Investigating the impact of field verses university-based science methods on preservice teachers' belief and abilities to design inquiry-based science instruction for diverse learners

Author: Anne Pfitzner Gatling

Persistent link: http://hdl.handle.net/2345/1163

This work is posted on eScholarship@BC, Boston College University Libraries.

Boston College Electronic Thesis or Dissertation, 2010

Copyright is held by the author, with all rights reserved, unless otherwise noted.
INVESTIGATING THE IMPACT OF FIELD VERSES UNIVERSITY-BASED SCIENCE METHODS ON PRESERVICE TEACHERS’ BELIEF AND ABILITIES TO DESIGN INQUIRY-BASED SCIENCE INSTRUCTION FOR DIVERSE LEARNERS

Dissertation
By

ANNE PFITZNER GATLING

submitted in partial fullfillment of the requirements for the degree of Doctor of Philosophy
March 2010
ABSTRACT

INVESTIGATING THE IMPACT OF FIELD VERSUS UNIVERSITY BASED SCIENCE METHODS ON PRESERVICE TEACHERS’ BELIEF AND ABILITIES TO DESIGN INQUIRY BASED SCIENCE INSTRUCTION FOR DIVERSE LEARNERS

Author: Anne Gatling
Advisor: Michael Barnett

Elementary science instruction and teacher preparation need improvement for various reasons: 1) preservice teachers lack opportunities to experience (Windschitl, 2003) or observe (Smith, 1999) inquiry science, 2) pre-service teachers have even fewer opportunities to practice teaching science in a classroom settings (Hewson, Tabachnick, Zeichner, & Lemberger, 1999); and 3) methods courses and field experiences fail to provide proper scaffolding and support for science teaching (Crawford, 1999). One way to improve preservice teacher growth and understanding in teaching inquiry science is through supported field based teaching experiences (Eick, Ware, & Williams, 2003). However, research is necessary to examine how innovative field-based science methods courses compare to traditional, university-based science methods course.

This mixed methods study compares the experiences of thirty-two preservice teachers with a specific focus on four preservice teachers involved in either a field-based science methods course or a university-based science methods course. It examines the impact of the two courses on preservice teachers’ confidence in teaching science content and beliefs regarding the role of inquiry-based science instruction with culturally and linguistically diverse students.

Data sources included a pre/post survey that was distributed to preservice teachers in both courses, with additional interviews and final unit reviews for each of the four preservice teacher case studies. Themes were identified and re-examined through an analysis of the data which informed the development of four case studies, two from each class, to investigate specific trends between the two methods courses.
Findings indicate that both field- and university-based instruction have strengths and weaknesses. This research suggests that field-based methods have a stronger impact on improving preservice teachers’ beliefs and skills in regard to designing inquiry-based instruction for diverse students, while university-based course promotes greater confidence in preservice teachers’ ability to teach different science content areas. However, preservice teachers in both courses struggled to create inquiry-based science lessons where students used evidence to support claims or construct explanations.
DEDICATION

To my husband, Michael,
And my mother and father,

For your love, constant support, and unwavering belief in me throughout this journey.
ACKNOWLEDGEMENTS

This research would not have been possible without the support of the faculty and staff at the Lynch School of Education, and my family and friends. I would first like to thank my committee.

Mike Barnett, my advisor, has enriched my experience as a doctoral student throughout my program helping me to gain collaborative and leadership skills that I will carry throughout my career. Thank you! I could never thank Kate McNeill enough for all of her guidance, encouragement, and support, as I began to tackle this dissertation. I have learned so much and gained so much confidence in my ability to contribute to the field. Thanks for lighting the fire under me. For Maria Brisk whose interest and passion for English Language Learners inspired me and challenged me to improve my methods of instruction for both preservice and inservice teachers. For Eric Strauss for his amazing knowledge and support of my work throughout my program here.

I would also like to thank the rest of my family for your words of encouragement and urging me on. You will never know how much that has meant to me. For my husband’s family, thank you so much for your belief in me and for welcoming me into your family. Connies your expert editing skills were great. And a special thank you for Judy whose interest and investment in my research was inspiring.

For my Grandmother who taught for 40 years, starting in a one room schoolhouse in the Ozarks and shared her love of teaching. I know you were there with us, you have done so much to inspire me throughout my life. And Dr. Popp who inspired this path of education.

I will never be able to thank my dear friends who have been so supportive of my work through challenges and successes. Ann Marie Gleeson, Margarita Zisselsberger, Deborah Bennett, Meredith Houle, and Janice Anderson. I couldn’t have done it without you!

Special thanks to Sang Han who continually checked on my progress from all points around the world.

Thank you to my neighbors who always checked in on my progress while on my walks and offered many prayers along the way. Kathleen, _____ or get off the pot. Patricia – ‘Get that paper done, Annie’ Harold and Ruth and Harold, Kate and Doug, Debb and Neill. Thank you to the Alaska Contingency: Mary Armstrong who called to keep me on track and focused on the prize, Donna Rea, Robin Nyce, Rocky Ward and Jessica Summer. To the many other graduate students and friends over the years who have touched my life and influence my work.

And finally to my dear Michael, Isabelly (who is also working on her dissertation) and little Grommie with all his/her little kicks reminding me to stay focused and eat! I love you all so much. Isabelly now we can play!
# TABLE OF CONTENTS

Abstract ............................................................................................................................................ iii  
Dedication ......................................................................................................................................... v  
Acknowledgements .......................................................................................................................... vi  
Table of Contents ............................................................................................................................. vii  
List of Tables ...................................................................................................................................... x  
List of Figures ...................................................................................................................................... xi  
Chapter 1: Introduction ...................................................................................................................... 1  
Chapter 2: Review of the Literature ................................................................................................... 5  
  Current Status of Science Teaching at the Elementary Level........... 6  
  Inquiry Science ................................................................................................................................. 7  
  Preservice Teachers’ Beliefs & Knowledge about Teaching Science 9  
  Elementary Teacher Preparation for Science Instruction ........... 10  
  Arts and Science Courses ................................................................................................................. 11  
  University-based Science Methods Courses .................. 12  
  Field Experiences ............................................................................................................................ 14  
  Transition into the Classroom ........................................................................................................... 16  
  Teaching Science to Diverse Students ......................................................................................... 16  
  Field-based Science Methods Courses ......................................................................................... 20  
  Bridging Theory into Practice ........................................................................................................ 22  
Chapter 3: Methods .......................................................................................................................... 25  
  Methodological Approach .............................................................................................................. 26
<table>
<thead>
<tr>
<th>The Elementary Science Methods Course Sections</th>
<th>27</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Field-based Science Methods Course</td>
<td>29</td>
</tr>
<tr>
<td>The University-based Methods Course</td>
<td>35</td>
</tr>
<tr>
<td>Comparison of the Two Sections</td>
<td>36</td>
</tr>
<tr>
<td>Participants</td>
<td>38</td>
</tr>
<tr>
<td>Data Sources</td>
<td>39</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>42</td>
</tr>
<tr>
<td>Quantitative Analysis</td>
<td>45</td>
</tr>
<tr>
<td>Qualitative Analysis</td>
<td>46</td>
</tr>
<tr>
<td>Chapter 4: Results</td>
<td>57</td>
</tr>
<tr>
<td>Survey Results</td>
<td>57</td>
</tr>
<tr>
<td>Qualitative Results: Introduction to Case Studies</td>
<td>60</td>
</tr>
<tr>
<td>Case 1: Cindy</td>
<td>64</td>
</tr>
<tr>
<td>Case 2: Connie</td>
<td>96</td>
</tr>
<tr>
<td>Case 3: Karen</td>
<td>119</td>
</tr>
<tr>
<td>Case 4: Emily</td>
<td>151</td>
</tr>
<tr>
<td>Analysis Across the Two Cases</td>
<td>184</td>
</tr>
<tr>
<td>Chapter 5: Discussion and Implications</td>
<td>200</td>
</tr>
<tr>
<td>Limitations and Future Directions for Research</td>
<td>215</td>
</tr>
<tr>
<td>Implications</td>
<td>218</td>
</tr>
<tr>
<td>References</td>
<td>305</td>
</tr>
<tr>
<td>Appendix A: Pre-ServiceTeacher Survey</td>
<td>223</td>
</tr>
</tbody>
</table>
Appendix B: Interview Protocol ................................................................. 238
Appendix C: Student Misconception Interview Field Based ........ 240
Appendix D: Student Misconception Interview University Based 245
Appendix E: Curriculum Evaluation Field Based ......................... 251
Appendix F: Curriculum Evaluation University Based ................. 253
Appendix G: Reflection Field Based ......................................................... 255
Appendix H: Reflection University Based .............................................. 257
Appendix I: Final Curriculum Field Based ............................................ 259
Appendix J: Final Curriculum University Based ................................. 263
Appendix K: Factors Survey ................................................................. 268
Appendix L: Coding Preservice Teacher Interviews ...................... 277
Appendix M: Consolidation Codes .......................................................... 287
Appendix N: Sample Lesson Plan for Unit Coding ......................... 288
Appendix O: Coding Preservice Teacher Unit ................................. 294
LIST OF TABLES

Table 1  Instructional Sequence for Both Courses......................... 33
Table 2  Research Questions, Data Source & Analysis..................... 44
Table 3  Elementary Science Inquiry Continuum............................ 49
Table 4  Case Study Survey Data .............................................. 62
Table 5  Cindy Final Unit Overview........................................... 67
Table 6  Cindy’s Instructional Strategies for Diverse Learners............ 78
Table 7  Connie’s Unit Summary ............................................... 99
Table 8  Class Developed Chart – Properties of Matter .................... 101
Table 9  Connie’s Instructional Strategies for Diverse Learners......... 106
Table 10 Karen’s Unit Summary ............................................... 123
Table 11 Karen’s Instructional Strategies for Diverse Learners......... 132
Table 12 Emily Unit Overview.................................................. 156
Table 13 Emily’s Instructional Strategies for Diverse Learners......... 165
Table 14 Cross Case Analysis Table ......................................... 186
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Cindy’s Final Unit Overview</td>
<td>92</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Connie’s Final Unit Overview</td>
<td>112</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Karen’s Final Unit Overview</td>
<td>140</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Emily’s Final Unit Overview</td>
<td>175</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Continuum Teaching Science</td>
<td>213</td>
</tr>
</tbody>
</table>
CHAPTER 1: INTRODUCTION

Teacher quality has a great impact on student learning. Traditional methods of preparing teachers have come under fire across the country for their inability to address the needs of students in increasingly diverse classrooms and to provide adequately supported clinical field experiences (2006). This issue is of particular importance given the current education climate. Criticism of university-based teacher education program suggests teachers are not being prepared for outcome based, accountability-driven educational systems.

Additionally, upcoming state and federal testing of science is creating an educational shift toward increasing science content taught at the elementary level. The No Child Left Behind (NCLB) legislation mandates that schools begin testing science knowledge in the 2006-2007 school year ("No Child Left Behind Act," 2001). This increased focus on science has placed a significant need for schools of education to prepare teachers to meet the needs of an increasingly diverse student body in a high stakes testing atmosphere. Schools of education placement offices struggle to provide science based field experiences for elementary preservice teachers since science is a subject many elementary teachers have traditionally avoided teaching due to poor experiences as a student and/or a lack of content understanding (Fulp, 2002). Historically, up to this point, even teachers more comfortable with teaching science, particularly those in urban settings, have pushed the subject aside due to the focus of high stakes testing of literacy and math (Falk & Drayton, 2004).
In response to the national attention on science education, the NCLB legislation has brought the focus to the classroom level. It is here where research demonstrates that teachers at all levels are struggling to raise student science scores (Cavanagh, 2005). The urban classroom offers even more challenges, further widening the achievement gap found between high and low performing students. Therefore, if we, as teacher educators, do not prepare our elementary teachers to teach science during their years at the university they will be at a significant disadvantage in helping their students learn science.

Most teacher educators agree that providing authentic classroom experience for pre-service teachers is critical to their development as teachers. Unfortunately providing quality field experiences is rather problematic. For many schools of education, it is logistically difficult, if not impossible, to locate a sufficient number of teachers who are (1) teaching science, and (2) using and modifying standards-based curriculum and appropriate teaching practices. In addition, given the varying contexts, schedules, and demands of practicum offices, beginning teachers are often expected to complete one set of assignments for their early field experiences and another set for their methods courses. This situation often leads to a disconnected relationship between what is learned in preservice teachers’ methods courses and what they are learning as a part of their field experiences (Foote & Cook-Cottone, 2004).

There is a growing consensus that much of the coursework in science methods courses is too disconnected from the context of practice making a preservice teacher’s transition into the classroom difficult (Crawford, 1999). There is question as to whether
the current required science content and methods courses and university supported field experiences provide enough scaffolding and support for teachers to gain the skills necessary to instruct and respond to diverse student needs and develop their skills and knowledge.

In response to this great need, we designed a science method course to be an intensive field-experience driven course in which our preservice teachers teach a complete standards-based curriculum module to urban elementary students in an afterschool program. In this course our students adapt, modify, and teach a standards-based curriculum to a group of diverse urban students in an after-school program as a core component of the course. We have maintained the second section of our science methods to be more traditionally based in the university setting.

This research will allow me to highlight the affordances and constraints of a field-based science method course and a university-based science methods course. What is gained in the university-based section that the field-based experience may miss? To that end, the questions that are the focus of my dissertation are:

• How does the type of methods class (field-based or university-based) influence preservice teachers’ comfort level in terms of the science content?

• How does the type of methods class (field-based or university-based) influence preservice teachers’ beliefs about teaching SES, linguistically and ethnically diverse students science?

• How does the type of methods class (field-based or university-based) influence preservice teachers’ beliefs on teaching science through science inquiry?

• How does the type of methods class (field-based or university-based) influence the preservice teacher's ability to design a lesson to meet the needs of SES, linguistically, and ethnically diverse urban students?
My study will allow me to explore the interaction between the preservice teachers, their instructors and their students in the field-based methods course and the interaction between the instructors and the students in the university methods course. My study will inform the field of elementary science education about the effectiveness and challenges of both a university science methods course and a field-based science methods course on preservice teachers self efficacy, and their ability to plan and teach inquiry-based science to meet the needs of their diverse students. My hypothesis is that a more effective approach to teaching preservice teachers science methods is a supported field methods science course. In the process I will be able to provide information about the impact these two approaches have on preservice teachers ability to teach inquiry-based science.

Four chapters will follow this introduction. Chapter 2 presents a review and evaluation of the literature on elementary science teacher education. Chapter 3 will explain the methodology of my study. Chapter four provides both the quantitative and qualitative results of my research as well as the cross case analysis.
CHAPTER 2: REVIEW OF THE LITERATURE

Elementary science instruction is in great need of improvement (National Research Council, 2007). Teachers lack opportunities to learn science inquiry, the teaching practice endorsed by the science standards and benchmarks. University science methods courses and field experiences offer few opportunities to experience learning through inquiry and even fewer opportunities to practice this type of instruction in a classroom setting. The difficult transition from science methods courses to the classroom has great impacts on teacher self-efficacy and their ability to incorporate this inquiry-based instruction in their future classroom, particularly those with diverse populations. The debate in current literature is how to reform science education at the university level to make it more connected to practice and diverse learners so that preservice teachers are more prepared to teach science once in the classroom. In this study the term diverse learners refers to elementary students from low socioeconomic status (SES), and/or diverse cultural, and linguistic backgrounds. My study, therefore, is comparing two approaches to instructing preservice teachers, one the traditional university-based science methods course and the other a field-based science methods course based in an urban afterschool science club.

The focus of this review is to explore ways in which the field of elementary science education has worked with preservice teachers to develop this vision of inquiry science so that they may incorporate it into their future instruction. Several studies have examined how to improve the design and implementation of elementary science methods courses so that preservice teachers are prepared to teach science once in the classroom.
This review serves to explore the current field of elementary science education and its impact on elementary preservice teachers’ self-efficacy and readiness to teach science and address the needs of their diverse students. I will begin this by describing the incredible disparities that science instruction represents for diverse students in many of today’s elementary classrooms. I will then highlight the research examining inquiry science and its role in the traditional university-based science method route of preparing preservice teachers to teach inquiry-based science. This will include the current status of university-based science methods courses, related field experiences in elementary classrooms, and their impacts on teacher self-efficacy and their ability to teach diverse students. Finally I will review the small amount of literature focusing on new approaches to preparing preservice teachers, particularly those that work to connect their preservice teachers to practice.

**Current Status of Science Teaching at the Elementary Level**

An increased focus on science has placed a significant need for schools of education to prepare teachers for the high stakes testing atmosphere. This can be challenging since science is a subject many elementary teachers have traditionally avoided teaching due to poor experiences as a student and/or a lack of content understanding (Fulp, 2002). Elementary teachers often do not see themselves as science teachers (Collins, 1997). Teachers rarely specialize in the subject in their college coursework, have one science methods course and have few if any opportunities to teach the subject before having their own classroom. Consequently, once in the classroom they
often avoid teaching science due to their lack of confidence in teaching it effectively (Akerson, 2004).

The situation in the urban setting is often more difficult. In that setting teachers lack the time, expertise, and materials necessary for their diverse students (Cawley, Foley, & Miller, 2003) and as a result often resort to whole class instructional approaches (Haberman, 1991). Therefore, when teachers are required to teach science in their elementary classroom, they must resort to what they know or believe which may be weak as well as inconsistent with the goals of the science reform effort (Lynch, 1997). These prior beliefs can range from student-centered inquiry-based instructional approaches to strongly didactic and teacher-centered approaches. These low teacher expectations for diverse students create inequitable learning environments and the qualities (National Research Council, 2007). Thus, preparing teachers to meet the expectations of today’s elementary classroom and student needs is quite challenging.

**Inquiry Science**

To avoid having science being viewed as fragmented bits of information the National Research Council (1996) and American Association for the Advancement of Science (American Association for the Advancement of Science, 1993) recommend inquiry oriented science instruction at all levels of schooling. Scientific inquiry is defined by the National Research Council (NRC) in the National Science Education Standards (NSES) as

“a multifaceted 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 known in light of experimental evidence; using
Instruction based in inquiry has a wide range of approaches, ranging from confirmation or structured inquiry where the students are given a direct procedure to follow from the teacher, to guided inquiry where the students are provided with a problem to investigate but given freedom to determine the best methods to resolve it, and finally to open or independent inquiry where students develop their own questions and design their own investigations. As one progresses from structured to open inquiry, the investigations become more challenging for the students and more complex for teachers to manage and prepare (National Research Council, 2000). Inquiry-based instruction has been shown to result in greater student achievement, particularly those of diverse backgrounds, than more traditional science instruction (Duschl, Schweingruber, & Shouse, 2006).

A recent synthesis suggests that teachers will teach a subject the way they encountered it as a learner (Baxter, Jenkins, Southerland, & Wilson, 2004). This suggests that teachers need to first experience this type of instruction before learning to teach this way. Yet, preservice teachers typically experience and observe science instruction that is teacher centered (Smith, 1999), much different from the instruction recommended by the NSES. Jarrett (1999) found that pre-service teachers who demonstrated interest in science and confidence in teaching science had a quality elementary science experience followed by subject matter knowledge measured by the number of science courses taken. Furthermore, pre-service teachers who engaged in authentic inquiry research were able to
translate that experience into their own teaching and were better able to support their students in developing skills for inquiry (Britner & Finson, 2005). Yet these examples are more the contrary than the norm. Preservice teachers rarely receive opportunities to participate in inquiry-based instruction in their science classrooms or courses at the university.

This leads to the question of how to design science methods classes to provide preservice teachers with effective experiences that will support them in engaging their elementary students in scientific inquiry.

*Preservice Teachers’ Beliefs and Knowledge about Teaching Science*

Crawford (2007) found the most critical predictor for preservice teachers to teach inquiry in practice was their complex set of personal beliefs based on their understanding of science as inquiry, and their belief of teaching and learning. Preservice teacher encounters with new material needs to be engaging and powerful, since learning and inquiry are dependent on prior beliefs that help to make current information intelligible and also helps to organize and define new information (Lynch, 1996). Otherwise, teachers can gravitate to the familiar rejecting ideas that do not match their beliefs (Chinn & Anderson, 1993). They need more formal learning opportunities than in-service teachers as they have little experience to base understanding (Melear, Goodlaxson, Warne, & Hickok, 2000).

