teaching*, 44(5), 653-680.

Appleton, K. (1999). Why teach primary science? Influences on beginning teachers' practices. *International Journal of Science Education*, 21(2), 155-168.

Appleton, K. & Kindt, I. (2002). Beginning elementary teachers' development as teachers of science. *Journal of Science Teacher Education*, 13(1), 43-61.

Ball, D. L. & Cohen, D. K. (1996). Reform by the book: What is: Or might be: The role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 25(9), 6-8, 14.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). New York: Academic Press. (Reprinted in H. Friedman [Ed.], *Encyclopedia of mental health*. San Diego: Academic Press, 1998). Downloaded, December 15, 2007 from http://www.des.emory.edu/mfp/BanEncy.html.

Beyer, C. J. & Davis, E. A. (2007). Fostering second graders' scientific explanations using educative curriculum materials: A beginning elementary teacher's perspective and practice. Paper presented at the *National Association for Research in Science Teaching Annual Meeting*.

Bleicher, R. E. (2007). Nurturing confidence in pre-service elementary science teachers. *Journal of Science Teacher Education*, 18, 841-860.

Bredekamp, S. & Copple, C. (1997). *Developmentally appropriate practice in early childhood program.* Washington, D.C.: National Association for the Education of Young Children.

Brickhouse, N. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice. *Journal of Teacher Education*, 41, 53-62.

Brooks, J. G. & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

Buchanan, T. K., Bidner, J., White, F. and Charlesworth, R. (1998). Predictors of the developmental appropriateness of the beliefs and practices of first, second and third grade teachers. *Early Childhood Research Quarterly,* 13(3), 459-483.

Cobern, W. W. & Loving, C. C. (2002). Investigation of pre-service elementary teachers' thinking about science. *Journal of Research in Science Teaching,* 39(10), 1016-1031.

Crawford, B. A. (1999a). Is it realistic to expect a pre-service teacher to create an inquiry-based classroom? *Journal of Science Teacher Education,* 10(3), 175-194.

Crawford, B. A. (1999b). Teaching through inquiry: A novice teacher's authority of experience. ED 443 656, 1-46.

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching,* 44(4), 613-642.

Davis, E. A. (2005). Pre-service elementary teachers' critique of instructional materials for science. *Science Education,* 90(2), 348-375.

Davis, E. A. & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher,* 34(3), 3-14.

Davis, E. A. & Krajcik, J. S.(2004). Supporting inquiry-oriented science teaching with curriculum materials: Design heuristics for educative curriculum materials. A paper presented at the 2004 American Educational Research Association Annual Conference in San Diego, CA.

Davis, E. A. & Petish, D. (2005). Real-world applications and instructional representations among prospective elementary science teachers. *Journal of Science Teacher Education* 16, 263-286.

Davis, E. A., Petish, D. & Smithey, J. (2006). Challenges new science teacher's face. *Review of Educational Research,* 76(4), 607-651.

De Laat, J. and Watters, J. J. (1995). Science teaching self-efficacy in a primary school: A case study. *Research in Science Education*, 25(4), 453-464.

Dickerson, D. L., Dawkins, K. R. & Len, A. (2007). Scientific fieldwork: an opportunity for pedagogical-content knowledge development. *Journal of Geoscience Education*, 55(5), 371-376.

Ekborg, M. (2005). Student-teachers' learning outcomes during science subject matter courses. *International Journal of Science Education,* 27(14), 1671-1694.

Enochs, L. G. & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A pre-service elementary scale. ED 319601, 1-30.

Everett, S. A., Luera, G. R. & Otto, C. A. (2006). Pre-service elementary teachers bridge the gap between research and practice. *International Journal of Science and Mathematics Education,* 6(1), 1-17.

Fleer, M. & Robbins, J. (2003). "Hit and run research" with "hit and miss" results. *Early Childhood Science Education,* 33, 405-431.

Flick, L. B. Lederman, N. G. & Enochs, L. G. (1996). Relationship between teacher and student perspectives on inquiry oriented practice and the nature of science. ED 394833, 1-22.

Forbes, C. T. & Davis, E. A. (2007a). Beginning elementary teachers' learning through the use of science curriculum materials: A longitudinal study. Paper presented at the annual meeting of the National Association for Research in Science Teaching, NARST, 2007, 1-24.

Forbes, C. T. & Davis, E. A. (2007b). Exploring pre-service elementary teachers' critique and adaptation of science curriculum materials in respect to socio-scientific issues. *Science and Education,* published online 14, February 2007.

Gado, I. (2005). Determinants of k-2 school teachers' orientation toward inquiry-based science activities: A mixed method study. *International Journal of Science and mathematics Education*, 3, 511-539.

Gee, C.J., Boberg, W. S. and Gabel, D. L. (1996). Pre-service elementary teachers: their science content knowledge, pedagogical knowledge, and pedagogical content knowledge. ED 393702, 1-26.

Gehrke, N. J., Knapp, M. S., & Sirotnik, K. A. (1992). In search of the school curriculum. *Elementary School Journal*, 18, 51-110.

Ginns, I.S. & Watters, J. J. (1999). Beginning elementary school teachers and the effective teaching of science. *Journal of Science Teacher Education*, 10(4), 287-313.

Goldstein, L. S. (2007). Beyond the DAP versus standards dilemma: Examining the unforgiving complexity of kindergarten teaching in the united states. *Early Childhood Research Quarterly*, 22, 39-54.