Many pre-service teachers tend to hold beliefs that are consistent with didactic approaches that emphasize lecturing and memorization of content, despite the inquiry-based instruction they encounter in science methods courses. This could be a result of
what Lortie (1975) calls the “apprenticeship of observation” where ideas and beliefs become so engrained by years sitting in K-12 classrooms. These beliefs can be further solidified once novice teachers enter a school whose prevailing culture does not match the inquiry-oriented approaches they experienced in their university coursework. Rather, their teaching experience in schools tends to match their experiences as a student in K-12 classrooms instead of their experiences in the university setting (Richardson, 1996). This research highlights the incredible need for science methods course instructors to structure their courses in a manner that aids preservice teachers in confronting their beliefs and to provide experiences for them to experience or at least see inquiry in action in an elementary classroom.

*Elementary Teacher Preparation for Science Instruction*

To develop a vision of practice, teachers must develop knowledge of their learners and their development in social contexts, knowledge of their subject, and knowledge of teaching (Darling-Hammond, Hammerness, Grossman, Rust, & Shulman, 2005). It is also understood in the educational community that teachers should be expert in both the subject matter content and pedagogical knowledge (Shulman, 1986).

In an effort to achieve this vision, traditional elementary science teacher preparation programs generally consist of three different components: arts and sciences classes, education classes and field-based experiences. Arts and Science courses are generally geared toward one of the science disciplines and taught outside the school of education. Science education methods courses are traditionally taught to preservice elementary teachers in the university setting. Instructors of university-based science
methods courses have varied philosophies and approaches in an effort to best prepare their preservice teachers for their future elementary classrooms. Field placements generally occur as a separate entity from the university courses and have their own set of assignments and protocols for the preservice teachers to follow as they observe their cooperating teacher (Smith, Banilower, McMahon, & Weiss, 2002). I will discuss the research regarding each of the components of a traditional elementary teacher preparation program below.

*Arts and Science Courses*

Content knowledge is an important component of a preservice teacher’s preparation. As discussed above, the *Standards and the Benchmarks* recommend inquiry and open-ended investigations for K-16 classrooms and science teacher education. Yet in a study of the relationship between science and math teacher preparation and new teacher knowledge, beliefs and performance and student learning outcomes, it was discovered that neither Arts and Science nor teacher education faculty incorporated such methods in their classes (Melear et al., 2000). The content courses that pre-service teachers are required to take often fail to incorporate strategies that promote learning through inquiry and thus do not improve the pre-service teacher’s ability to create an inquiry lesson plan (Luera, Moyer, & Everett, 2005). Teachers who majored in a subject were no more able to explain the fundamental concepts of their discipline than nonmajors (Kennedy, 1991). These types of experiences have the potential to lead preservice teachers to view science as mastering a body of facts and principles and thus once in a classroom align their instruction along those same principles (Loucks-Horsley, 1997).
Furthermore, many pre-service teachers demonstrate success in science content courses where explicit instructions are either presented in a traditional lecture based classroom and/or through “cookbook” laboratory exercises. These pre-service teachers can experience tension however, when presented with science instruction that is more nontraditional and open-ended (Melear et al., 2000). It is not surprising then, that Roth, McGuinn, and Bowen (1998) described a case where pre-service science teachers preformed poorly, nearly at the level of eighth graders, when asked to do an authentic representation of data. Since preservice teachers rarely experience inquiry in their science classes and when they do they often struggle with it, it becomes even more important to incorporate scientific inquiry into their elementary science methods course and other experiences in their teacher preparation program.

*University-based Science Methods Courses*

Professors of science education choose from various frameworks in which to base their course. Some of the frameworks include the Learning Cycle Theory (Cavallo, Miller, & Saunders, 2002; Marek, Laubach, & Pedersen, 2003) and the Nature of Science framework (Akerson, Morrison, & McDuffie, 2006; Baxter et al., 2004). The learning cycle theory offers three phases of learning science: 1) exploration, 2) concept invention/term introduction, and 3) concept application. The Nature of Science (NOS) framework reflects science as a way of knowing or the values and beliefs fundamental to the development of scientific knowledge (Lederman, 1992). For the purposes of this review however, I will focus on research that explores inquiry-based science methods courses and field experiences. The purpose behind this is twofold. First, the research on
inquiry-based science methods courses is much more extensive, ranging from preservice teachers personal experience in their K-12 years, through their college preparation and into their own classrooms. Second, both the National Science Education Standards (National Research Council, 1996) and the Benchmarks (American Association for the Advancement of Science, 1993) state that scientific inquiry (as explained above) should be the basis of science instruction.

The research base on inquiry-based science methods courses is vast. Therefore, I selected the following only to give a sample of the research on methods courses grounded in science inquiry. Melear, Goodlaxson, Warne, and Hickok (2000) described a program where they directly introduce pre-service teachers to the inquiry process through small, seven person, laboratory sessions. It was their hope to mirror the methods scientists use to approach questions in the laboratory. Despite students’ initial uneasiness with the unstructured nature of the class all students reflected positively about the class. Journaling between the students and instructors became a key element in the success of the course. In the end students learned to design extended open-ended self-initiated experiments, interpret experimental data, formulate results, and present a portion of their work in a scientific format both orally and in writing. Crawford (1999) found that it is realistic for preservice teachers to develop the skills to teach inquiry with the proper training. This training began by having preservice teachers explore their beliefs about teaching science, then providing them with authentic investigations and later models of inquiry teaching in field placements or through video cases. Finally, the instructor worked with them to create long term units, and engaged them to inquire into their own
teaching and subsequent student learning in preparation for upcoming lessons. Crawford found that the one focal student of this study was able to teach two full inquiry-based units that she had developed. Crawford questions why other students in her cohort were unable to accomplish the same. Science methods courses can be grounded in a large variety of frameworks. Of these frameworks, inquiry science based science methods courses require a great amount of preparation on the part of the teacher educator in hopes that the preservice teachers leave their course prepared to engage students in inquiry-based instruction.

*Field Experiences*

Research demonstrates that a one-semester science methods course may be insufficient in developing the skills necessary for effective science inquiry instruction (Newman et al., 2004) and that pre-service teachers have difficulty in transferring knowledge and skills gained in methods to their classroom (Black, 2004). Even with the completion of two pre-service science education courses researchers found that teacher self-efficacy increased but had little impact on their Science Teaching Outcome Expectancy (STOE) (Mulholland, Dorman, & Odgers, 2004).

Therefore, field experiences are intended to provide pre-service teachers with opportunities to apply the knowledge and teaching strategies learned in their methods courses. These field experiences, coupled with the methods courses, work to build the skills necessary for a successful student teaching experience.

The field placement component of a science education program can be critical to a science education program’s success (Ellis, 2001). The time pre-service teachers spend
teaching science to elementary students can greatly enhance their confidence in science instruction (Cantrell, Young, & Moore, 2003; Crawford, Zembal-Saul, Munford, & Friedrichsen, 2005). Cantrell et. al., (2003) found that preservice elementary teachers who were able to teach science for at least 3 hours over a period of three weeks demonstrated a greater growth in self efficacy than those who taught less or were unable to teach science.

Yet, field experiences offered through many schools of education struggle to make the positive impact they were designed to have on preservice teachers particularly in the field of science education. It can be challenging to place pre-service teachers with enough teachers who are working against the grain (Cochran-Smith, 1991) of teacher directed science teaching. Often pre-service teachers are placed in classrooms where science is taught are placed with learning environments based in lecturing and the memorization of content (Hewson, Tabachnick, Zeichner, & Lemberger, 1999). The field placement for pre-service teachers can result in tensions between what the pre-service teacher has learned in the science methods course and what they experience in the classroom (Hancock & Gallard, 2004).

In addition, given the varying contexts, schedules, and demands of practicum offices beginning teachers are often are expected to complete one set of assignments for their early field experiences and another set for their methods courses. This situation often leads to a disconnected relationship between what is learned in pre-service teachers’ methods courses and what they are learning as a part of their field experiences (Foote & Cook-Cottone, 2004). Such situation leads to, as Fullan (1985) pointed out, technical
field experiences. That is field experiences that lead to an apprenticeship in which critical, reflective conversations give way to an image of teaching as a technical field. Berliner (1985) even suggested that early field experiences operate against improved practice by emphasizing technical skills at the expense of analytic development.

Unfortunately, for many pre-service teachers these early field placements often fail to provide the opportunity to teach science either because science is seen as the role of a science specialist or because their cooperating teacher does not feel confident in teaching science (Clift & Brady, 2005). As a result the pedagogical strategies that were emphasized in their science methods classroom are lost when the pre-service teachers reach the elementary classroom due to the barriers facing them. To complicate matters more, a field placement has the potential to negatively effect a pre-service teachers belief that teachers can positively influence children in elementary science (Plourde, 2002).

As indicated above, each stage of elementary preservice teachers’ preparation presents challenges to their ability to understand and present science content and challenges to their own self-efficacy that they can teach inquiry-based science to diverse students effectively. There are steps that can be taken at each level to work to improve preservice teachers’ experience and preparation so that they can have a greater impact in diverse classrooms.

TRANSITION INTO THE CLASSROOM

Teaching Science to Diverse Students

It is important that educators who teach science to students identified as English Languages Learners be well versed in science content and pedagogy, and also skilled in pedagogical approaches for integrating language acquisition and science learning. (National Science Teachers Association, 2009)
With classrooms becoming increasingly diverse, preservice teachers must be prepared to meet the needs of all students educating them to higher levels of understanding and competence (Bryan & Atwater, 2002, Melnick, 1998). Yet, the complexities in learning to teach in diverse settings are great. For science teacher educators who are preparing teachers for urban schools the issues are also more pronounced because there is often a disconnect between the experience and culture of pre-service teacher and the students that they will be teaching. To further complicate matters few science teacher educators themselves have experienced teaching students who are culturally different (Bryan & Atwater, 2002) and are not prepared to teach new teachers in this area. It follows that preservice teachers in many multicultural programs developed by teacher educators leave the program unaware of the lives and communities of their diverse students, remain unaware of their own beliefs, stereotypes and prejudices, and leave the program lacking the skills needed to effectively instruct diverse students (Zeichner & Hoeft, 1996). The result is that instruction often fails to provide equitable learning opportunities for these students (Lee, 2005).

The complexity involved in meeting students’ needs while instructing them is great. Poorly trained teachers can do more harm to students understanding and appreciation for science than good. It is found that low self-efficacy in teaching science is characterized by authoritative, teacher-centered approaches, while high self-efficacy centers around inquiry and student-centered teaching strategies (Lee & Houseal, 2003). Additionally, a strong contributor to low achievement among African–American students’ is inappropriate teaching strategies that include a reliance on reading as a sole
source of information (Teel, Debruin-Parecki, & Covington, 1998).

However preservice teacher education programs are being developed to better prepare preservice teachers for culturally diverse classrooms. Research shows that it is important for pre-service teachers to develop knowledge in both content and language instruction in order to adequately teach and assess science writing and content knowledge in their ELLs (Huang & Morgan, 2003).

Southerland and Gess-Newsome (1999) found strategies to assist their preservice teachers in understanding the intent of inclusive science teaching that builds upon student diversity. To begin with, preservice teachers must come to understand their own cultural biases before beginning to understand the knowledge and needs their students bring to the classroom. Second, they maintain that their students gained skills to make effective decisions regarding the curriculum to be used in inclusive classrooms. Third, novice teachers must be supported as they investigate their student abilities, habits, cultures and the impact of these attributes on learning that teaching. Finally, the preservice teachers’ image of fixed abilities needs to be challenged.

Research also indicates that hands-on, inquiry-based science is particularly effective for ELL students, as it bridges contextualized exploration of natural phenomena, authentic language activities, and communication of ideas in a variety of formats, including written, oral, gestural, and graphic (Fathman & Crowther, 2006; Lee, Deaktor, Hart, Cuevas, & Enders, 2005; Rosebery, Warren, & Conant, 1992).

Case studies based on diverse learners experiences with inquiry based science like this one represented here, can be a start to helping preservice teachers see the great
potential that is possible. Ballenger, Ogonowski and Rosebery’s study (2001) found that a fifth grade Latino student and his classmates were capable of developing a scientific inquiry-based investigation related to his class’ long-term study of ants. This open student led investigation demonstrated their ability to engage in scientific inquiry, including reasoning and argumentation.

However, the research on urban field experiences is beginning to note certain qualities of experiences that enhance the probability of prospective teachers developing the skills and confidence to teach in urban settings. In fact, studies of the effects on teacher candidates field experiences in urban and diverse schools are complex and, at times yield contradicting results (Cook & Van Cleaf, 2000; Fry & McKiney, 1997; Weiner, 1990). It appears that although quality placements in urban schools may inspire teacher candidates to become dedicated to teaching in urban settings, field experiences in urban schools can also cause culture shock, cognitive dissonance, and a lack of efficacy among future teachers (Rushton, 2000).

Fortunately, recent research has documented strategies that can help to ease the pre-service teacher transition from the science methods course to the classroom. Placing pre-service teachers in urban schools as pairs can aid in providing a positive experience for the students (Tobin, Roth, & Zimmermann, 2001). Strong relationships between the pre-service teacher and the cooperating teacher in urban schools can also help to improve student self-efficacy related to teaching in the urban setting (Ruston, 2003).

Foote and Cook-Cottone (2004) in their study of pre-service teachers and urban field placement supervisors found that successful urban field experiences must include
mutually beneficial interactions for teacher candidates. This means that future teachers need to be intimately involved in their practice in order to develop knowledge, skills, and dispositions that might provoke an interest in urban service. They also found that supervision during the field placements and critical feedback on their lessons is critical to the growth of the pre-service teachers. There would be little disagreement with the latter point, however, there is often the practical reality that most schools of education do not have sufficient resources, particularly supervisors that are knowledgeable in science, to provide the necessary supervision that is required (Clift & Brady, 2005). The lack of consistency of connecting with high quality elementary science teachers for field placements, especially in our urban schools, highlights the critical need for science educators to rethink the role of the science method course. These studies suggest that more structured field placements with critical feedback directed toward the science content and student learning may be able to address this need.

**Field-based Science Methods Courses**

A major criticism of university-based methods courses is that much of what is taught in methods courses is taken out of context of the schools (Goodlad, 1990) and reflects on teaching and learning in the abstract (Darling-Hammond & Baratz-Snowden, 2005). The theory becomes far too removed from practice.

Problems can arise when teachers struggle to transition from learning how to think like a teacher to learning how to act like a teacher (Darling-Hammond, 2006). Preservice teachers in field placements often do not feel as if they are the teachers and rarely get enough opportunities to practice (Boz, 2006) especially in the field of science.
Without the proper supports, teachers struggle with this “problem of enactment” (Kennedy, 1999) once they reach their new classroom.

Science methods courses work to improve the way preservice teachers think about teaching science. In practice preservice teachers are often left on their own to make the transition from thinking like a teacher to actually having to teach. The current structure can leave the key part of actually knowing how to teach science to be learned in poorly supported field placement assignments or even worse this cycle has great potential to leave preservice teachers struggling to understand how to teach science in their own future classrooms.

Therefore, it is recommended that teacher education programs offer student teachers “consistent opportunities to apply what they are learning, analyzing what happens, and adjust their efforts accordingly” (Darling-Hammond & Baratz-Snowden, 2005, p. 31). Bransford, Brown, & Cocking concur stating that teacher education programs often “fail to provide the types of learning experiences which lead to learning for understanding or teaching for understanding” (1999, p. xvii). They suggest that in order for preservice teachers to become effective teachers they need opportunities for deliberate practice where coaches provide specific feedback to improve instruction.

It is important that field-based experiences are integrated with university-based courses. Using a situated learning model, Eick, Ware, and Williams (2003) placed preservice teachers from their science methods course in a coteaching placement with middle school teachers once a week. One partner would teach the first period, reflect in a free period and then the second partner would teach. They found that these preservice
teachers gained comfort and confidence in science teaching, built critical reflection through modeling their cooperating teacher’s lesson, were more confident in managing student behavior, and experienced the positive effect of seeing and doing inquiry in practice. They suggest more research on the effects of real time teaching assistance.

Ohana (2004) did a comparison study between two different groups in her university-based science methods courses. One was a traditional science methods course with regular college students, and the other, an experimental cohort group that took each of their methods courses and extended field experiences together for three years. She found that students in the cohort related much of their journal entries to their experience in the field placement to each other while the traditional students however referred continually to the readings and class lectures making few references to their field placements. Evaluations revealed that the cohort had left her class without changing their perceptions on teaching science, while the traditional students only made reference to science education in practice toward the end. She felt that despite the extended experiences, the cohort had missed an opportunity to grow in their understanding of science. In fact, neither group in her mind had bridged from practice to theory or theory to practice. She suggests field experiences that are structured for a purpose.

_Bridging Theory into Practice_

The lack of experience in teaching science in urban settings and the current structure of field experiences in most schools of education leave preservice elementary teachers ill prepared to teach science to diverse students (Metcalf, Hammer, & Kahlich, 1996; Moore, 2003).
There are strategies that can aid this transition for preservice teachers. Darling-Hammond (2006) found strong teacher preparation programs to have several common approaches to bridge theory into practice through field experiences. These components include: case studies written by preservice teachers based on observations, interviews and data collection of pupils; analysis of teaching and learning via student work samples, videotapes of instruction, and curriculum materials; teaching portfolios where preservice teachers collect materials and documents to represent their work in a field placement; logs, journals and reflective essays to support preservice teacher reflection with specific feedback from instructors or supervisors; and autobiography and self-reflection to promote self-awareness of the preservice teachers’ philosophies (Darling-Hammond & Baratz-Snowden, 2005).

While these instructional techniques provide preservice teachers opportunities to work more closely and purposely with students they still lack continuity between a science methods course and the field placement. More specifically, the field portion is still a separate entity to the course. For science, particularly in this political climate, a field placement separate from the science methods course can present a problem as represented by the research in this review. More and more research speaks to providing more authentic experiences for preservice teacher preparation. Situated cognition, (Brown, Collins, & Duguid, 1989; Cobb & Bowers, 1999) a theoretical framework of learning offers a lens through which to consider this. From a situated cognition perspective learning and action are not separate constructs, but rather learning, action, and context are deeply intertwined with one another. From this perspective, preservice
teachers who are expected to teach students from significantly different cultural and
ethnic heritages from their own need to be immersed in experiences in which they can
implement and reflect upon the practices of what it means to be teacher of diverse
students. Lave and Wegner (1991) purport the importance of situating learning in a
context. Further, according to Sherin (2002) the act of teaching and learning for teachers
is intricately connected. Teaching inevitably leads not only to improved pedagogical
practice but also to enhance understanding of content and how to design and sequence
instruction to support student learning. Thus, from Sherin’s perspective if beginning
elementary teachers are to learn to teach science they must have experience in teaching
science to students.

The research question for this study is how to improve elementary preservice
teacher preparation so that preservice teachers are prepared to teach inquiry science to
diverse students once in the classroom. Research in this review indicates preservice
teachers need solid experience in the arts and science and methods course with open
inquiry, and more authentic experiences with elementary students. But preservice
teachers attempts to teach inquiry-based science to diverse elementary students must be
supported by supervisors knowledgeable of both science inquiry and diverse student
needs.

This study will make a contribution to this body of literature by addressing a lack
of studies in the science education literature on field-based science methods courses and
to the broader literature by connecting preservice teacher science learning to their growth
and preparedness to teach inquiry-based science to diverse students.
CHAPTER 3: METHODS

The purpose of this study is to identify those factors and/or experiences associated with preservice teacher learning, to teach inquiry-based science to diverse learners. Additionally, it is important to learn how a methods course can support that learning. I hope to generate specific recommendations for improving the preparation of elementary preservice teachers. I studied two sections of an elementary preservice teacher science methods course.

Many of the studies reviewed in the previous chapter were based on science methods courses and preservice teachers. In this chapter, I begin by describing my methodological approach. Then, I describe my research study including the context of the two methods courses, the role of the methods courses in this study, the research design, data sources and management and data analysis. The specific exercises and activities offered in each of the methods courses will also be included. My research questions are:

1. How does the type of methods class (field-based or university-based) influence preservice teachers’ comfort level in terms of the science content?

2. How does the type of methods class (field-based or university-based) influence preservice teachers’ beliefs about teaching culturally and linguistically diverse learners science?

3. How does the type of methods class (field-based or university-based) influence the preservice teachers’ ability to design a lesson to meet the needs of culturally and linguistically diverse urban students?

4. How does the type of methods class (field-based or university-based) influence preservice teachers’ beliefs on teaching science through science inquiry?
METHODOLOGICAL APPROACH

Given the nature of this study, in order to test the effect of the two different types of methods classes, I will use a mixed-methods research design where measures include comparison groups with both pre and post surveys. I will also utilize design based research (Brown, 1992). Design based research plays an important role in this study, because it “focuses on understanding the messiness of real-world practice, with the context being a core part of the story and not an extraneous variable to be trivialized” (Barab & Squire, 2004). While few designed based studies with preservice teachers have been done, the context of the science methods course aligns well with design-based research (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Additionally, the value of design-based research in education is that it uses the results of its studies to continually refine and guide instruction (Bell, Hoadley, & Linn, 2004). This methodology works with our research because it takes place during both a field and university-based science methods course where a professor, doctoral student and classroom science specialist continually collaborate to revise the courses as needed to meet preservice teacher needs.

This study will be looking at preservice teacher learning while simultaneously looking at the effectiveness of the tools used to support that learning (Shavelson, Phillips, Towne, & Feuer, 2003). In this study, I am evaluating preservice teacher learning based on the artifacts created as a result of their experience within the messy context of both a field- and university-based science methods course. By using a designed based model,
this research has potential to inform the improvement of the preparation of our elementary science teachers to teach inquiry based science to diverse learners both within our own science methods course as well as help other teacher educators think about potential applications to their science education programs.

**CONTEXT – THE ELEMENTARY SCIENCE METHODS COURSES**

This study takes place in two sections of a one-semester elementary science methods course, a field-based science methods course and a university-based science methods course. The science requirement for the preservice teachers at our university is to take two science courses, one lab based, with the Arts and Science faculty in addition to the methods course. Over the past two years, Professors from the School of Education in collaboration with the Geology and Biology departments in the School of Arts and Science have developed a science sequence for the elementary preservice teachers. The sequence consists of an educationally oriented geology and a biology/physics based science course, where a team consisting of a geophysist, biologist, astrophysist and science educators specifically designed labs to promote content knowledge knowledge coupled with scientific inquiry. Each lab in the Geology course is designed to engage the preservice teachers in authentic inquiry practices similar to those of practicing seismologists. The labs in the Biology/Physics based course continue to build the preservice teachers experience with scientific inquiry. Some of the labs in these courses introduce preservice teachers to water filtering, conservation of angular motion, physics of the design and development of a roller coaster, and the design and redesign for experimental error to determine the amount of calories (energy) in a nut. Therefore, we
expect at least a portion of the preservice teachers enrolled in our science methods course arrive with a few guided inquiry experiences.

Additionally our preservice teachers are required to fulfill three pre-practicums, one in an urban classroom, one in a suburban classroom and one in a private school if possible. The practicum office hires field supervisors to observe the preservice teachers on a weekly basis providing feedback on one to three lessons, depending on which level of practicum the preservice teacher is completing. The final step, like most universities, is for the preservice teacher to complete their student teaching in a school setting of their choice.

The preservice teachers also take one elementary science methods course, generally in the last two to three semesters of their program. The same faculty member and myself, the teaching assistant, teach both sections of that course. I also performed the interviews for the focus preservice teachers and have also spent one year designing and teaching the lab portion of the collaborated science content course and three years working with the science methods course. While all attempts to avoid bias in the analysis of this study will be taken, there is still a possibility that some amount of bias remains. I have incorporated multiple sources of data including pre/post surveys, pre/post interviews, and final units in an attempt to minimize that bias that may exist because as one of the instructors who have helped to develop the field based model.

My dissertation focuses on preservice teachers in each of the two sections of the science methods course, the field-based section and the university-based section. This study occurs during the spring semester of 2007 of both sections of the elementary
science methods class with approximately 20 preservice teachers enrolled in each. The students chose to enroll in one class or the other so I was not able to randomly assign them to the two different classes yet, preservice teachers often are placed in a particular class due to overflow or schedule conflicts.

   Each section meets for two-and-a-half hours per week for fourteen weeks. The course is structured around the concept of a teaching cycle (Wilson, Shulman, & Richet, 1987) and explores four different stages involved in instruction: 1) clarifying learning goals: students’ knowledge and practice, 2) learning environment: teacher planning and strategies, assessment reflection, and revision, and 3) reflection and inquiry on teacher practice. Also note that as part of this science methods course and research we have adopted the definition by the National Research Council in the National Science Education Standards.

   “a multifaceted 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 known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions, and communicating the results”, (National Research Council, 1996).

   This is the model that serves as the foundation for our work with inquiry. Next I will describe both the field and universities based course sections and then draw comparisons between the two sections.

   The Field-based Science Methods Course

   Over the past two years a team of science educators (both university and school district based), former science methods students and myself as the teaching assistant have redesigned one of the two sections of our elementary science methods course at a New
England university. In an effort to provide a focused, supportive field experience for our preservice teachers the preservice elementary teachers in the new section teach an afterschool science club as part of the school’s academic based afterschool program. The class meets for one afternoon a week for two and one-half hours. For eight weeks each pair of pre-service teachers teaches three to five of the elementary afterschool students for 45 minutes once a week. A typical class held at Eisenhower Elementary begins with a 20-minute period to gather supplies and prepare final preparations for the day’s lesson. The students are then released to their science club classrooms where our preservice teachers will teach elementary students for a 45-minute period. Once the science club ends, students go home and preservice teachers gather back together to debrief as a class, to reflect on things that went well and cover any celebrations, questions or concerns the preservice teachers may have to share. That begins a detailed discussion where both peers and instructors are responding with instructional techniques and other suggestions for the preservice teacher pair to consider for the next lesson the following week. The last 30 minutes of class, we, the instructors, cover topics to build their understanding of science instruction including such topics as scientific inquiry and strategies for diverse. This is the only university supported opportunity for preservice teachers to teach in the school setting outside of the college mandated pre-practicum experience, and almost the only opportunity for these preservice teachers to teach science to students. Meanwhile the second section continues to be taught solely on campus, and will be described in more detail later.

The first three and last two weeks of the field-based course are taught on the
college campus in which preservice teachers are introduced to curriculum materials, learn how to evaluate and sequence instructional materials, and discuss and participate in inquiry-based science. This particular semester, due to winter and spring breaks, the field-based science methods course initially meet for three classes on campus. This allowed us to introduce the curriculum and its content to the preservice teachers and work with them to prepare the initial misconception interview, pretest, and the first lesson in detail. We then had two weeks at Eisenhower Elementary, the first week being the misconception interview and the second week being the first lesson (see Table 1).
### Table 1: Instructional Sequence of Both Science Method Courses

<table>
<thead>
<tr>
<th>Week</th>
<th>Field-based</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Introduction to the course Goals and expectations What does it mean to know science? Student misconceptions (Met on campus)</td>
<td>Day 1: (started mid week) Introduction to the course Goals and expectations What does it mean to know science?</td>
</tr>
<tr>
<td>Week 2</td>
<td>Science Standards Energy and Motion Evaluating Curriculum (Met on Campus)</td>
<td>Day 1: What does it mean to know science? How do students learn science? Student misconceptions Day 2: Science Standards Energy and Motion</td>
</tr>
<tr>
<td>Week 3</td>
<td>Evaluating Curriculum (con’t) Designing an Instructional Sequence (Met on Campus)</td>
<td>Day 1: Evaluating Curriculum Force and Motion Day 2: Evaluating Curriculum</td>
</tr>
<tr>
<td>Week 4</td>
<td>Student Misconception Interviews Designing Science Lessons (1st day at Eisenhower Elementary – Afterschool Science Club)</td>
<td>Day 1: Evaluating Curriculum selected by Preservice teachers Day 2: Designing science lessons (Preservice critique of example of a fairly strong lesson)</td>
</tr>
<tr>
<td>Week 5</td>
<td>Designing Science Lessons (Afterschool Science Club)</td>
<td>Day 1: Designing Science Lessons Day 2: Critique videotaped science lessons</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>Scientific Inquiry (con’t) Literacy Strategies (Afterschool Science Club)</td>
<td>NOTE: PST pairs begin teaching lessons to their peers and receive feedback to start each class from now till the end of the semester.</td>
</tr>
<tr>
<td>8</td>
<td>Understanding and designing for diversity. Look at continuum of ELL student work. (Afterschool Science Club)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Understanding and designing for diversity (Afterschool Science Club)</td>
<td>Day 1: Understanding and designing for diversity.</td>
</tr>
<tr>
<td>10</td>
<td>Assessment (Afterschool Science Club)</td>
<td>Day 1: Instructional strategies, Observe video from urban science classroom</td>
</tr>
<tr>
<td>11</td>
<td>Assessment Design (Afterschool Science Club)</td>
<td>Day 1: Assessment Development of assessment items</td>
</tr>
<tr>
<td>12</td>
<td>Connecting Science Club to Classroom Science (Afterschool Science Club)</td>
<td>Day 1: School holiday, no class</td>
</tr>
<tr>
<td>13</td>
<td>Science Centers of various science content (Met on campus)</td>
<td>Day 1: Utilizing the outdoors for science instruction</td>
</tr>
<tr>
<td>14</td>
<td>Technology and Science and Society (Met on campus)</td>
<td>Day 1: Technology</td>
</tr>
</tbody>
</table>
Then, due to a public school holiday, we had a week to meet at the university campus to regroup. This was beneficial because it gave the preservice teachers time to analyze the pretests taken by their students, and prepare for the next few weeks of lessons with our assistance. Then, the next six weeks were back at the science club where preservice teachers taught the remainder of the unit and gave final assessments. The last two classes were held back at the university. These two classes gave us time to cover additional content and instructional methods.

The unit that the preservice teachers field-based methods section taught to their afterschool school second and third grade students was based on Delta Education *Science in a Nutshell Energy and Motion Kit*. This kit was selected due to the active nature of the lessons and the science materials it provided that could be used for investigations with the elementary students. The content was selected to aid the elementary preservice teachers in becoming comfortable with physics, a topic elementary preservice teachers often avoid. And finally, this kit was selected because the lessons have much room for improvement in their ability to engage and instruct diverse students. As instructors, we provided the preservice teachers with other key materials and key curriculum resources for them to refer to. Some of these resources included the National Science Teacher Association’s *Stop Faking It Force and Motion* book (2002) and Wenham’s *Understanding Primary Science Ideas, Concepts and Explanations* (Wenham, 1995). This will offer me an opportunity to determine teacher effectiveness at modifying and adapting curriculum to meet the needs of their students.
Please note, that the science specialist at the urban school plays a key role in helping the field-based section succeed. This science specialist plays a key role in his school district by leading professional development sessions for teachers, and has been a leader in his own school by developing a school garden that is a focus for many investigations. As part of our science methods course, he walks into each ‘classroom’ to observe the preservice teachers and later give feedback, brings the practical experience and insight to group discussions, and helps to bridge our work at the university to the urban school.

*The University-based Methods Course*

The university-based methods course expands on the curriculum material evaluation and sequence mentioned in the field based section above (see Table 1). This section met for two mornings a week for one hour and fifteen minutes each morning. Additionally, as a part of the course the preservice teachers teach one short lesson to their peers, receive critical feedback immediately following and then reflect on a video of their lesson. Preservice teachers also do student misconception interviews with a student in their prepracticum placement, evaluate elementary science curriculum, review English Language Learner (ELL) student work over time, and develop assessments and rubrics based on their final science unit topic.

This university-based course also works to build on the preservice teachers’ experience with inquiry through in class activities and by looking specifically at strategies and methodologies so that they have the skills to bring these types of experiences to their students in their future classroom. The preservice teachers engage in
a variety of scientific inquiry investigations taking the role of elementary students. For example, they conduct investigations that address force and motion, engineering and simple machines, chemical reactions, outdoor ecology, and plant growth. The university-based course also incorporates classroom writing from diverse elementary students and urban classroom video cases. The writing and video are analyzed as a class to review for inquiry and diverse learner strategies.

Comparison of the Two Sections

As you can see in Table 1 there are similarities and differences between the two sections of the course. Preservice teachers in both sections of the methods course complete similar assignments that included a student science misconception interview, curriculum evaluation, reflection journal entry on a lesson taught, and a six-lesson science unit as a final project.

The science misconception interview is an interview developed and administered by preservice teachers in both course sections so that they learn their student’s existing understanding of a particular science topic. It is important that teachers take their students’ misconceptions into account for their instruction. In the university-based section preservice teachers administered their misconception interview with a student in their practicum classroom and then develop a six-lesson unit. Their unit is based on a self-selected topic. The misconception interviews for the field-based science methods section, however, were completed with students enrolled in afterschool club. This misconception interview became part of the pre/post-assessment for the physics based unit the preservice teachers will teach. The final unit for the field-based section focused
on the lessons the preservice teachers developed, taught and revised for their students. See appendices C and D to see how the misconception assignment for each course aligns with one another.

We had the preservice teachers use an adapted version of the Project 2061 curriculum evaluation criteria (Kesidou & Roseman, 2002). Initially, both sections adapted and identified strengths and weaknesses Delta in a Nutshell Force and Motion curriculum using the curriculum review. This assignment was graded for the field-based students. The university-based section, however, continued to do a second evaluation of science curriculum of their choice, which became the graded curriculum assignment for these preservice teachers. See Appendices E and F to see the curriculum assignment for each of the methods courses.

Content addressed in each section also varies. The field-based methods section focuses on one content area, physics, by teaching a unit on force and motion. Meanwhile, the university-based section covered various science domains, for example, inquiry projects based on puddle explorations, evaporation etc.

Direct instruction for diverse learners strategies in each section is comparable. Lectures, activities such as analyzing a continuum of ELL student work, and analyzing lessons for evidence of supportive instructional strategies. Additionally, the university-based methods section focuses literacy strategies like analyzing ELL student writing. The field based preservice teachers do get the opportunity to discuss issues they may have encountered as they worked with diverse students in their science club with their teaching partner, peers in the course, and the three instructors.
Participants

*University participants.* Subjects in this study are preservice teachers in their second or third year of an elementary education degree at a Northeastern University who gave me permission to interview and use their work for research purposes. The preservice teachers in each of the sections are predominately white, Caucasian females, which corresponds closely with the make up of students in the larger education program. All pre-service teachers in the two courses are traditional college students being in their early twenties and in their second or third field placement before entering student teaching.

The case studies in this study consist of four preservice teachers, two from each of the sections. Preservice teachers are selected in terms of their pre-survey scores on content knowledge and background, self-efficacy, inquiry based instructional preferences and interest in teaching diverse learners. In this research, though, eight preservice teachers were initially selected based on the above qualities. However, this dissertation represents four of those preservice teachers who best exemplify the range of inquiry and diverse learner beliefs. For each section, I selected one preservice teacher who scored low or the middle and/or were mixed in their thinking in these areas, and one preservice teacher in each who scored toward more toward the higher end. Toward the end of the selection process, the defining factor for selected participants was based on their inquiry beliefs. Therefore, the preservice teachers beliefs at the low to middle end would be considered more toward the traditional or teacher guided levels of inquiry and the beliefs of the preservice teachers on the high end would be considered more open or student
directed inquiry. This selection works to represent a range of all of the preservice teachers in the two courses.

_Eisenhower Elementary Students._ Eisenhower Elementary, the site for the afterschool science club, is an extended services elementary school and is among the most culturally and ethnically diverse in a large New England city. It has 311 students and 36 different languages represented among the student body. Twenty-one percent of the students are English Language Learners (ELL). Currently, 49% of students identify as Hispanic, 23% as African American, 17% as Caucasian, and 11% as Asian. Eighty percent (80%) of the Eisenhower students meet the federal poverty guidelines to participate in the Free or reduced price lunch program. Currently 60 first through 5th grade students are enrolled in the science club taught as part of the field-based methods course.

In the next section, I describe the data sources and then discuss the analysis procedures.

**DATA SOURCES**

I collected data from multiple sources to measure preservice teacher understanding and beliefs on inquiry science and diverse learners: pre/post course wide teacher surveys, pre/post teacher interviews, and final units.

_Teacher Survey._ Each preservice teacher in both sections agreed to be part of the study at this level. I administered identical pre-post surveys based upon Horizon Research Inc.’s instrument measuring preservice teacher beliefs regarding their preparation to teach science through inquiry to diverse students. The instrument has 17 multiple-choice items and three open ended responses. The survey highlights any
changes in how well preservice teachers feel prepared to teach multiple disciplines of science content including Earth science, biology, chemistry, physics, and environmental and resource issues. It addresses changes in preservice teacher beliefs and understanding around the importance of inquiry based science instruction and how well they feel prepared to teach it. Sample questions in this section include: ‘provide concrete experiences before abstract concepts’, ‘and ‘plan and conduct a simple investigation’. Other inquiry questions ask preservice teachers to anticipate how often they will incorporate certain instructional strategies and how often their students will participate in various types of activities in their future classroom. Questions in this section include: ‘use open ended sentences’ and ‘lecture on science content’, and how often students in their future class will: ‘analyze data, ‘read from a science textbook’. Additionally, preservice teachers share their teaching philosophy by responding to questions related to two paragraphs that briefly describe two teachers with very different instructional styles, a more traditional style of teacher led questioning and a more open style where the teacher didn’t necessarily know the answers to student questioning. Preservice teachers were also asked to share their opinion about teaching science to SES, ethnically and linguistically diverse students that occurred throughout the semester. Questions in this section included: ‘I will be able to teach science to children whose first language is not English’, ‘I do not know teaching strategies that will help children who are English Language Learners (or those from low socioeconomic backgrounds) achieve in science’. And finally, the survey gathered a bit of personal background information from the preservice teachers which included gender, ethnicity, year in school, high school and
college level science courses completed, grade levels of students they have worked with in prepracticum placements, interest in which grade level they hope to teach, and experience with diverse populations, related training, and any other languages spoken. I drew comparisons between participant self-reported growth in the survey and other course assignments. However it is important to note that preservice teachers’s self reports should not be taken as necessarily accurate reports of their subject matter knowledge. See Appendix A for a copy of the Preservice Science Teacher Survey.

Pre and Post Interviews. Preservice teachers may be unable to express their true ideas and understandings through surveys and written work alone. In many of the assignments, preservice teachers could focus on many aspects of their experience other than their self-efficacy related to content and diverse student learning. Therefore, in an effort to more fully probe their thinking, I interviewed the four focus preservice teachers at the beginning of the semester and at the end, with the same interview protocol. The pre interviews were administered within the second week of the class. The topic of the classes they had already experienced included a discussion around “what is science” and the National Science Education Standards. The post interview was administered in the two weeks following the end of the semester.

The purpose of the interview was to gain a deeper understanding of the preservice teachers ideas, beliefs, and confidence around teaching inquiry based science instruction to diverse students in urban settings. During the interview I asked about their interest in teaching science and to describe an example of what they felt was an excellent lesson and then later to explain their understanding of inquiry. I also asked how they felt about
working with and teaching diverse students, and to describe strategies they felt would support a diverse learner during a science lesson. This variety of questions provided a window for preservice teachers to speak openly about their ideas around what inquiry based science instruction for diverse looks like in the classroom. Finally, in the second interview I asked preservice teachers to describe their impressions of the course. See Appendix B for the interview protocol.

**Final Unit Plans**

Preservice teachers in both sections developed a final curriculum unit with an instructional sequence for six 45-60 minute lessons. The unit requirements included: a unit introduction, science background (detailed explanation of the meaning of the science standards), six detailed lessons, references, individual reflections based on unit development and expected outcomes, and three unit extensions. The field-based methods section additionally handed in copies of their student work (pre/post tests, formative assessments etc.) from the afterschool club. This unit will serve to measure the preservice teachers’ understanding of diverse student learning by the manner in which they design their lessons. Note that the individual reflections from the unit plans was also analyzed for each of the case studies. See Appendices E and F for each section’s assignment.