Hammer, M. & Polnik, B. (2006/2007). Preparing tomorrow's science teachers. *Educational Leadership*, 64(4), 80-83.

Harlen, W. & Holroyd, C. (1995). Primary teachers' understanding of concepts in science and technology, *Interchange* 34, ED 462251, 1-13.

Hudson, P. (2004). Toward identifying pedagogical knowledge for mentoring in primary science teaching. *Journal of Science Education and Technology*, 13(2), 215-225.

Jarvis, T., McKeon, F. & Taylor, N. (2005). Promoting conceptual change in pre-service primary teachers through intensive small group problem solving, *Canadian Journal of Science, Mathematics and Technology,* 5(1), 21-39.

Keys, C. W. & Bryan, L. A. (2001). Co-constructing inquiry-based science with teachers: Essential research for lasting reform. *Journal of Research in Science Teaching,*38(6), 631-645.

Lederman, J. S. & Ko, E. K., (2003). *Views of scientific inquiry-elementary school version.* Unpublished paper. Illinois Institute of Technology, Chicago, IL.

Lederman, J. S. and Lederman, N. C. (2005). Developing and assessing elementary teachers' and students' understanding of nature of science and scientific inquiry. A Paper presented at the National Association for Research in Science Teaching Annual Meeting.

Lederman, N. G., Schwartz, R. S., Adb-El-Khalick, F., & Bell, R. L. (2001). Pre-service teachers' understanding and teaching of the nature of science: An intervention study. *Canadian Journal of Science, Mathematics, and Technology Education*, 1, 135-160.

Lee, E., Brown, M. N., Luft, J. A. & Roehrig, G. H. (2007). Assessing beginning secondary science teachers' PCK: Pilot year results. *School Science and Mathematics*, 107(2), 52-60.

Lotter, C. Harwood, W. S. & Bonner, J. J. (2006). The influence of core teaching conceptions on teachers' use of inquiry teaching practices. *Journal of Research in Science Teaching,* 44(9) 1-30.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (2000). Assessing teachers' beliefs about their science teaching context. *Journal of Research in Science Teaching*, 37(3), 275-292.

Merriam, S. B. (1988). *Case Study Research in Education: A Qualitative Approach.* San Francisco: Jossey-Bass.

Mullholland, J. & Wallace, J. (2003). Facilitating primary science teaching: A narrative account of research as learning. *Teachers and Teaching: Theory and Practice*, 9(2), 133-155.

Mullholland, J. & Wallace, J. (2005). Growing the tree of teacher knowledge: Ten years of learning to teach elementary science, *Journal of Research in Science Teaching*, 42(7), 767-790.

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

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

NSTA Teacher Standards (2003), Retrieved on August 27, 2007 at http://www.nsta.org/pdfs/NSTAstandards2003.pdf.

Park, S. & Oliver, S. (2007). Revisiting the conceptualization of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, Published online, 16, June 2007.

Peers, C. E., Diezmann, C. M. & Watters, J. J. (2003). Supports and concerns for teacher professional growth during the implementation of a science curriculum innovation. *Research in Science Education,*33: 89-110.

Petish, D. A. (2004). Using educative curriculum materials to support new elementary teachers' practice and learning. Unpublished doctoral dissertation. University of Michigan, Ann Arbor.

Plevyak, L. H. (2007). What do pre-service teachers learn in an inquiry-based science methods course? *Journal of Elementary Science Education*, 19(1), 1-13.

Porlan, R. & Martin del Pozo, R. (2004). The conceptions of in-service and prospective primary school teachers about the teaching and learning of science. *Journal of Science Teacher Education*, 15(1), p. 39-62.

Riggs, I. & Enochs, L. (1990). Toward the development of an efficacy belief instrument for elementary teachers. *Science Education*, ED 308 068, 1-31.

Schneider, R. M. & Krajcik, J. (2002). Supporting science teacher learning: the role of educative curriculum materials, *Journal of Science Teacher Education,* 13(3), 221-245.

Schneider, R. M., Krajcik, J. and Marx, R., (2000). The role of educative curriculum materials in reforming science education. *Fourth International Conference of the Learning Sciences,* 54-61, Mahwah, NJ: Erlbaum.

Schwartz, R. S. & Crawford, B. A. (2005). Authentic scientific inquiry as a context for teaching nature of science: Identifying critical elements for success. In Flick, L.B. and Lederman, N. G. (Eds.), *Scientific Inquiry and Nature of Science*, Netherlands: Springer.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

Smith, R. G. (1997). “Before teaching this I’d do a lot of reading” preparing primary student teachers to teach science. *Research in Science Education*, 27(1), 141-154.

Squire, K. D., Makinsler, J. G, Barnett, M, Luehmann, A. L. & Barab, S. L. (2003). Designed curriculum and local culture: Acknowledging the primacy of classroom culture, *Science Education*, 87(4), 468-489.

Weiss, I., Banilower, E. McMahon, K. & Smith, P. (2001). *Report of the 2000 National Survey of Science and Mathematics Education.* [online]. Available: www.horizon-research.com.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Teacher Education*, 87, 112-143.

Windschitl, M. (2004). Folk theories of “inquiry:” How pre-service teachers reproduce the discourse and practice of an atheoretical scientific method. *Journal of Research in Science Teaching*, 41(5), 481-512.

Yin, R. K. (2003). *Case study research: Design and methods.* Sage Publications, Thousand Oaks, California.

Yoon, J. & Onchwari, J. A. (2007). Teaching young children science: Three key points. *Early Childhood Education Journal.* 33(6), 419-423.