**DATA ANALYSIS**

After collecting these data sources, I analyzed the data to address my different research questions. In Table 2 I have listed my research questions, the data sources for each question and how each source was analyzed. In this section, I discuss how I
analyzed each of the individual data sources as well as how I combined the data sources to address my four research questions.
Table 2: Research Questions, Data Source, and Data Analysis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does the type of methods class (field-based or university-based) influence preservice teachers’ comfort level in terms of the science content?</td>
<td>Preservice teacher survey data</td>
<td>Survey data were analyzed using a principle component factor analysis. The factors were then analyzed using a paired t-test for each methods class.</td>
</tr>
<tr>
<td></td>
<td>*Interviews</td>
<td>Qualitative data were used to create 4 case studies. These case studies will be entered into a multilevel data reduction where cross case analyses look at differences and themes across the cases and sections of courses.</td>
</tr>
<tr>
<td>How does the type of methods class (field or university-based) influence preservice teachers’ beliefs about teaching linguistically, and ethnically diverse students science?</td>
<td>Preservice survey data</td>
<td>Survey data were analyzed using a principle component factor analysis. The factors were then analyzed using a paired t-test for each methods class.</td>
</tr>
<tr>
<td></td>
<td>*Interviews</td>
<td>Qualitative data were used to create 4 case studies. These case studies will be entered into a multilevel data reduction where cross case analyses look at differences and themes across the cases and sections of courses.</td>
</tr>
<tr>
<td>How does the type of methods class (field-based or university-based) influence preservice teachers’ beliefs on teaching science through science inquiry?</td>
<td>Preservice teacher survey data</td>
<td>Survey data were analyzed using a principle component factor analysis. The factors were then analyzed using a paired t-test for each methods class.</td>
</tr>
<tr>
<td></td>
<td>*Interviews</td>
<td>Qualitative data were used to create 4 case studies. These case studies will be entered into a multilevel data reduction where cross case analyses look at differences and themes across the cases and sections of courses.</td>
</tr>
<tr>
<td>How does the type of methods class (field-based or university-based) influence the preservice teacher's ability to design a lesson to meet the needs of linguistically, and ethnically diverse students?</td>
<td>*Preservice teachers’ final unit plans</td>
<td>Qualitative data were used to create 4 case studies. These case studies will be entered into a multilevel data reduction where cross case analyses look at differences and themes across the cases and sections of courses.</td>
</tr>
<tr>
<td></td>
<td>*Interviews</td>
<td>*Data from four case studies</td>
</tr>
</tbody>
</table>
Quantitative Analysis

Pre and Post Teacher Survey

For all participants in both sections who agreed to be part of the study, pre-post surveys were administered based upon Horizon Research Inc.’s instrument measuring preservice teacher beliefs regarding their preparation to teach science through inquiry to diverse students. I then used principle component factor analysis using Varimax rotation to combine multiple items from the survey into constructs in order to increase the reliability of our measures and to create more manageable constructs for analysis. I conducted factor analyses around our three main areas of interest: science content, diverse learners and scientific inquiry. All factors with an eigenvalue greater than 1 were then checked for reliability using Cronbach’s alpha. The nine resulting factors all had reliabilities of 0.71 or higher. The analysis resulted in four content factors (physics, chemistry, earth science and biology), one diverse learners factor (race and gender) and four inquiry factors (traditional science, inquiry practices, discussion, openness).

Unfortunately, I was unable to construct another reliable factor around the preservice teachers’ level of comfort with English Language Learners (ELL). Although I had included eight items on the survey targeting ELLs, the reliability of the factor was only 0.5351 so I am not confident in its ability to reliably measure the construct. This low reliability suggests the preservice teachers were not consistent in how they responded to the eight items.

The survey questions that make up each factor are in Appendix K and will be described in more detail here. Survey questions for the Science Content factor included
questions related to biology, chemistry and physics. A sample question in this factor was for preservice teachers to indicate how prepared they felt to teach 'chemical reactions (chemistry)' or 'energy and heat (physics)'. The diverse learner factor is made up of questions asking preservice teachers to provide their opinion about statements related to teaching diverse learners including: ‘I do not know teaching strategies that will help children who are English Language Learners achieve in science,’ and ‘use strategies that specifically encourage participation of females and minorities in science.’ Questions that made up the discussion factor asked preservice teachers to anticipate how they will do each of the following in their science class included, ‘encourage students to consider alternative explanations,’ and ‘require students to supply evidence to support their claims’. The openness factor pulls from the section of the interview that addresses whether preservice teachers were comfortable with a more teacher directed form of questioning or a more student led discussion type of instruction. The inquiry factor explores how well prepared preservice teachers felt to teach using scientific inquiry skills including: ‘plan and conduct a simple investigation’ and ‘use data to construct a reasonable explanation’. Finally, the traditional view of science measures preservice teacher growth in what they anticipated their students would take part in, including: ‘read from a science textbook in class’ and ‘answer textbook/worksheet questions’.

Qualitative Analysis

The analysis focuses on four case studies, two in each science methods section. As mentioned previously, for the case studies I collected data from the multiple sources to provide me with the information necessary to perform a multilevel data reduction case.
I did three levels of data reduction analysis across common themes to highlight the difference between the two sections. I first wrote a case study for each of the four students selected, and then look for themes across the four cases in each section. I then looked across the cases to identify themes from each section of the science methods course. Next, I analyzed those themes to look for differences and similarities across the courses. Finally, I construct the themes from tables looking for things that are key out of the cases that I studied (Miles & Huberman, 1994).

*Interviews*

Looking more closely at this process, I will now review how I analyzed the interview data. The analysis occurred in several stages. Each interview was recorded and transcribed. For the coding of the interviews, a coding scheme was created to help analyze preservice teacher understanding of teaching inquiry based science to diverse students. There were six codes for the interview protocol (Appendix L) which will be described in more detail below.

After the initial design of the interview protocol a second rater was trained. Each rater scored two interviews individually with an 82% overlap. For the first preservice teacher there were 11 disagreements out of 55 for an inter-rater reliability of 80%, 44/55. For the second preservice teacher there were 17 disagreements out of 55 for an inter-rater reliability of 69%. Nine of the disagreements were around one specific code, inquiry. All disagreements, though, were resolved through discussions. Typically, comparing the interview transcripts was sufficient to resolve the disagreement. These discussions resulted in the revision and clarification of a number of codes. Once again, the two raters
chose two interviews to code independently. From thereon the final six interviews for the inter-rater reliability rose to a stable 78.3%. The final codes are listed in Appendix M, and the final coding scheme for the interviews is in Appendix L.

The six codes for the interview protocol were based on preservice teachers understanding and belief around inquiry, teaching diverse students, opportunities to teach or observe and how well they feel prepared to teach. I will now discuss each code in more detail. A key aspect of the coding scheme is the inquiry section. The first code determined the preservice teachers’ belief and understanding of inquiry based science instruction based on how they described an excellent lesson. As the preservice teacher described her idea of an excellent science lesson I mapped her ideas onto an elementary focused Inquiry Continuum, Table 3, that we adapted from the National Research Council (2000, p. 29).
<table>
<thead>
<tr>
<th>Level /Criteria</th>
<th>Level 4</th>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
<th>0 (didn’t do)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Develop Research Questions or Challenge</strong></td>
<td>Learner poses a question independently.</td>
<td>Learner selects among questions or poses new questions with support from teacher.</td>
<td>Learner sharpens or clarifies question provided by teacher, materials, or other sources.</td>
<td>Learner engages in question provided by teacher, materials, or other sources.</td>
<td>No Response</td>
</tr>
<tr>
<td><strong>Design Investigation or Structure</strong></td>
<td>Learner designs investigation procedure or structure including choosing variables and controlling variables.</td>
<td>Learner given some variables and controls, and/or designs investigation procedure or structure.</td>
<td>Learner given most of the variables and controls as well as a model investigation procedure or structure from teacher, curriculum or other materials.</td>
<td>Learner given entire investigation procedure or structure by teacher, curriculum, or other sources.</td>
<td>No Response</td>
</tr>
<tr>
<td><strong>Collect and Acquire Data</strong></td>
<td>Learner collects all data.</td>
<td>Learner collects majority of data, but given some data.</td>
<td>Learner given the majority of data, but collects some.</td>
<td>Learner given all data.</td>
<td>No Response</td>
</tr>
</tbody>
</table>

More--------------------------Amount of Learner Self Direction-------------------Less
Less--------------------------Amount of Direction from Teacher or Material-------------------More

(Adapted from NSES Inquiry Chart, p. 29, 2000)
### Table 3: Elementary Science Inquiry Continuum (Continued)

<table>
<thead>
<tr>
<th><strong>Organizing Making Sense of Data</strong></th>
<th><strong>Constructing Explanations and Models</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner determines how to organize data (e.g. graph, table, drawing).</td>
<td>Learner formulates explanations or models using evidence from their investigation and reasoning (including appropriate scientific concepts). Learner provided opportunity to share connections, does more interpretation</td>
</tr>
<tr>
<td>Learner provided guidance on how to organize data (e.g. create a graph).</td>
<td>Learner guided in including evidence and reasoning to formulate their explanation or model. (e.g. write a conclusion using evidence from your investigation. Explain why the evidence supports your conclusion). Provide less structured guidance that allows them to interpret the data themselves and provide explanation.</td>
</tr>
<tr>
<td>Learner told how to organize data (e.g. make a line graph with heights of plants on the y-axis and time on the x-axis).</td>
<td>Learner given context specific prompts or examples to use evidence and reasoning to formulate their explanation or model. (e.g. Write a claim that more friction either causes a car to go faster or slower. Use the speed of the car from your experiment as evidence. Explain why you think friction influences the speed). Learners provided opportunity to share connections they make, some guidance is offered.</td>
</tr>
<tr>
<td>Learner given specific structure or scaffold to organize data (e.g. line graph with x and y axis already labeled and learner just fills in data).</td>
<td>Learner given explanations or models to choose from. (e.g. provided with three possible models about how we see object and the student has to circle one of the models considering what he/she found in their investigation). Learner provided opportunity and told precisely what data to share. Very guided.</td>
</tr>
</tbody>
</table>

| More---------------------------------| Amount of Learner Self Direction----------------| Less |
| Less---------------------------------| Amount of Direction from Teacher or Material-----| More |

(Adapted from NSES Inquiry Chart, p. 29, 2000)
The Inquiry Continuum lists the features of an inquiry-based investigation and their range of variations in the amount of support provided by the teacher as determined by the National Research Council. It specifically identifies the key features of an inquiry-based investigation which includes: developing research questions or challenge, designing an investigation, collecting data, making sense of that data, and constructing explanations or models.

The inquiry continuum played a key role in the coding of both the interviews and the final units due to its ability to highlight whether a lesson incorporated key aspects of an investigation. By mapping out each of the lessons in each preservice teachers’ unit, it immediately becomes evident whether the preservice teacher understood inquiry based science simply by whether an investigation has been presented. The rich descriptions of each step involved in an investigation helped to guide the scoring of each of the five key features or criteria.

Each of the inquiry continuum criteria are ranked from 0-4, where 0 represents that a statement that did not include any aspect of an inquiry based investigation. If the statement does represent some level of inquiry then the idea is ranked from 1 Teacher Directed to 4 Student Directed. This was a challenging thing to determine in our initial coding. We finally were able to clarify it by indicating if a response happened to bridge two categories, we would select the more structured category.

Preservice teachers were then asked to describe how prepared they feel to teach in that manner and why. Then, preservice teachers were asked directly to describe their understanding of inquiry. These responses were once again mapped onto the inquiry
continuum. The interview continues by asking the preservice teachers how they feel about working with diverse learners and then to describe the strategies they would use in a science lesson to support these students.

Another important aspect of my interview was to determine the preservice teachers’ belief around working with diverse students. We had to revise the criteria a bit initially, but finally decided that preservice fell into one of these categories, Level 3, excited, confident, optimistic; Level 2, Comfortable; and Level 3, Cautious. Our clarifications in this category were also a great help wherein Level 3, the preservice teacher was positive, Level 2, neutral, and Level 1 slightly negative, concerned, worried or nervous. And finally for diverse learners preservice teacher comments were carefully reviewed to determine what strategies they felt would best support diverse student learning. These strategies included: structured routine, kinesthetic, visuals, semantic maps, charts, and word charts. Other strategies include: using student language to introduce new terms, connect the science instruction to student’s background, build rapport with the students family, and bring students cultural heritage into the classroom. Specific strategies were initially selected for the coding based on research in the field that demonstrates effective instructional interventions for diverse learners (Fathman & Crowther, 2006; Lee, Deaktor, Hart, Cuevas, & Enders, 2005; Rosebery, Warren, & Conant, 1992). Final ratings from the pre and post interviews and the final science unit related to this code were placed in a table to highlight preservice understanding of strategies for diverse learner instruction at each given time.
In the interview preservice teachers then share their personal experiences observing or teaching science to elementary students. This response was coded as to whether the preservice teacher had taught, assisted or observed and whether the lesson they experienced represented any inquiry. Once again, any preservice teacher inquiry experience was mapped onto the inquiry continuum. Finally, preservice teachers were asked to share how confident they felt about teaching science, marked with similar criteria as the confidence in teaching diverse learners discussed above, in their future classroom and why. The reasons for increased or decreased confidence grew a bit initially and finally became one of the following seven reasons for changes in confidence for teaching science: previous experience, content (hard/easy), behavior management, structure of the classroom, and emotional (good or bad experiences).

Final Science Unit

For the final science unit I followed much the same data reduction process as I did with the interviews. The second rater here was not as familiar initially with the science or the protocol so the training was much more detailed which included closely analyzing strong units and weak units using the unit protocol and mapping lessons onto the inquiry continuum. In the end though we were able to get an inter-rater reliability of 75%.

The units were quite detailed and sometimes hard to categorize. So before coding would begin if lessons were not already separated into introduction, investigation and closure, I indicated where these divisions seemed to naturally lie so that it would be explicit to the second rate. This protocol also incorporated the Inquiry Continuum, as part of its analysis. As stated before, each lesson was coded first to determine whether
there was an inquiry-based investigation for the students to participate in. Another key factor that was taken into consideration included whether each essential feature of the continuum, listed above in the interview section, had been incorporated into the lesson. If the inquiry feature was included, then it was coded from more teacher directed (1) to more student directed (4). These ratings were then plotted onto a continuum to highlight the level of inquiry that each lesson developed by preservice represented.

Taking the above factors into consideration when looking at one of the field based preservice teachers’ lesson entitled “Lesson 1: What things move: An introduction to Force” one sees that inquiry indeed plays a role in this lesson (See Appendix N). When looking at the inquiry continuum (Table 3) this activity would receive a 1 for the criteria develop research questions because the teacher announced the research questions. Yet, for the criteria designing investigation the students played more of a role in the investigations by conducting three guided trials to determine what caused a ball to move and what direction it moved. This criteria received a 2 because the preservice teacher gave students most of the variables and controls as well as offered a model investigation in the beginning. Students were given full responsibility to collect data on a worksheet provided by the teacher so this criteria received the highest score, a 4. The criteria Organizing/ Making Sense of the Data in this lesson received a 1 because the student was given a worksheet where they are only responsible to report the data. Finally, the criteria Construct Explanations and Models for this lesson received the score of 1 because students were told what data was to be shared, and closely guided by the teacher in developing explanations.
The final codes for units are listed in Appendix N. Codes related to the overall unit include whether the preservice teacher includes the term inquiry or hands on in their unit introduction, conveying a sense of purpose in the overarching goal, appropriate sequencing of the lessons, and accuracy and depth of content. Looking more closely at the lessons, the code *Accessing Prior Knowledge* explores whether the lessons indicate that the teacher accesses student prior knowledge through discussion, writing or drawing, or through connections to everyday life. The model lesson on force did two of the three approaches by asking students to recall times when they either rode a roller coaster or had thrown a ball and discuss it.

The diverse learner code looks to see how many lessons the preservice teacher provides support for diverse learners. The levels for the diverse learner supports code ranged from provided supports throughout the unit marked as a 2, to occasionally provided supports in at least 2 lessons marked as a 1, or failed to provide supports marked as a zero. The force unit received the score of 1 indicating that it provided supports for diverse learners in many of the lessons. The second part of the diverse learner code looked to see what strategies the preservice teachers were incorporating into their unit. The same diverse learner strategies as mentioned above in the interview were utilized in the unit protocol as well. When a strategy was incorporated into a lesson, it received a 1 on the protocol. Surprisingly one of the challenges here was whether a strategy mentioned in the lesson was kinesthetic or not. The initial description, “a physical representation of the concepts beyond the text” was a bit vague and proved to be a challenging point for the coders. It finally was clarified by stating “students act out or
teachers demonstrate” and providing an example from a lessons which stated, “um, keeping it all very physical, so for example exploring potential or kinetic energy with words that she could show it and label it”. The model force lesson represented the following diverse learner strategies: structured routine, kinesthetic activity, visuals, and a word chart.

The case studies were developed incorporating the quantitative results of the pre/post survey, and the qualitative results of the pre/post interviews and final unit. Each section of the case study was developed to address each of my research questions. Each case is presented addressing preservice teacher confidence in teaching science content and diverse learners. I also address preservice teacher understanding of strategies to support diverse student learning and understanding and interest in teaching inquiry based science.
CHAPTER 4: RESULTS

My data analysis address four specific research questions regarding how the field or university based science methods course influences preservice teachers’: 1) comfort level in terms of science content, 2) beliefs about teaching culturally and linguistically diverse urban students, 3) ability to design a lesson to meet the needs of culturally and linguistically diverse urban students, and 4) beliefs on teaching science through science inquiry. In this chapter the quantitative results from the pre/post survey are presented and discussed first. Then four case studies, two from the university based science methods course and two from the field based science methods course will be presented. Finally, a cross case analysis will be presented.

Quantitative Results

I investigated whether preservice teachers’ beliefs about science instruction and student learning changed over the semester and whether or not that growth varied depending on which methods section they were in. I conducted paired t-tests for each methods section to determine where there was significant growth. Table 5 presents my results from this analysis.

The four science content factors focus on preservice teachers’ comfort level with teaching physics, Earth science, biology, and chemistry. Students in both the field based and university-based sections had significant increases in their comfort level with the physics content based on the t-test. The asterisks next to scores indicate significance. The effect sizes for physics were fairly large for both sections. The university group had significant growth in earth science and biology content scores while the field group did
not have a significant change. Both groups showed a significant growth in their comfort level with chemistry content. This suggests that the students enrolled in the university course had a greater increase in comfort level for more science content areas compared to the field based section.

The second area focused on diverse learners where we were only able to reliably construct one factor. The race and gender factor focused on preservice teachers’ comfort level in meeting diverse learner needs while teaching science. Both groups had significant growth in race and gender. This suggests that there was not a difference in terms of the two courses ability to prepare students to teach diverse learners.

There were four factors around scientific inquiry: traditional science, inquiry practices and discussion, and openness. A low score for the traditional science factor would represent a preservice teacher who feels more comfortable with a level of structure that may include lecturing and following textbooks closely. A high score for traditional science represents a preservice teacher who is comfortable with inquiry-based instruction. A negative effect size is the desired outcome because it illustrates that the preservice teachers are developing a more inquiry view of science. A high score for inquiry practices means that the preservice teacher feels prepared to teach using scientific inquiry skills such as asking a question or planning and conducting a simple investigation. A high score for discussion represents a preservice teacher who feels comfortable with discussion and communication allowing students to explain their ideas. Finally, the openness factor had questions that focused on a preservice teacher’s comfort level with allowing students to explore content through their own questions, questions the
A preservice teacher may not know the answers to which would represent a high score. A low score here would represent a preservice teacher who used simple easily understood questions to lead discussion with her students.

Survey results from the t-test indicate that for traditional science, inquiry practices and discussion the field section demonstrated significant growth while the university section did not have significant growth. This indicates that the preservice teachers in the field-based science methods course overall may feel more comfortable allowing students to ask questions that the preservice teachers may be unfamiliar with, feel prepared to teach using inquiry skills such as planning or conducting a simple investigation, yet feel more comfortable with a level of structure which may indicate a more traditional textbook or lecture style of instruction. However, for the openness factor the university section had significant growth, while the field section did not. This indicates that the preservice teachers in the university-based science methods course are comfortable with allowing students to explore content using their own questions. It is important to note here, however, that the field-based preservice teachers may have experienced a ceiling effect which could have impacted their ability to show growth. They started the semester so high there wasn’t room for them to grow on the instrument.

**Qualitative Results: Case Studies**

These survey findings overall show specific trends developing for each of the two methods courses. The following four case studies will allow me to dive more into the potential ‘why’ behind these findings. For each of the four case studies I present the related survey results as compared to their peers see Table 5. It represents the data
gathered from both the pre/post interviews and final unit. I introduce the two university based preservice teachers first and then the two field based preservice teachers.
### Table 5 Case Study Survey Data

<table>
<thead>
<tr>
<th>Preservice Teacher</th>
<th>Pre PST Score</th>
<th>Pre Survey Mean (SD)</th>
<th>Post PST Score</th>
<th>Post Survey Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONTENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Physics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>15</td>
<td>11.00 (3.42)</td>
<td>15</td>
<td>14.43 (2.71)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>15</td>
<td>11.00 (3.42)</td>
<td>18</td>
<td>14.43 (2.71)</td>
</tr>
<tr>
<td>University Connie</td>
<td>9</td>
<td>9.6875 (3.38)</td>
<td>14</td>
<td>14.0625 (3.38)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>5</td>
<td>9.6875 (3.38)</td>
<td>12</td>
<td>14.0625 (3.38)</td>
</tr>
<tr>
<td><strong>Chemistry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>4</td>
<td>8.29 (2.46)</td>
<td>5</td>
<td>10.29 (3.10)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>8</td>
<td>8.29 (2.46)</td>
<td>10</td>
<td>10.29 (3.10)</td>
</tr>
<tr>
<td>University Connie</td>
<td>9</td>
<td>7.75 (2.54)</td>
<td>10</td>
<td>10.63 (2.99)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>8</td>
<td>7.75 (2.54)</td>
<td>12</td>
<td>10.63 (2.99)</td>
</tr>
<tr>
<td><strong>Earth Science</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>6</td>
<td>7.50 (1.51)</td>
<td>9</td>
<td>8.29 (2.02)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>9</td>
<td>7.50 (1.51)</td>
<td>12</td>
<td>8.29 (2.02)</td>
</tr>
<tr>
<td>University Connie</td>
<td>8</td>
<td>6.81 (2.83)</td>
<td>9</td>
<td>8.88 (1.45)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>3</td>
<td>6.81 (2.83)</td>
<td>9</td>
<td>8.88 (1.45)</td>
</tr>
<tr>
<td><strong>Biology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>17</td>
<td>12.64 (2.68)</td>
<td>15</td>
<td>13.39 (2.24)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>15</td>
<td>12.64 (2.68)</td>
<td>15</td>
<td>13.39 (2.24)</td>
</tr>
<tr>
<td>University Connie</td>
<td>17</td>
<td>10.56 (4.30)</td>
<td>16</td>
<td>15.56 (3.22)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>9</td>
<td>10.56 (4.30)</td>
<td>12</td>
<td>15.56 (3.22)</td>
</tr>
<tr>
<td><strong>DIVERSE LEARNERS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Race and Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>21</td>
<td>20.79 (2.15)</td>
<td>17</td>
<td>22.36 (2.56)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>17</td>
<td>20.79 (2.15)</td>
<td>21</td>
<td>22.36 (2.56)</td>
</tr>
<tr>
<td>University Connie</td>
<td>15</td>
<td>20.56 (2.06)</td>
<td>16</td>
<td>22.06 (2.32)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>17</td>
<td>20.56 (2.06)</td>
<td>16</td>
<td>22.06 (2.32)</td>
</tr>
</tbody>
</table>
Table 4: Case study Survey Data (continued)

<table>
<thead>
<tr>
<th>Preservice Teacher</th>
<th>Pre PST Score</th>
<th>Pre Survey Mean (SD)</th>
<th>Post PST Score</th>
<th>Post Survey Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INQUIRY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Traditional Science</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>11</td>
<td>15.14 (3.25)</td>
<td>15</td>
<td>13.39 (2.24)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>8</td>
<td>15.14 (3.25)</td>
<td>9</td>
<td>13.39 (2.24)</td>
</tr>
<tr>
<td>University Connie</td>
<td>12</td>
<td>15.93 (2.86)</td>
<td>11</td>
<td>15.73 (3.26)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>16</td>
<td>15.93 (2.86)</td>
<td>13</td>
<td>15.73 (3.26)</td>
</tr>
<tr>
<td><strong>Inquiry Practices</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>20</td>
<td>14.92 (3.20)</td>
<td>16</td>
<td>19.46 (.88)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>20</td>
<td>14.92 (3.20)</td>
<td>20</td>
<td>19.46 (.88)</td>
</tr>
<tr>
<td>University Connie</td>
<td>15</td>
<td>12.88 (3.07)</td>
<td>15</td>
<td>17.75 (2.41)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>15</td>
<td>12.88 (3.07)</td>
<td>19</td>
<td>17.75 (2.41)</td>
</tr>
<tr>
<td><strong>Discussion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>20</td>
<td>21.36 (2.65)</td>
<td>25</td>
<td>22.65 (1.86)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>21</td>
<td>21.36 (2.65)</td>
<td>24</td>
<td>22.65 (1.86)</td>
</tr>
<tr>
<td>University Connie</td>
<td>20</td>
<td>21.13 (3.54)</td>
<td>23</td>
<td>22.06 (2.08)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>19</td>
<td>21.13 (3.54)</td>
<td>24</td>
<td>22.06 (2.08)</td>
</tr>
<tr>
<td><strong>Openness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Emily</td>
<td>12</td>
<td>8.43 (1.65)</td>
<td>12</td>
<td>9.50 (1.83)</td>
</tr>
<tr>
<td>Field Karen</td>
<td>9</td>
<td>8.43 (1.65)</td>
<td>9</td>
<td>9.50 (1.83)</td>
</tr>
<tr>
<td>University Connie</td>
<td>11</td>
<td>6.93 (2.02)</td>
<td>11</td>
<td>8.67 (1.29)</td>
</tr>
<tr>
<td>University Cindy</td>
<td>8</td>
<td>6.93 (2.02)</td>
<td>8</td>
<td>8.67 (1.29)</td>
</tr>
</tbody>
</table>
CASE 1: CINDY – UNIVERSITY BASED PRESERVICE TEACHER

This study was conducted when Cindy was a junior and placed in a first grade urban classroom for her third prepracticum placement. She was an Elementary Education and a Human Development major, which in this university was a program that prepares students for work in social and community service. As a part of this course, Cindy developed a water cycle unit for third and fourth graders.

Cindy had no opportunity to observe students learning through science inquiry in her prepracticum placements. Cindy also reported no opportunities to teach science in any of her prepracticum placements, and one opportunity to observe a science lesson. Her previous two prepracticum placements were in a first grade classroom and later a resource room with special needs Kindergarten through fourth graders. “I haven’t (taught science) because my 1st prepracticum was reading and writing, other prepracticum was in a special needs elementary resource room” (preinterview). Her primary responsibilities in this prepracticum placement were to observe and grade papers. She did not observe a classroom for a prepracticum during the current semester. Cindy planned on teaching once she graduates.

Cindy’s extensive background in working with diverse students through summer positions and one prepracticum placement made her have a fondness for teaching special needs and diverse learners. Cindy was typical of elementary preservice teachers in that she was not very interested in science and math as subjects. She was excited, however, by the idea of teaching science because she felt it was a great subject to incorporate the
hands on instructional features which would reach diverse students so much better than traditional ‘lecture’ based lessons. “I see the students being very hands on because I think science is like the thing that you can do hands on, especially with kids. I think that is really exciting” (preinterview). In her final unit reflection, Cindy once again emphasized the role science can play in the education of diverse students. She shared, In my future classroom, I hope that science is a large part of my class. I think that science is a fun subject that can really get in touch with a lot of students. I believe that all students have different ways of learning, multiple intelligences, and I think that science is the subject to reach them all (final unit reflection.)

Cindy was enrolled in the university-based science methods course. Her attendance record was poor, attending only 65% of the class sessions, which was unusual for this class. This record may have hindered her ability to gain experiences and knowledge presented in the course. Her final unit for the course was based on the water cycle and designed for third through fifth graders.

As I present Cindy’s case I will illustrate her enthusiasm about teaching diverse students science and share how her personal experiences contributed to her interest. While she did show growth in her understanding and interest in teaching inquiry-based science to diverse students in her post interview, she struggled to incorporate that energy and related instructional strategies into her final science unit. She had difficulty in translating the theory of the course into practice. In the following sections I will address Cindy’s understanding and confidence in the areas of content knowledge, teaching diverse students, and inquiry teaching.
Content Knowledge and Confidence

Initially, Cindy’s presurvey and preinterview responses indicated that she was not confident with her content knowledge in science despite having taken biology, chemistry, physics in high school. Generally Cindy’s responses on the pre survey indicated that she felt less knowledgeable about science content than her classmates. She did, however, show stronger growth than her peers in her content understanding of physics ($\Delta 7$/class $\Delta 4.38$), Earth science ($\Delta 6$/ class $\Delta 2.07$), and chemistry ($\Delta 4$/class $\Delta 2.88$), with a lower level of growth than her peers in biology ($\Delta 3$/ class $\Delta 5$) (See Table 5). This strong growth in confidence in content could be supported by the content-based activities presented in the university based science methods course that semester. During her interview Cindy showed great excitement in referring to her high school Chemistry labs due to the lack of lecture, hands on nature of them. “I loved chemistry lab, my freshman year, I thought chemistry was so much fun, the lecture was the worst thing in my entire life. I couldn’t wait for the 3 hour labs” (preinterview). This ‘hands on’, fun nature of science became a theme with Cindy in her unit and will be explored in more detail in the following sections.

In summary, Cindy’s survey indicated strong growth in her understanding of science in each of these content areas: physics, chemistry, and earth science. She made no reference to her confidence with science in her final interview.

Unit Overview

For Cindy and her partner’s final unit, they designed a six-lesson unit entitled “Water, Water, Everywhere” for third and fourth graders (See Table 5). The final units
of these preservice teachers provided insight into their understanding of the content and inquiry-based teaching strategies for diverse learners. They began the unit with an introduction to the water cycle and then consecutively covered the concepts of evaporation, condensation, and precipitation over the next three lessons. Then the unit took on a social justice focus covering water quality and acid rain in the final two lessons so that the students would be able to determine safe drinking water since the water in local schools is undrinkable. The majority of these lessons were teacher directed and offered limited opportunity for students to engage in asking their own questions, working with data or developing their own explanations or models. For purposes of this research, I have referred to the unit as Cindy’s to simplify language.
<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Lesson Title/Content</th>
<th>Lesson Objective</th>
<th>Lesson Question</th>
<th>Lesson Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intro to Water Cycle</td>
<td>Students will identify: Evaporation, condensation, precipitation and collection</td>
<td>How is water as old as the Earth itself?</td>
<td>Discussion and demonstration: Students draw a water droplet journey (to address student misconceptions) and Velcro different pieces of water cycle on interactive board. Demonstration (15 min. allotted): What happens when the surface of an object or material is cooler than the air surrounding it?</td>
</tr>
<tr>
<td>2</td>
<td>Evaporation</td>
<td>Students should be able to state what evaporation is and about the different weather conditions necessary for this to happen.</td>
<td>Have you ever noticed how a local river or lake looks different throughout the year?</td>
<td>Discussion, demonstration, and investigation: Share story about a local lake. Why did the level of water go up and down? Evaporation Investigation – predict level of water for 1, 3, &amp; 5 days?</td>
</tr>
<tr>
<td>3</td>
<td>Condensation</td>
<td>Students should see how condensation occurs in the beakers in the classroom and connect to how it occurs naturally in the environment.</td>
<td>What happens when you put a glass of water on your kitchen table on a hot summer day?</td>
<td>Discussion, demonstration, and evap. investigation follow up: Students will record the amount of water left in the beaker. Students will look for condensation on beakers from last lesson. Did the water come from the outside of all your classmates’ beakers?</td>
</tr>
<tr>
<td>4</td>
<td>Precipitation</td>
<td>Students will be able to describe precipitation, its four types in video, why it is created and can be in different forms.</td>
<td>How can all these household items relate to science, do you think I can create precipitation with these items?</td>
<td>Discussion and demonstration: Precipitation demo: Boiling water and ice. Do you think I can create precipitation with these items? What would happen if there were plants beneath the pyrex?</td>
</tr>
<tr>
<td>5</td>
<td>Water quality</td>
<td>Students should be able to define collection and areas where collection takes place and discuss the definitions and imp of groundwater and surface water.</td>
<td>Have you ever seen, “The water from this faucet is not for drinking? Does anyone know why cannot drink from those certain faucet but not others?”</td>
<td>Discussion, investigation and demonstration: Determine water quality under a microscope. “The importance of this activity was to see that we cannot drink certain types of water due to the addition of ‘other things’ within it.”</td>
</tr>
</tbody>
</table>
When looking specifically at the science content and sequencing of concepts Cindy presented in her final unit, gaps in her understanding of the water cycle began to present themselves in the lessons she developed. An analysis of the unit determined a rank of one out of two in each of the following categories related to the appropriateness and accuracy of its content, content depth, and its sequencing (see Appendix N).

Cindy’s final unit did not completely or accurately address the key science concepts around the water cycle. The content presented in the fifth lesson, see Table 6, was inaccurate. At least one half of the lessons built a foundation of experiences for students allowing the concepts to build in complexity, but the connections between lessons were weak. More specifically, the unit offered a strong final goal of having students create a water droplet story but failed to present the lessons in a way that would help the students develop a conceptual understanding of the water cycle. Weak connections were made between the water cycle concepts. Each of these categories will be discussed in depth below. According to the American Association for the Advancement of Science (AAAS) benchmarks students at the elementary third through fifth grade level should understand that “when liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water (4B, The Earth #3 grades 3-5). The standards also suggest
that instruction at this level should focus on phase changes, and that clouds and rain are
interrelated (American Association for the Advancement of Science, 1993, p. 336).
At first glance it appeared that Cindy worked to address these standards in her final unit.
She had some strong qualities of instruction represented in her unit. She offered a strong
final goal for the students to work towards and made her instruction visual and fun for the
students, and tried to have them involved in the activities at least at some level.

Yet, upon closer evaluation, one realizes that out of all the phases of the water
cycle she chose to do condensation, a challenging stage in the water cycle, as a short 15-
minute piece at the end of the first introductory lesson. Rather than introducing the water
cycle as a set of integrated concepts, it appeared as though she was letting this key lesson
be driven by time management issues, fitting a challenging concept into an introductory
lesson rather than introducing it as the focus of the lesson.

After the introductory lesson, Cindy took a traditional approach to the water cycle
by presenting students with the concepts of evaporation, condensation, and then
precipitation, in that order. This sequence disregarded the fact that students at the third
and fourth grade levels may more easily be able to relate to precipitation; and if presented
initially in a water cycle unit, may help them to make stronger connections on subsequent
topics. Continuing on in lesson three when Cindy made condensation the focal point in
the unit she had the students check for condensation on the beakers students had set
around the classroom the previous day for an evaporation investigation. As part of the
lesson, she directed the students to make appropriate observations “based on what they
(the students) have learned in this lesson about condensation, they will make predictions
as to whether the water level in the cup will continue to rise, lower or stay the same and why.” Then she inaccurately indicated that students were to discuss the following questions with their partners: “1.) How did the water get onto the outside of the cup? 2) Where did the water come from? 3.) Did the water come from the outside of all of your classmates’ beakers?” It is important to note here that water vapor will only condense onto another surface when the temperature of that surface is cooler than the temperature of the water vapor, in other words there needs to be a temperature difference between the temperature of the liquid in the beakers and the air surrounding it. Beakers that were set out during the previous day’s evaporation lesson have had at least 24 hours to reach room temperature. Therefore, the students in this lesson had great potential to find their beakers with water present only on the inside, no condensation would be present.

Later, toward the end of the unit, in lesson 4 of 6 Cindy turned the focus of the unit from concepts of the water cycle to the importance of ‘water in our lives’. Throughout this portion of the unit, Cindy’s attempts to make the science connect to her students carried her away from the purpose and content focus of the unit, the water cycle, and in the process lose the interrelated nature of the water cycle. In one particular lesson, she indicated that the students were to test whether various water samples are drinkable by looking at the clarity of water though microscopes. She wanted to connect the lesson to the students’ lives by reminding them of the water coolers in the school hallways used in place of the unsafe drinking water in the water fountains. Students were to determine whether a sample of water was safe to drink based on the water’s clarity alone. In this lesson Cindy stated, “The importance of this activity was to see that we cannot drink
certain types of water due to the addition of other things within it. (Lesson 5)” This could be a strong activity when used in conjunction with other water quality tests. This lesson however was isolated, and furthermore not connected to gaining a deeper understanding of the water cycle. Similar to above, this again represents Cindy’s thinking of her unit as a series of activities rather than a coherent sequence of inquiry.

In her final unit reflection Cindy indicated that she understood that the water cycle was a “continuous process,” and that “it is important for students to realize how this cycle is constantly happening and is what helps us through many things.” But then, it seemed as if she didn’t expect all of the students to understand it. She continued by saying “I think that if the students could not truly discuss the stages of the water cycle, I think that it is still important for the students to recognize the importance of the water cycle to life.” Upon analysis of Cindy’s unit, this understanding seemed to drive her unit development. Cindy presented an abbreviated version of the water cycle presenting only the isolated concepts of evaporation, condensation and precipitation. Therefore, Cindy failed to make critical connections between conceptual ideas needed to help her students understand the relationships between the phases of the water cycle. While she did address concepts of evaporation, condensation, and precipitation she was lacking the interrelated nature of the water cycle.

In summary, Cindy’s lessons when analyzed indicated that there’s an incoherent picture of the water cycle as it was presented. Cindy’s lessons seem to be based on science facts rather than on the evolving changing understanding that science is a process. Cindy’s lessons indicate that she wasn’t helping the students to make connections
between conceptual ideas necessary to understand the relationships between the phases of
the water cycle. Therefore, the unit lacked a conceptual sequence as noted. The water
cycle is a traditional elementary science unit. Yet, in selecting lessons for her unit, Cindy
failed to introduce the water cycle as a cycle. Rather than appreciating its complex
relationships, it almost seemed as though she picked water cycle concepts based on the
length of a lesson or how well it fit into the unit as she had created it. Additionally she
only briefly touched on the related science concepts of evaporation, condensation, and
precipitation before moving on to water quality testing.

Confidence in Teaching Science Content

Cindy felt confident about teaching science as a subject due to its flexibility in
providing space for hands on activities and visual aides like powerpoint presentations. It
seems that because these instructional approaches worked for her as a student, they would
benefit all students, especially diverse students. “I see the students being very hands on
because I think science is like the thing that you can do hands on especially the kids, I
think that is really exciting” (Preinterview). In the post interview Cindy continued to
describe teaching science as something hands on and visual, a style that worked well for
her as a student.

I think I feel confident because I like the lessons that happen in science just
because I am a very hands on visual person, that’s why powerpoints with teachers
help me because if a teacher just lectures to me I kind of get this blank stare and I
don’t know what is important and I think it is all important I will just write it all
down. I just really like the visual hands on stuff, I feel like science is a subject
you can do that with and I think that is important because it can help all students (post interview).

Here she drew a correlation between science and a power point’s role in being straightforward and visual, both having the ability to benefit student learning. Through both interviews, Cindy’s understanding of teaching science reflected someone who believed it was a simple, straightforward subject that was hands on and visual. This was the belief she came to the course with and based all of her teaching on.

In her post interview, Cindy shared an experience from a science course that appeared to frustrate her. She disliked not having an answer for her inaccurate results during a chemistry lab and felt that science instruction at the elementary level would be different.

I know in my freshmen year, my experiment turned purple and it’s wasn’t supposed to turn purple and I was like why? And my Teaching Assistant was like you did something wrong, do it over, so there’s no answer. So I think like with these kids I am more prepared because I’ve had the hands on we did like the needs for seeds and we worked with pulleys, and I think it is just that I can relate to it and I can see what goes wrong. . . . I’m like, “ok this is what an experiment is going to look like through a kids eyes”. Like your not going to be like, “oh well it didn’t work because of like . . and then say some chemical equation”, no their misconception is like the rain comes because someone pocked a hole in the clouds, not because the water droplets and everything like that (post interview).
Here Cindy demonstrates her appreciation for the ‘hands on’ experiences she had as a student in the science methods course. She was further encouraged by reviewing the elementary science curriculum and learning how those investigations might be interpreted and explored by students. Cindy appeared to feel that elementary science and related student misconceptions were approachable for her as a teacher because she could understand the content and know what it is that goes wrong.

Diverse Students, Teaching Strategies and Confidence

Cindy scored high on both her confidence and interest in teaching science to diverse students in both her pre and post interview. Yet, her survey score dropped slightly (Δ-1/class Δ1.5) while her peers demonstrated slight growth. This was surprising, considering her glowing remarks about her experiences working with diverse students. A closer look at her pre and post survey responses consistently indicate that she did not feel she will be able to teach diverse students because she did not know any teaching strategies or ways to monitor their understanding through formative assessment measures.

Yet, Cindy’s high score in her interviews for interest in teaching diverse learners was supported by her extensive experience in working with diverse learners in various settings. When asked what she thought about teaching diverse students on the pre-interview Cindy exclaimed, “I love it, I love it, I think it is so much fun. . . my first prepracticum over half of my students spoke Spanish… so much fun.” “Fun” is how Cindy repeatedly describes her extensive experience with special needs students through university placements in schools and as a counselor at summer camps. Her post-interview

74
also supported this positive emotion, explaining that despite the constant repetition of
information sharing and frustrating moments with diverse students you do not give up,
“Certain days you came home crying I can’t do this, but the next day you come back no
matter what.”

Cindy also spoke passionately about reaching out to the students and celebrating
their culture. As a child adopted into this country, she felt a closeness to diverse students.
In the process she believed the students become more connected to the classroom and
their teacher. Cindy felt this connection helps students to want to learn more. Cindy even
connected her readiness to teach to her experience in working with diverse students in her
prepracticums.

In my other prepracticum (there) was a lot of Korean (students). I’m Korean.
There were two Korean bilingual teachers. Cool to have such diversity I saw the
teacher there tailoring it so that there was culture and diversity everywhere you
looked. Also you reach out to that child’s culture, especially if they are the only
one if they are the minority in the classroom if you reach out to that culture, at
least your saying to the kid I’m trying to connect with you. . . . Huge thing - when
you connect with a kid then they want to learn more. Then they’re like OK so
someone does care. . . .It’s like we’re going this extra mile, we will talk about
your culture it is all about you today… culture, food, family, experience it (pre
interview).

Here Cindy demonstrated her understanding and appreciation for teachers who
through their instruction acknowledge and appreciate the rich culture that students of
diverse backgrounds bring to the classroom. This statement contributed to her high score for interest in teaching diverse learners.

Cindy felt strongly about making her instruction visual for diverse students in the pre-interview. In her post-interview, she added strategies which included: ‘simplifying tasks’, pairing students, and ‘aiding vocabulary acquisition’ by providing synonyms. Here, she described in the pre-interview an experience where she found drawing illustrations to be helpful with, Katie, an ELL student she worked closely with as part of a prepracticum assignment:

I feel you can only explain things so far. Katie, she could see things, but if you wrote it down in English she couldn’t understand it. But if you drew a picture of a plant growing and you drew a seed, and a root, sprout and you keep going. It could take 5, 10, or more minutes but you can reach more kids, cause they can see this little drawing and they will soon be able to associate the drawing with the word. Putting everything more visually will help kids understand more (pre interview).

Using visuals to enhance science instruction, particularly for ELL students, was a common theme for Cindy.

She also viewed student engagement in science as being “really important” and felt objects from real world science could help gain their attention. In her preinterview she said that there should be “a lot of student interaction between the students” (pre interview). Later in her post interview she continued to describe the importance of bringing the real world into the classroom by stating, “they can pull from their real world
cranes, or I saw my dad work in construction . . . I just think it is cool to take what they know from the outside world and try to apply because then it is all fresh right there.” (post interview).

Cindy held a great appreciation for the following instructional approaches which included: appreciating the rich culture diverse students bring, real world science connections, simplifying tasks, pairing students, visuals and ‘aiding vocabulary acquisition’ by providing synonyms. She incorporated these strategies a few times in her unit. Below these and other strategies Cindy incorporated into the final unit will be discussed.

*Instructional Strategies Discussed and Incorporated in the Final Unit*

Despite Cindy’s enthusiasm for teaching diverse students described so elaborately in the interview, the diverse student instructional strategies Cindy discussed in the interview and incorporated in her final unit were limited. In her interviews Cindy mentioned just three strategies to aid diverse student learning (See Table 7) connecting science to the students everyday life, visuals and celebrating student culture. She continued to have trouble articulating further strategies when writing her lessons for her final units.
Table 6

_Cindy’s Instructional Strategies for Diverse Learners_

<table>
<thead>
<tr>
<th>Strategies for diverse learners</th>
<th>Pre Interview</th>
<th>Post Interview</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured Routine</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Modeling activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinesthetic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visuals</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Maps, word charts, KWL</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Use student language</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Build rapport w/ family</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bring student culture</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Throughout the unit, each lesson was based on powerpoint lectures and often coupled with a short related video. These were noted as a visual strategy in Table 7 above. However, she and her partner did provide a felt water cycle model with Velcro for one or two students to manipulate as part of the introduction to the first three lessons and a science journal. The limited strategies incorporated in her unit included consistent student discussion (listed under structured routine), a KWL (What do we know? Want to Learn? And Learned) Chart and visuals including powerpoint presentations and a felt board model of the water cycle. Here, Cindy’s beliefs and practice did not mesh, in other words, her final unit didn’t support her interest in helping diverse students learn. She had very strong beliefs of wanting to help diverse students learn, but failed to implement a variety of strategies into her final unit.

In summary, Cindy’s enthusiasm for working with diverse students was quite evident in her statements. Her experience with individual students helped Cindy to see
small but impressive gains in their understanding that continued to fuel her interest. Her own ethnic background seemed to help her be sensitive to the needs of the diverse students as she spoke about students in a future classroom. Yet, despite this enthusiasm, as she indicated on her survey she did not feel prepared to teach diverse students. To further support this survey response, there was little evidence of strategies incorporated into her unit that would support diverse student learning and understanding. Additionally, Cindy made few attempts to connect the topic of the water cycle to their everyday life. It was important to note however, that Cindy had limited opportunities to teach science to diverse students in a classroom setting and this may have contributed to the disconnect between her beliefs and her performance on the final unit.

_Beliefs About Teaching Science Through Inquiry_

Cindy’s statement here represents her initial understanding of science inquiry. Inquiry science based in my mind, I think, it is more like the students and the teachers will have this idea and then they go forth, it is not just so much like ‘ok making you read the textbook, Chapter 1, and answer the questions at the end’. I think it is more they have a question of the day and then they will go on the internet and then they’ll go to the textbooks and that is how they will learn. It is not just Chapter 1, ok did, done Chapter 2 (Preinterview).

Through much of Cindy’s preinterview she failed to describe any level of inquiry-based science instruction as defined by NSES to be “scientific process for building new knowledge--posing a question, carrying out an investigation, critiquing and
communicating its results— as much as the existing facts and concepts of scientific knowledge” (National Research Council, 1996).

However, Cindy’s interest in incorporating inquiry skills into her instruction demonstrated growth in both the post survey and the post interview. Specifically, on the survey, Cindy’s score for traditional science went down which placed her ahead of other preservice teachers in her methods section (Δ -3/class Δ -2). This meant that on this scale she was growing toward a more inquiry stance of instruction and away from a more traditional lecture and textbook approach, (Table 5). This growth, however, was not supported by her final science unit and will be discussed more fully below. Cindy also felt that student engagement was important, which supported the strong growth she demonstrated for discussion on the survey as compared to her classmates (Δ6/ class Δ .93). However, she was hesitant to allow students opportunities to explore science content through their own questions (Δ0/ class Δ .174). Finally, despite Cindy’s lack of experience with inquiry science and related instruction, it was refreshing to see that Cindy’s responses on her post survey demonstrate growth in her beliefs on teaching science through inquiry (Δ4/class Δ -.66) as compared to the rest of her classmates who scores dropped slightly. Survey questions indicated that Cindy felt prepared to teach using scientific inquiry skills such as asking a question or planning and conducting a simple investigation.

Cindy’s initial understanding of inquiry-based science throughout much of the pre interview was vague, based around generic ‘experiments’. She explained that inquiry-based instruction would be ‘hands on” or more importantly ‘not lecture’. Cindy
continued, “I think inquiry science is like the thing that you can do hands on experiments with kids I think that is really exciting. It can be dry and dull if you just lecture and the kids copy it and I would think it would be the total opposite of that” (pre interview).

Further into the pre interview Cindy began to share what she felt teaching science inquiry at the elementary level represented. In the following quote, she vaguely described a student investigation that seemed to indicate an understanding of inquiry. Due to a negative experience she had in a high school chemistry course, Cindy explained how her instruction would be different. As a teacher she would allow students the freedom to explore and work to understand the investigation, unlike a lot of teachers who explicitly directed their students through an investigation. Cindy continued, briefly explaining that her future students would carry more responsibility in completing ‘experiments’, which could possibly involve students collecting and analyzing their data. Cindy stated:

A lot of teachers write them (instructions) down on the board, this is what we are going to do 1st, 2nd, 3rd, so that they have a visual representation of what they are going to do at the end. It (my experiment) will be an experiment they will be able to see the stations set up around the room. But they won’t be relying on the teachers they will be doing experiments trying to figure things out for themselves a little, maybe regroup at the end, come back together try to figure out and you know this is what I thought was going to happen like you know this was their misconception they kind of proved it to be wrong or right and they will have the
teacher to say ‘actually you know maybe you were right to begin with or you were wrong, but not say your wrong! Work on that!’ (preinterview).

While the instruction style Cindy described above ranked more on the teacher directed side of the inquiry scale (Figure 1) she appeared to be working toward trying to give the students a bit of room for self-direction.

Cindy’s initial weak understanding of inquiry could be explained by her lack of experience with inquiry in elementary classrooms. As mentioned previously, in her interviews Cindy reported no opportunities to teach science in any of her prepracticums, and one opportunity to observe a science lesson. Cindy did however speak highly of one opportunity she had to observe a science lesson and used it as an example to illustrate her understanding of inquiry science. She described how much students enjoyed holding marine invertebrates during a visit from a local aquarium. Cindy explained that the . .

New England aquarium came and brought little aquariums filled with different formations and different animals living in different habitats. I saw that lesson; it was cool. Kids got to hold the starfish, the sea urchin, oh that water is really cool, got to talk about all of this. That was really neat, the extent of science I saw but I think that was a great lesson to see because it was hands on (pre interview).

Her view of ‘hands on’ as represented in this lesson, was based on the fact that the students physically held the animals. While she labeled the experience as ‘hands on’ she failed to describe anything beyond students holding and talking about the marine invertebrates. She did not mention other forms of inquiry, other components of the aquarium visit, or any followup by the classroom teacher.
Cindy demonstrated growth in her beliefs in teaching inquiry in her interviews as well. In her post interview, Cindy described a lesson she designed for her final unit and while this failed to have an inquiry component in the lesson, it did begin to hint that she was trying to develop more active science instruction. Here she explained that a water cycle demonstration, complete with a bowl of steam and a bowl of ice is teacher directed due to students’ tendency to spill.

The lesson I sent to you and the instructor was a bowl of steam and a bowl of ice that created condensation and then there was precipitation you would catch. I did that as something so that the students would be observers they weren’t being the scientists, just because like you know like boiling water, kids that spill stuff all the time (post interview).

Cindy did indicate her that she understood that the students could be more involved in the demonstration but refrained due to a concern for student safety. This completely teacher directed would lesson not fall on the inquiry continuum due to the absence of an inquiry investigation and is indicated on Figure 1 as a straight line down the right side of the table.

Cindy’s small growth in inquiry practices on her post interview was based on her ability to describe the components of an inquiry-based experiment. However, it is important to note that Cindy’s description of an excellent lesson failed to include inquiry until she was specifically asked about inquiry-based lessons. When asked to describe an excellent lesson at the beginning of the post interview, Cindy’s initial description was based on a generic ‘experiment’ that did not include any components of an inquiry-based
lesson other than science journals. She continued to describe how the students will collect the data, “like the observing but also use the tools to gather data like that type of stuff, and I think using that so its not just lecture based, so in my mind that just translates to the hands on doing experiments, allowing the kids to mess up.” Finally, toward the end of the post interview, she shared a concrete example of an inquiry-based investigating. She described a scenario where she would have the students construct an explanation based on why their seeds didn’t grow. “So like if they messed up, their seeds didn’t grow, so ok let’s look at the reason why they didn’t grow” (post interview). While this description was vague, there was enough of a description to consider it a teacher directed investigation on the inquiry chart.

In summary, Cindy expressed her confidence in being able to go and teach inquiry which contributed to growth in her post interview responses. Additionally, she was fond of the hands-on, visualization component of science instruction noting often her fondness of using powerpoint slide presentations to aid student understanding.

Inquiry Instructional Practice as Represented in Final Unit

Despite Cindy’s growth in beliefs in teaching inquiry science in the survey and interview, she actually designed lessons in her final unit that built in insufficient supports for inquiry. While at times her activities were good isolated examples of science, her overall unit was poorly constructed. In her final instructional unit, the lessons Cindy designed offered students opportunities to do hands on activities but failed to incorporate inquiry components into most of the lessons. See Table 6 for a summation of her lessons and Figure 1 for her inquiry practices as part of her instructional unit. It appeared that
Cindy was more focused on providing the students with hands on activities rather than helping them gain a conceptual understanding of the content through inquiry-based investigations.
Figure 1

*Cindy’s Final Unit Plan, Water, Water, Everywhere for Third and Fourth Grades*
Cindy’s poor performance on her final unit happened despite her instructor’s request. When looking at a draft copy of Cindy and her partner’s unit the instructor for the course suggested they incorporate more inquiry-based investigations into their lessons. The instructor stated,

You should incorporate more hands on investigations and demonstrations in the unit. Ideally, the unit should engage the students in some aspects of scientific inquiry – such as designing experiments, analyzing results and drawing conclusions. Having students engage in inquiry can help motivate the students, promote higher order thinking, and an understanding of the content (class assignment, Spring, 2007).

The instructor went on to suggest resources that had quality investigations to incorporate into their unit and make comments on a draft lesson Cindy had submitted. Cindy responded to her instructor’s suggestion by creating an evaporation lesson that incorporated inquiry strategies. In fact, this was one of the few lessons in Cindy’s unit that could be considered an inquiry-based science lesson. When looking at the table it is evident that this lesson, lesson two in the Figure 1, was one of the few lessons that incorporated inquiry and the only one that gave the students some direction in an investigation. On the NSES inquiry scale this particular inquiry-based science lesson would rank primarily on the teacher directed side of the scale, where the teacher assigned the entire investigation only giving the students a small opportunity to design their investigation by determining the placement of their beaker of water and freedom to
gather their own data. In this lesson and its follow up the next day, students would receive, the opportunity to collect real data and even contribute to making sense of the data and a model to support their understanding.

Looking specifically at this evaporation lesson, it was grounded with a rather vague question, “Have you ever noticed how a local river or lake looks different throughout the year?” Then she had students predict what would cause the water level to change. The question Cindy posed above could prove to be challenging for her students to relate to, possibly causing them to think more on the level of seasonal changes, for example, frozen, thawed etc. Using a puddle would provide a clearer example for students at the third/fourth grade level. However, she did indicate that an article describing lake evaporation would also be distributed to the students that could help to add background content knowledge.

Cindy continued the evaporation lesson by having the students fill beakers with water and predict what they think would happen after one day, three days and five days. She noted in her lesson that students “will record the amount of water in it and where they placed it in the classroom. Predict whether water level in cup will rise, lower or stay the same and why? Also they will predict if the location they put the cup in affects their water level overnight.”

In the next lesson on condensation she ignored the details of the previous evaporation investigation by stating that the beakers are all placed on the windowsills. She explained, “The beakers from the evaporation experiment will be on the windowsills at the back of the room. I will have the powerpoint presentation on throughout the lesson.
and use the interactive board.” Yet, she contradicted herself by directing the students to “record the amount of water in it (the beaker) and where they placed it in the classroom and how that compared to the first day of the experiment.” She continued by stating, “they will see if their predictions from the first experiment rang true, and whether the results of the condensation on the beakers change their conception of the water cycle. Based on what they have learned in this lesson about condensation, they will make predictions as to whether the water level in the cup will continue to rise, lower or stay the same and why?”

While her probing questions were strong, the questions surrounding condensation were inaccurate. This inaccuracy was discussed in the above Content Knowledge and Confidence Section. In addition to evaporation, only two other lessons that incorporated inquiry-based science were the last two lessons related to water quality testing, with a teacher directed question and investigation. The focus of those final two lessons of the unit were based on water runoff as part of a water cycle unit. Here students were instructed to determine whether water is safe to drink based solely on observations of various water sources under a microscope and testing it w/ pH strips. These inquiry-based investigations were teacher directed.

In summary, of the six lessons Cindy presented in her final water cycle unit only three ranked as having inquiry-based instruction and would be placed on the teacher directed side of the inquiry chart (Figure 1). Two of these lessons, encouraged by the course professor, had students participate in an evaporation rate investigation; the other two were related to the water quality testing.
Final Reflections on the Methods Course Itself

When asked if she felt prepared to teach science, Cindy responded positively citing activities from the methods course as the source of her growth. She felt the hands-on, inquiry nature of the course helped her to understand science instruction as a child would interpret it. Cindy additionally credits the methods course for helping her be prepared to teach science, “as I mean this class has been really fun because it has been really hands on and because I’ve been able to observe science . . . I just think it is so fun something fun to do” (post interview).

Summary and Analysis of the Case

Cindy came to the university-based science methods course with no experience teaching science and few opportunities to view science being taught. More importantly, Cindy came to this course with no opportunity to experience the role inquiry played with students in the everyday classroom setting. Her extensive experience working with diverse students led to an increased interest in teaching diverse students. She viewed teaching science at the elementary level as the perfect forum to incorporate hands on strategies. Despite her poor attendance record she showed some growth in her understanding of inquiry science and teaching. However, she showed little growth throughout the semester in her ability to design instruction that was inquiry-based. Her final unit, based on the water cycle, failed to incorporate many of the inquiry science instructional strategies presented in class and ones she mentioned in her interviews.

In reviewing this case of Cindy and her experience with the science methods course, it was initially clear that Cindy had a strong interest bridging connections to
diverse students in her future classroom that was fueled in part by personal experiences at summer camps and one read aloud series with an ELL student as part of a prepracticum assignment. Cindy’s enthusiastic remarks in her interview indicated her interest in teaching diverse students would translate into a well developed theory of how to teach diverse learners, or at the very least lead her to want to learn more about effective teaching strategies for this population. Yet her scores on the survey indicated she did not feel prepared to teach diverse students and the instructional strategies she incorporated in the final unit were limited. This conflict could be due to the fun nature of the alternative settings in which Cindy grew to enjoy working with a diverse population of students where she could focus on entertaining the students and connect to her students by celebrating their culture. Cindy’s absences also indicate that she was not interested. Maybe she failed to demonstrate a change in her interest and understanding of diverse learners because she felt she already knew instructional strategies for diverse students though her prior experiences. There was nothing to challenge her beliefs.

Cindy demonstrated growth in her knowledge of each of the content areas (physics, chemistry, earth science, and biology) as measured by the survey which could be due to the fact that as a student in the university-based science methods course. She gained more experience with various content through science activities introduced throughout the semester. While one goal of the course was to build the confidence of preservice teachers in their ability to teach science, it was also important to have accurate science. While Cindy’s confidence was clearly stated in her interview and survey responses, her work on her unit, which translated the theory into practice, was lacking in
its accuracy and appropriateness related to the content presented. She did not seem to be aware of her misunderstanding, and lacked the ability to reflect on her own understanding of the content. There was nothing to challenge her beliefs and help her to see the inadequacy of them.

Her few memorable experiences with science in the classroom were special visitors from the aquarium or her own teacher directed labs in Chemistry, neither of which represented inquiry. So it was understood that she would have difficulty describing inquiry-based instruction in her initial interview. There was another concern here that having seen one science lesson taught by an outside source, might have her feel that teaching science is beyond the role of the regular classroom teacher. The belief that science can be taught hands on is through bringing in an outside source which could also have had an impact on the development of her unit.

Cindy appeared to appreciate the hands on, ‘fun’ nature of inquiry, as she explained it, and found that aspect of fun in her high school chemistry lab, the science methods course and in a lesson she observed. ‘Fun’ was also how she repeatedly described her unit. When looking at the lessons, most were active hands on lessons, but she only designed three lessons beyond hands on activity-based instruction to be inquiry-based. In fact, in her initial design of the unit little inquiry was present. Only after the instructor stepped in did she attempt to give the students a bit more responsibility in designing their investigation. Through analysis of the final unit three of the six lessons included inquiry, and each of those were teacher directed.
How, though, does a preservice teacher design lessons for a unit to build up to that big idea? In examining the final unit, Cindy’s first step was good, creating lessons that somehow apply to the water cycle. But then the unit fell apart in coherence; rather, the lessons in the unit lacked a good conceptual sequence.

In the second section of the unit, Cindy’s lack of understanding of the content may have contributed to the development of a unit that demonstrated little reasonable coherence. Without the strong background knowledge, her attempts to make the science connect to her students carried her away from the purpose of the lessons. While her final unit goal of writing the story of a drop of rain was strong, Cindy sequenced her instruction throughout the unit in a conceptually inappropriate way. In which case, this assignment may prove to be a difficult assignment for students to complete. For example, in her demonstration of precipitation, Cindy understood why the cloud rains but her lesson failed to get her students to that step. She did recognize that her students may not understand the stages of the water cycle but maybe didn’t recognize that there were many instructional approaches that she could have done to help her students develop an understanding despite the many resources offered through the course. She just accepted that students would understand. Cindy did not get a chance to test it and quickly realize its limitations. Cindy could use the right language in her interviews but in reality not apply the best pedagogical approach. She was approaching the unit with a big idea wanting the students to have fun. While there is nothing wrong with kids having fun the content needs to be presented in a coherent way that challenges their understanding.
Her unit lessons began to crumble in the second half of the unit as the language did not play out into a strong concept of activities. It was not a strong unit for inquiry. She didn’t have the experience of teaching inquiry to draw on and was therefore unsure how it could play out in her classroom. While she spoke about it being a great unit offering alternative representations she failed to represent each subtopic within the unit, in more than one way.

At this point one might wonder why Cindy made the decision to briefly cover the concepts around the water cycle before moving toward a water quality focus? Was it an attempt to find a way to have the students personally connect to the topic, possibly a social justice approach? As their instructors, we want preservice teachers to connect their instruction to students’ lives and this connection can help to drive the pedagogy. But this approach needs to be done in such a way that the content is not compromised. In many ways, it appeared that Cindy did want her instruction to be connected to students, but in the process forgot about the overriding concepts of the water cycle that she needed to teach. Cindy’s beliefs in science instruction could also play a role in this. As mentioned above, if she did not feel it was important or maybe even possible for students to understand the water cycle, she may not have made the effort to ensure the students truly grasp the concepts and their interrelatedness. Ultimately, Cindy’s struggle with incorporating an appropriate depth and sequence for a water cycle unit could possibly be due to her lack of content knowledge around the content area. As professors of science education we want students to produce a final science unit that is represented by a series of inquiry-based lessons that are connected and sequenced in a manner that builds on
student understanding. The last thing we expect to see from our students are activities that are disjointed. While the unit had potential to be a strong approach to social justice her inability to keep the content strong and focused made her instruction weak.

Beliefs can be predictors about what practices she is doing, provide insight into why she designed her unit the way she did. If she believed the students probably wouldn’t be able to fully understand the water cycle, then would she go to the extra effort to present multiple representations of each phase?

Furthermore, it was challenging to design lessons for inquiry investigation. It requires good pedagogical content knowledge and content knowledge, and Cindy was struggling on both accounts, despite a growth in her confidence in teaching science content. Nothing challenged her beliefs, it never came into question that her teaching approaches for inquiry were not adequate. The way many traditional methods courses are structured at this point makes it difficult for preservice teachers to have their beliefs challenged. She didn’t have experience teaching students inquiry-based science and missed her opportunity to test out her ideas. Preservice teachers need formative feedback.

In summary, despite her success in terms of her growth in inquiry-based science on the pre and post survey Cindy’s lack of experience with inquiry-based instruction could have been a key contributor to the final unit Cindy developed. While the surveys demonstrated some growth in her understanding of inquiry, she seemed unable to bridge theory into practice, making it difficult for her to apply it to actual lessons in her final unit.
CASE 2: CONNIE - UNIVERSITY BASED PRESERVICE TEACHER

This study was conducted while Connie was a junior enrolled in both the Elementary Education degree program and Human Development. This decision was made after several different interests and majors in her first two years at the university, including biology, communications, prelaw, political science, and educational psychology. She seemed to have found an interest in education because as she said, “with education, you bring it all together.” As part of this course, Connie designed a final six-lesson unit on the states of matter for third graders. She did not teach this unit because she was enrolled in the university-based science methods course.

Connie had little recognition of her science experiences as an elementary student but memories of a strong science program in middle school. In high school as a girl she felt she was bad in science. Connie had completed two prepracticums prior to taking this course and completed her third during the current semester. Neither experience provided her with opportunities to observe science being taught with the exception of one lesson. In the second placement however, Connie was able to observe a science investigation on plants being taught by a local researcher who visited the class. She was disappointed by the teacher’s carry through with the investigation once the researcher left and felt much more could have been done. Her third placement offered her a few opportunities to observe and one opportunity to assist in the lesson.

Connie had an interest in working with diverse students feeling the experience would help her to grow as a person. It is important to note that Connie’s prepracticum
placement for the current semester was to be her first experience to work with diverse students.

In her interviews, Connie indicated that she was interested in teaching third, fourth or fifth grade stating, “I love the little kids, but I would just like to do more, I feel that instruction and academic and all of that is kind of my strength, so I would like to give that to the kids who can really benefit from it” (preinterview).

As I present Connie’s case in the following sections, I will address her understanding and confidence in the areas of content knowledge, teaching diverse students and inquiry teaching.

Content Knowledge and Confidence

The majority of Connie’s growth in science content was in the areas of Physics, Chemistry, and Earth Science. Surprisingly, the subject she mentioned to be her weakest, Physics, demonstrated the strongest growth, ($\Delta$=5/class $\Delta$=4.38). Chemistry ($\Delta$=1/class $\Delta$=2.88) and Earth Science ($\Delta$=1/class $\Delta$=2.07) showed modest increases. In both subjects Connie started higher than her peers, but had the same level by semester’s end. And finally, Connie’s score in biology actually dropped, ($\Delta$=-1/class $\Delta$=5) while her peers demonstrated great growth.

Connie’s first memory of science instruction as a student was from her middle school years. There she felt the instruction was excellent, stating, “I had good science teachers, middle school especially. I had a good experience definitely.” In high school she took biology, chemistry and AP physics. Yet, in high school she felt she wasn’t strong in science. She explained, “In high school I though I was bad at science, as a girl
it wasn’t my specialty.” Yet, due to influences from her aunt and cousin, both biologists, she came to the university as a biology major. She took both semesters of a survey of biology course but then later switched out of the program into a few different programs before finally deciding on Education.

Unit overview

Connie designed a six lesson final unit on matter entitled “Solid, Liquid or Gas? An Exploratory Unit on the States of Matter.” for third graders (See Table 8). The final units developed by preservice teachers provide insight into their understanding of the content and inquiry-based teaching practices. Here I will discuss the content portions of the unit.
<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Lesson Title</th>
<th>Lesson Objective</th>
<th>Lesson Question</th>
<th>Lesson Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matter – An Introduction</td>
<td>Students will examine examples of all three types of matter.</td>
<td>What is matter?</td>
<td>Discussion and demonstration: Students share their preconceptions of matter and then pass samples of the three types of matter around the room.</td>
</tr>
<tr>
<td>2</td>
<td>What is a Solid?</td>
<td>Students will measure and observe different solid objects and will use these observations to determine some of the properties.</td>
<td>What is a solid?</td>
<td>Discussion and investigation: 1. Observe blocks. Predict what will happen as you move the blocks to the box. Will it change shape and size? 2. What happens to the shape of a sweater as you move it? 3. Play with clay, still a solid?</td>
</tr>
<tr>
<td>3</td>
<td>What is a Liquid?</td>
<td>Students will compare and contrast the liquid’s shape and volume in one container to another.</td>
<td>What is a liquid?</td>
<td>Discussion (about properties of various liquids) and investigation: Students will predict what will happen when you take 30cc of water and pour from small container to large.</td>
</tr>
<tr>
<td>4</td>
<td>What a Gas!</td>
<td>Students will use hands-on investigations to demonstrate air is a gas and takes up space.</td>
<td>What is gas?</td>
<td>Demonstration and discussion: Students will first do centers determining that there is air in the bottles and then will observe the changes in a balloon when it is warmed and cooled in a teacher-led demonstration.</td>
</tr>
<tr>
<td>5</td>
<td>The Mysterious Ooblick!</td>
<td>Students will make and manipulate Ooblick and observe changes.</td>
<td>What are particles in a substance and what made them change?</td>
<td>Demonstration and discussion: Students take Ooblick and explore its properties. Then get to roleplay what is happening to the particles as force is applied and released.</td>
</tr>
<tr>
<td>6</td>
<td>Matter Matter Matters</td>
<td>Students will explore heat transfer and its effect on phase changes in matter.</td>
<td>Can matter change states?</td>
<td>Demonstration of how particles are arranged and behave in the three states of matter with a tray of marbles and a discussion about the force of heat and its impact on the molecules. How do particles behave in the three types of matter when heat is applied?</td>
</tr>
</tbody>
</table>
Connie had wanted to model her final unit close to a science curriculum, Matter and Energy, produced by FOSS, but was unable to obtain it from the library. This made her unit development rather challenging, as she had to utilize several different resources. In the end Connie was quite pleased with the outcome, and should be.

Connie’s final unit was a well-conceived and designed unit, receiving the highest score on the overarching goal, Solid, Liquid or Gas, and the sequencing of the content. The content was grade level appropriate for third graders and was consistent with the AAAS benchmark standards. The content level did however receive a slightly lower score because Connie was a bit brief in her description and definition of the ‘properties’ of objects and materials throughout the unit. The unit began with a lesson to introduce and review properties of the three states of matter, solid, liquid, and gas. Connie’s lessons in the unit then continued on to cover solids, liquids, gas, ‘particles in a substance’ and finally ‘the impact that the introduction of heat has on particles in the three states of matter’.

Connie made several efforts to help students make explicit connections between key concepts throughout the unit. Her logical progression of concepts related to the properties of matter was greatly supported by activities she introduced such as a four-corner activity and a class developed table of the properties of matter. The four-corner activity opened the unit in the first lesson. Students rotated around the room responding to true or false statements about matter posted on large sheets of paper in each of the corners of the classroom. Connie also had her students create a table listing the properties of solids, liquids and gases (Table 9). Students could determine whether the
state of matter maintained a definite shape, size or volume. This table helped students to make explicit links between the different concepts and served as a resource throughout the unit. Both of these activities were referred back to in the second, third and fourth lessons.

In summary, Connie’s final unit on matter was well sequenced and grade appropriate. Each of these items received high scores in coding. The content was just a bit compromised by the lack of description and definition for the term ‘properties’ and received a one out of two. Finally, the final overarching goal of determining whether items were solid, liquid or gas provided a strong conclusion for the unit.

Table 8: Class developed chart Properties of Matter

<table>
<thead>
<tr>
<th>State of Matter</th>
<th>Has a definite shape?</th>
<th>Has a definite size?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Liquid</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Gas</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Confidence in Teaching Science Content

At the beginning of the semester, it seemed that Connie’s comfort level in teaching science lies in biology, not in physics, but finds a challenge in that. “I love science, but I am kind of picky. I love biology a lot, but physics not so much. I don’t feel completely uncomfortable teaching . . . where it is not my specialty. It is a challenge and I like that about it” (preinterview).

By the end of the semester Connie appeared to discover that her coursework in high school was beneficial in teaching science and demonstrated growth in this area.
Connie also demonstrated great confidence when, as a prepracticum student she interrupted a science lesson she was observing to introduce viscosity, a term that would help students understand the investigation more accurately. Connie explained, “They (the student teacher and other prepracticum student) used the word stickiness of water and I actually introduced the word viscosity and I brought just some of my background knowledge in science” (post interview).

Connie continued to explain how she came to be a type of science resource person for the science lessons she observed during this placement in an urban school, explaining that “The prepracticum student and the student teacher would turn to me and kind of go ‘is this right?’. So I had a lot of experiences where I added to the content knowledge just by what I know and what I have learned in science growing up” (post interview). She was quite proud of this and felt she was also able to contribute to the quality of the science instruction by drawing diagrams to help explain a challenging topic. She explained that it was “good to be able to do that, and a lot of times I would go to the board and I would draw diagrams because I thought it would help them interact with it a little better. I wasn’t teaching myself, but I was able to add to the overall lesson. That was really good” (post interview).

Yet, in the post interview when asked explicitly whether she felt confident to teach science, Connie appeared to hesitate a bit, explaining that it depended on which science discipline was to be taught. She replied, “um, as far as subject matter, depending on what the subject is, I’m not 100%. I don’t know if I will be able to spit our factual knowledge without first before starting a unit, really doing some background research on
it so I will feel more comfortable” (post interview). It was encouraging to see that Connie felt the need to understand the subject matter prior to teaching it, and that she felt it was possible to be prepared, through independent research, to teach a subject.

By the end of the semester, Connie had a positive experience sharing her science understanding during the science lessons she was observing in her prepracticum placement. She shared facts with the class, but also found ways to better represent the science knowledge being taught to make the science content more accessible for students in the class. Connie also expressed a healthy appreciation for the need to understand the science behind the lessons she plans to teach, and felt that with independent research she could be prepared to teach a lesson in a topic area unfamiliar to her.

Diverse Students, Teaching Strategies and Confidence

Early in the semester Connie’s confidence and interest in teaching diverse students started lower and ended lower than her peers, but did show a slight growth (Δ=1/class Δ=1.5). Comments in her pre and post interviews were neutral, indicating she was neither nervous nor comfortable. This could be contributed to her lack of experience in working with diverse students, particularly at the beginning of the semester. However, she did show interest in gaining experience with diverse students. She was just beginning her first placement in a diverse classroom when the semester started, when she explained, I think it is such a challenge in a lot of ways, but it is an amazing experience and I know that especially in this day and age, like it is impossible to avoid and it is not something you want to avoid. . . It is important to see how other cultures view reality and the human condition as a teacher. It helps you grow, but even more so as a person. I look forward
to it a lot. I’ve had some very basic experiences, not basic, but not very diverse classrooms that I have done my prepracticums in. And this semester, I am in a very diverse school and it will be different and very exciting (preinterview).

Here she demonstrated an appreciation for the growth she would experience personally by working with diverse students. Yet, by the end of the semester, having worked as a prepracticum student in a diverse elementary classroom, Connie described her experience cautiously stating, “Very good, it was a very diverse student body. It was very interesting, not what I had seen in my previous prepracticums. It was a very interesting experience” (post interview).

Despite this, Connie indicated in her interview that she felt well prepared to teach diverse students due to her other coursework in the university, and in the science methods course. She explained that teaching diverse students was, “an underlying theme in everything we do here (at the university). So for the most part I feel very well prepared to teach in diverse settings” (post interview).

Throughout the semester, Connie demonstrated a slight growth in the type of instructional strategies she identified that could be used to aid diverse student understanding of science instruction. During her preinterview Connie only mentioned incorporating active kinesthetic activities and visuals into instruction to aid diverse student understanding in science. Later in her post interview Connie named visuals again, stating their value even for her as a student. She explained, “I think visuals are huge. Even for me to this day, I like to have the written things, and then I like to have the
diagrams that show the semantic maps that show how things interact with each other” (post interview). She didn’t mention any kinesthetic instructional activities however.

In her post interview, Connie talked generally about working with diverse students. While she was positive and indicated that she felt well prepared to teach ELL students, she failed to share any explicit personal examples of working with ELL students.

*Strategies Incorporated in Final Unit*

Connie’s demonstrated understanding of instructional strategies for diverse learners showed an interesting trajectory throughout the semester. In her pre and post interview Connie shared only a few instructional strategies for ELL students, two strategies in each interview including kinesthetic activities, visuals, and KWL charts (See Table 10). Connie’s initial response in the post interview was rather vague stating, “multiple interactions with the material”. In fact during the post interview when the interviewer went further to ask Connie if she had any specific strategies to share, Connie stated, “I think that visuals are huge.”

However, just two weeks later, Connie incorporated numerous diverse learner strategies to enrich the lessons she developed for her Matter unit, see Table 11. Among the strategies she incorporated, included a well-developed structured routine into each lesson where students reflected in science journals and shared ideas through discussion. She also utilized kinesthetic activities through role-play to aid the introduction of solids and gases. Multiple visuals, and a four corner activity were introduced to address student misconceptions and help to draw connections between the concepts. In most lessons,
Connie also incorporated several ways to connect the lesson activities to the personal lives of the students.

Table 9

<table>
<thead>
<tr>
<th>Connie’s Instructional Strategies for Diverse Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategies for diverse learners</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Structured Routine</td>
</tr>
<tr>
<td>Modeling activity</td>
</tr>
<tr>
<td>Kinesthetic</td>
</tr>
<tr>
<td>Visuals</td>
</tr>
<tr>
<td>Semantic maps, word charts, KWL</td>
</tr>
<tr>
<td>Use student language/connect science to student</td>
</tr>
<tr>
<td>Build rapport w/ family</td>
</tr>
<tr>
<td>Bring student culture</td>
</tr>
<tr>
<td>Other</td>
</tr>
</tbody>
</table>

In summary, Connie, overall seemed to feel somewhat prepared to teach diverse students. With only one prepracticum experience with ELL students that she simply described as interesting, and the little growth demonstrated in both her survey and interviews, she was a bit hesitant. She listed kinesthetic, visuals, and semantic maps as strategies to aid diverse student understanding in science in both her interviews, but incorporated a few more strategies in her final unit.

Beliefs About Teaching Science Through Inquiry

Connie’s interest in incorporating inquiry into her instruction demonstrated a slight growth over the semester. Specifically on the survey, Connie demonstrated a slight decrease in Traditional Science \( (\Delta=-1/\text{class } \Delta=-.2) \) which on this scale indicated that she was moving ever so carefully away from a more traditional lecture and textbook.
approach toward inquiry-based science instruction. Additionally, Connie indicated that she was comfortable giving students opportunities to communicate and explain their ideas through discussion. Connie demonstrated a growth of three for this factor while her peers showed less than one ($\Delta=3$/class $\Delta=.93$).

However, Connie indicated that she was still a bit hesitant when it came to other aspects of inquiry. For the openness factor, Connie showed no growth in her interest in providing students opportunities to explore science content through their own ideas ($\Delta=0$/class $\Delta=1.74$). However it was important to note that overall her score started and ended much closer to open than her peers. And finally, Connie demonstrated no growth in her inquiry practices factor ($\Delta=0$/class $\Delta=4.87$), indicating she was not prepared or comfortable to teach allowing students to use scientific inquiry skills such as asking a question or planning and conducting a simple investigation. In her post interview, while Connie did not initially indicate that inquiry strategies were a contributor to an excellent lesson she later described a lesson that did incorporate those strategies. Finally, Connie did indicate that she felt well prepared to teach science in her postinterview. This contradiction will be further explored in detail in the following sections.

Connie had limited opportunities to observe science being taught at elementary prepracticum placements and only one opportunity to see an inquiry science investigation in a first grade classroom. A community scientist and parent taught the one investigation she was able to observe. He had the students test plant growth in different settings around the classroom. Connie explained that this investigation was not incorporated into the classroom teacher’s instruction possibly due to her discomfort with the science
content. Connie explained, “My teacher was not very comfortable with science and after
the parent walked out the door it (the lesson) kind of fell apart. That was hard to watch
happen, it was such a great opportunity and I think it was kind of lost” (preinterview).
When asked what she would have done differently if she had been the teacher in this
situation, Connie demonstrated great insight. She explained that “I would definitely keep
going with it . . make it (the watering) part of my daily routine . . .they (the students) take
that responsibility, and then we would have a 10-15 minute conversation (preinterview).

Connie went on to describe other strategies she would do to help the students gain
a better understanding of this particular investigation and investigations in general. Here,
she was referring to the plant lesson described above. She stated,

when they started off that way, what was introduced was that they didn’t ask a lot
of ‘what do you think will happen?’. I mean they did to an extent, but I think the
kids were kind of confused about what was going on. And why it was designed
that way to. I think I would be a little more explicit about the design and why we
had one group with no sunlight from below, and the other group from above and
try to explain why do you even think we need to have the one with no sunlight?
Just to get the kids to understand what an experiment is set up like”
(preinterview).

Here Connie placed emphasis on the students gaining a better understanding of the design
of an experiment, focusing on a question and observation related to the plant
investigation. She did not however, talk about working with the data, including the
collection, making sense, or constructing explanations around the data.
Connie’s description of an excellent science lesson during the preinterview, identified a few key factors of an inquiry-based lesson, but failed to include any specific examples to apply the factors. Connie described her image of an excellent science lesson would begin with a question to “peek everyone’s interest” (preinterview). This lesson according to Connie would also provide students the opportunity to determine the best way to test a hypothesis. She explained, “I would like it to be something where the students get to decide for themselves what is the best way to test the hypothesis” (preinterview). Connie proceeded to describe a lesson where there would be more student observation than teacher instruction. Similar to Connie’s description of the plant investigation above, she once again failed to mention students collecting or making sense of the data.

In both the preinterview and post interview, Connie saw the need to make her science instruction apply to real world problems that connect to their lives beyond the classroom, and engaging the students by giving them opportunities to “have a choice about the steps they want to take or maybe even the subject matter itself” (preinterview). In her post interview, Connie felt in order to keep students engaged, she “wanted to make sure every student in the group had a role that they were trying to complete.”

In her preinterview, Connie did not mention inquiry as term, but in her post interview she described inquiry instruction and curriculum as starting with a question and “a lot of hands on activities where kids can see directly and observe changes and their phenomena that they are trying to teach” (post interview).
When asked for an example of an excellent science lesson, Connie shared her experience teaching a lesson on hot and cold liquids to her classmates as part of a course assignment for our science methods course. Here she described once again the importance of connecting the investigation to student lives, by giving an example of hot or cold tea as the introductory question. Connie also emphasized the importance of students designing their experiment and coming up with their own questions. She explained,

I taught that hot and cold lesson. There was that beginning portion where you ask the students if they could make tea and make it with hot or cold water and that is something that connects to their daily lives. And I thought that was a good, I thought, introduction to the topic. . . And also I think allowing students to design their own experiment is a really good thing. First I think students need to be acquainted with how experiments are typically set up. But once they had that kind of basic understanding just letting them try and figure out for themselves how they could test a certain question that they have (postinterview).

Connie continued to describe the remainder of her lesson which included portions of an inquiry-based science lesson that she had previously ignored both in the preinterview and earlier in the post interview. In this description of her Hot and Cold Liquids lesson, Here, Connie described how her classmates were able to make sense of the data in an investigation that didn’t turn out as she had planned, “it was interesting to see the kids or ‘the students’ working on the experiment; one group got a different result than the other and coming up with reasons why that might be” (postinterview).
When asked whether she was prepared to teach inquiry in the postinterview, Connie responded that she felt inquiry instruction was really more guiding rather than just giving the students what they need to learn. Its more guiding their thought processes and helping them learn to ask questions about their environment and what is going on in a given situation. I think that it is something that was really emphasized and I do feel confident with it (postinterview).

Here Connie’s idea of inquiry-based instruction was growing toward a more student directed approach.

_Inquiry Instructional Practice as Represented in Final Unit_

Connie demonstrated a strong growth in her understanding of inquiry-based science instruction as represented in her pre and post interviews. She additionally designed a unit that built supports for students as they encountered the lessons.

The chart below (See Figure 2) represents the level of inquiry represented in each of the six lesson in Connie’s final science unit entitled, _Solid, Liquid or Gas? An Exploratory Unit on the States of Matter._ Each lesson was mapped out carefully onto the inquiry continuum as described in the methods section. The first step was to determine a lesson’s eligibility for an inquiry-based investigation, whether there is a testable question presented. Then it was determined whether each lesson was teacher guided or student guided for each of the six criteria. Next, I will include an example of how lesson one was mapped onto the table.
Figure 2
Connie’s Final Unit Plan, Solid, Liquid, or Gas Unit for Third Grade
Looking closely at Lesson 1 entitled Matter – An Introduction, students were given the following teacher directed question, “What is matter?” This was not a testable question, rather it was an exploratory one. This lesson, while it may not be inquiry-based, was a perfectly reasonable one to introduce students to the properties of matter. However, in looking at the next three lessons, each exploring the states of matter: solids, liquids, or gases, respectively represented a guided inquiry approach. In these lessons students were following a teacher-directed inquiry-based question during their investigation. Lessons here further indicated that students would gather data, and work to make sense of that data using worksheets designed by Connie. She even provided students opportunities to share connections they discovered during the investigation.

Connie’s final two lessons, did not map onto the inquiry chart, but did introduce the students to demonstrations that greatly supported and expanded their understanding of the properties of matter. The fifth lesson had students make and manipulate Ooblick, a substance that continually changes between solid and liquid as students handle it. It would help students to realize that the boundaries between the three states of matter is not set. The final lesson, also a demonstration, helped students to see the force of heat and its impact on molecules.

Connie incorporated several instructional strategies that support inquiry-based science instruction. She provided students with guided inquiry experiences so that they could better understand the science concepts. For example, Connie gave the students opportunities to experience and explore phenomena first before she provided them with
the explanations of the science concepts. For example, in Lesson 2 had students explore both the boxes and clay before providing them with a definition of a solid.

Connie also demonstrated a growing understanding of inquiry by modifying a commercial curriculum’s worksheets to ask the students why they thought something occurred. The commercial curriculum’s worksheets failed to help students construct explanations for the investigations it introduced.

While Connie’s survey responses demonstrated a student whose understanding and comfort level with inquiry was mixed, she described a lesson she taught to her classmates as part of the methods course that incorporated aspects of an inquiry lesson. Interestingly, Connie in her preinterview and earlier post interview descriptions of inquiry lesson, she consistently described the development of a research question, and the design of an investigation, but failed to mention whether students would gather or make sense of the data as part of that investigation. Yet, in her unit, Connie incorporated teacher-guided inquiry into the three center core lessons. Here students work to investigate a teacher directed question and gather and organize data based on teacher designed worksheets and constructed explanations for the investigation with the teacher’s assistance.

*Final reflections on the methods course itself*

Connie knew that she had an option to choose between two different science methods courses, a more traditional university-based course and a field methods course. She explained that she decided to enroll in the university-based course due to her
obligations as resident assistant in the dorms and that the 8:30 am science methods course was more tolerable to handle than an 8:30 am history course.

When speaking of the course, Connie also discussed her views of content verses process. While she was a bit hesitant with her content understanding, she seemed to understand the limitations of a semester long science methods course.

But a course couldn’t possibly address all the content you need to teach to your specific grade when all the elementary, it is a huge job. The process is what I feel is the most important. I do feel prepared with the way this course was set up to bring in a lot of different kind of techniques and methods for that type that kind of learning (post interview).

Here Connie recognized the importance of learning the process of science and the various methods that support student learning.

When asked if she felt the experience teaching students in an afterschool setting would have helped her feel more prepared she responded by saying, it would have been nice to see it throughout. Watching a video of the science specialist (from that urban school), it would have been an interesting thing to see, from classroom management, but I do feel like I got a lot from this course so I don’t feel cheated. I feel it would have enhanced it, but I don’t view it as being necessary. I feel that basic concepts were covered. I will get more of an opportunity in my full practicum to see how it is applied (post interview).
Here Connie shared that she felt that while the field-based experience may have provided her some classroom management skills and may have enhanced what she learned in the university-based course. However, she tempered that by explaining that the field experience wasn’t necessary to gain the basic concepts, and that her full practicum would provide the opportunity to apply the strategies she learned in context.

_summarizing and analyzing the case_

Even though Connie was a student enrolled in the university-based science methods course, she was fortunate enough to be placed in a prepracticum placement where science was being taught on the day of the week she was there to observe. This experience helped to serve Connie well because the teacher began to turn to her for further scientific explanation related to the lesson. She additionally was able to critique a lesson on plants she had observed. Connie identified key pieces of the lesson that needed to be taught differently. Even though Connie often questioned her content knowledge, particularly in physics, this experience helped her begin to trust herself and see the value of truly understanding the content before teaching it. More importantly, Connie felt that she could be prepared to teach a new subject through her own independent research.

It is possible that coming to this course with a strong background and some interest in science as a subject, helped Connie to come to this understanding. If experiences in the classrooms such as these were available to each preservice teacher, then a field-based science methods course may not be necessary.
Connie designed a six lesson final unit on matter entitled “Solid, Liquid or Gas? An Exploratory Unit on the States of Matter.” for third graders (See Table 7). Overall, Connie’s final unit on matter was well developed and grade appropriate. She incorporated instructional strategies that helped students make explicit connections between key concepts throughout the unit.

Connie’s interest in teaching diverse students demonstrated only a slight growth. She didn’t appear to have much experience or much interest beyond the general appreciation for the diversity ELL students bring to the classroom. Her only experience with diverse students was only described as interesting and credited her coursework through the university and through the science methods course as helping her to be prepared to teach in such settings. While the strategies Connie mentioned during the interviews for teaching diverse students were somewhat limited, ones incorporated in the unit were much more varied.

Connie’s demonstrated a slight growth in her understanding of and appreciation for inquiry-based science instruction. She indicated in her surveys and interviews that she was comfortable giving students opportunities to communicate and discuss science. Connie was not comfortable, however, in her ability to give students opportunities to explore their own ideas or allowing students to conduct a simple investigation. Connie’s beliefs around inquiry were supported when looking at the level of inquiry in her final unit. She did incorporate inquiry into 3 of the key lessons around the properties of matter. Each of those lessons demonstrates a teacher guided investigation where the students were given the freedom to collect the data using a teacher developed worksheet.
to organize and make sense of the data and offered some teacher support to construct an explanation for the investigation. This is understandable, as many new teachers are hesitant to give their students much freedom in inquiry-based science.

In her unit, Connie demonstrated a strong understanding of inquiry when she gave the students opportunities to experience and explore phenomena first before she provided them with the explanations of the science concepts. She additionally designed worksheets that helped students to construct explanations for the investigations.

Connie seemed and felt prepared to teach diverse students, but when it came to practical strategies it didn’t arise in interview. It is possible that Connie recognized how to identify quality science curriculum and recognize the key components that support diverse student learning.
CASE 3: KAREN- FIELD BASED PRESERVICE TEACHER

This study was conducted while Karen was a junior enrolled in an Elementary Education program while also pursuing a major in English. She was enrolled in the field-based science methods course. As part of this course, Karen designed and taught an eight-week unit on force and motion to second graders enrolled in an afterschool science club. As an elementary student, Karen had limited opportunities to observe science being taught and barely remembered doing science until her sixth grade year. She felt science at that level was too integrated with other subjects, mentioning that she would prefer doing strictly science lessons.

Karen had completed two prepracticum placements prior to this course and completed her third during the current semester. Her first experience was in a local urban third grade classroom where she primarily remembered observing interesting, interacting reading and writing lessons being taught while social studies and science were lecture and fact based. Karen’s second of two prepracticum placements was in a first grade classroom while she was studying abroad in Australia. While she saw more science being taught there than in her first prepracticum placement in the United States, she still found science instruction to be quite limited. She was, however, able to observe and participate in a few brief science lessons being taught, and even on one occasion taught a lesson based on seasons. Back in the United States, Karen’s third and final prepracticum placement was in a Kindergarten classroom in the same urban school where our field-based science methods course was taught. In this placement she helped the students work through centers set up by the Kindergarten teacher in an effort to support the science
being taught by a primary science specialist. In her interviews, Karen indicated that she was interested in teaching primary kindergarten through second grades.

As a sophomore Karen had a unique opportunity to teach students in an afterschool club as part of an experimental literacy methods course. Similar to our science methods course a select number of preservice teachers in that course were able to fulfill a portion of those course requirements through their teaching in an afterschool literacy and language skills club. Appreciating this experience Karen, now a junior, sought this field methods science course out. She overloaded her schedule despite having already fulfilled her science methods course requirement while abroad in Australia. She explained

the more time you are with students the more time you can better yourself as a teacher, and that is why I wanted to take it. I am really happy to be working with them (the students) because I feel that I am like the whole putting more things into my little box so that I can expose myself more and find out what my faults are (preinterview).

Karen had an interest in working with diverse students, and looked forward to working in diverse, urban schools. Her background in working with diverse students was limited to her first prepracticum and one afterschool teaching experience. In her preinterview she stated that she felt that the “differences are really positive rather than like negative.”

As I present Karen’s case I will discuss her growing confidence and understanding of inquiry as represented in her science instruction. In the following
sections, I will also address Karen’s understanding and confidence in the areas of content knowledge, teaching diverse students, and inquiry teaching.

Content Knowledge and Confidence

Karen provided a mixed message about her confidence in science content. While in her preinterview, Karen claimed, “science has never been my favorite, I should say it also isn’t my strong point”, her survey scores did not reflect this. The majority of her growth in science content knowledge and confidence demonstrated on the survey was at least equal to if not greater than her peers. On the survey, Karen demonstrated more confidence and a stronger growth in Earth Science ($\Delta=3/\text{class } \Delta=.79$) than her classmates. Her confidence scores in Physics started higher and ended higher than her classmates despite less growth ($\Delta=3/\text{class } \Delta=3.43$) because of a ceiling effect with the instrument. Karen’s growth in Chemistry was right in line with her classmates at ($\Delta=2/\text{class } \Delta=2$), and finally, while her score in Biology showed no change, it still remained higher than her peers who demonstrated a slight growth ($\Delta=0/\text{class } \Delta=.75$). See Table 4.

Karen came to the science methods course with an extensive background in her high school science courses despite a lack of science in her elementary years. According to Karen, due to the state testing in her home state, she didn’t have science till her middle school years and even at that point she only remembered taking notes from lectures. She explained, “We just didn’t do any science” (preinterview). As an eighth or ninth grader Karen did appreciate the opportunity to participate in a week long summer science course where she learned about and worked with toy airplanes and robots. In high school she
took several science courses including: High School Biology, Chemistry, Earth Science, and Advanced Placement Chemistry.

Interestingly, at the University level Karen was the only student in the two science methods sections to take Oceanography I & II, a course with labs for each semester. The minimum science requirement for elementary preservice teachers at this university included two science courses and only one lab. Unlike this general science course sequence taken by most elementary preservice teachers at this university, Oceanography, had a lab for each of the two courses. This could indicate that Karen wasn’t intimidated by a more challenging science course that carried a lab each semester. In the next section, I will review Karen’s unit looking closely at the accuracy of content presented, the sequencing of that content within the unit, and the quality of the overarching goal.

Unit Overview

For Karen and her partners’ final unit, they designed a six-lesson force and motion unit entitled “Building Roller Coasters” for third graders (See Table 11). Here I will discuss the content portions of the unit. For purposes of this research, I have referred to the unit as Karen’s alone to simplify language. It is important to note, however, that due to an odd number of students in that semester’s science methods class, Karen had two partners with whom she taught this unit.
<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Lesson Title/Content</th>
<th>Lesson Objective</th>
<th>Lesson Question</th>
<th>Lesson Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Friction</td>
<td>Students will identify what friction is and what causes it.</td>
<td>Which surface creates the most friction for the ball?</td>
<td>Discussion, demonstration, and investigation: Students test at least two surfaces (hardwood floor and shaggy carpet) to see how fast and how far the ball rolls. What is causing the differences in how far the ball rolls on different surfaces? What happens to the extra energy?</td>
</tr>
<tr>
<td>2</td>
<td>Energy</td>
<td>Students will be able to understand that the greater the input of potential energy (height of ramp), the greater the output of kinetic energy (distance traveled).</td>
<td>How can I get my rollercoaster car to have the most energy so that it travels the furthest distance in the fastest amount of time?</td>
<td>Discussion, demonstration, and investigation: 3 centers 1. Observe ball as it travels down varying heights of ramps. 2. Where does the ball have the most potential energy (on prebuilt roller coaster)? 3. Why do higher ramps allow the balls to go a greater distance? Students study a prebuilt roller coaster, predict.</td>
</tr>
<tr>
<td>3</td>
<td>Gravity and Acceleration</td>
<td>Students will be able to understand that changes in speed and motion are caused by forces.</td>
<td>What is pulling a roller coaster down the track?</td>
<td>Discussion, demonstration, and investigation: Students drop golf balls from different heights to determine the greatest acceleration.</td>
</tr>
<tr>
<td>4</td>
<td>Speed, Slope and Energy</td>
<td>Students will be able to understand that the greater the force is, the greater the change in motion will be. The more massive a force is, the less effect a given force will have.</td>
<td>Will the slope of the first hill affect how far my rollercoaster car will travel?</td>
<td>Discussion, demonstration, and investigation: Students will be given an expandable ramp, car, measuring tape, and books to experiment with and think about force, gravity, kinetic and potential energy while investigating. Students will also be able to differentiate between height and slope.</td>
</tr>
</tbody>
</table>
At the end of the semester Karen’s unit received the highest score, a two, on the overarching goal and on the accuracy of the content presented in the unit. The content Karen included in her unit to address force and motion was grade level appropriate for second graders consistent with the AAAS benchmark standards. The sequencing of the content had a solid base, but received a score of one out of two and will be described in more detail below. The unit began with a lesson on friction, and then each lesson consecutively covered friction, energy, ‘gravity and acceleration’, ‘speed, slope and energy’, ‘investigating rollercoasters’ and finally, ‘building a group rollercoaster’. While these topics represent a strong unit to teach force and motion a few small changes would have made the unit more solid. For example, while the topic of friction opened the unit, when a general overview of force and motion would have helped to create a stronger
introductory lesson for the students. Karen’s unit also introduced energy prior to gravity. Furthermore, gravity is a topic that would help prepare students better to understand both potential and kinetic energy, therefore, the subjects should have been taught in reverse order. This contributed to Karen’s score of one out of two for sequencing of content. It was important to note that Karen’s unit improved overall due to comments on her rough draft from her professor.

In summary the content in Karen’s final unit lessons was accurate and grade appropriate receiving high scores in coding. With one exception, the lessons were sequenced appropriately. And finally, the final overarching goal of building a group roller coaster based on the results of the unit investigations provided an excellent conclusion to the unit.

Confidence in Teaching Science Content

By the end of the semester, Karen’s confidence in teaching science content increased to the highest level. Yet, the beginning of the semester, Karen felt nervous about teaching science to elementary students, explaining, “I am a lot more comfortable with science if I can explain it and understand, instead of the creation and theory. The theory kind of confuses me sometimes” (preinterview).

Even at that point early in the semester, Karen appeared to understand the challenge elementary teachers often face when preparing to teach science content. She wanted to teach science clearly neither distorting the information nor simplifying it too much. She explained, “it is such a complicated topic so I don’t want to confuse them, but also don’t want to make it too easy for them” (preinterview).
Yet, by the end of the semester, Karen became more comfortable with the idea of teaching science. This appeared to be due to her growing awareness that while it is important as a teacher to know and understand the content associated with instruction, a teacher doesn’t have to know everything. In her post interview she stated, “I do feel a lot more confident than before . . . I know it is because of this course”. She continued, from this semester I do feel more prepared to teach science then I ever have before, just because I’ve done, I realize now . . . it’s ok as a science teacher to not know all the answers which is something I didn’t realize before. And I feel like I really didn’t realize it before in the sense that I didn’t want to give them the wrong answer. But I feel more prepared now (knowing) that science isn’t a yes or no answer to a subject. I feel more confident in my science knowledge so I don’t think I would be like nervous if a student asked me something. (I would) just say, ‘oh I don’t know. Do you think we could figure that out together?’ Whereas before, I would be embarrassed (post interview).

She continued with an example to clarify her thoughts on the amount of science content necessary for a teacher to know and understand the content they are teaching. “For example if you are teaching motion you don’t need to know everything about motion you just need to make sure you are solid with the facts you are teaching. If they ask other questions and you know it’s ok, if not you can research it together.” By the end of the semester she came to the understanding that teachers and students can work together to find and understand meaning in instances where the teacher may not have an answer to a student question.
Throughout the semester, Karen experienced a shift in her appreciation for science as a subject at the elementary level. Karen wondered at one point in her post interview whether having experienced science as an elementary student would have changed her low opinion of science as a subject. In an effort to prevent this from happening to her own students she felt it was important to offer her future students an experience in science. She stated, “granted science is just not my thing. I’m not sure if it is something that I chose, if it is that I just don’t like it, or if that the road wasn’t open, like as an elementary student. So I am going to try to incorporate it into my classroom as soon as possible” (post interview). She then continued to also accredit her willingness to incorporate science into her elementary instruction to her increased confidence. Since I am more comfortable now I am definitely going to make sure science is incorporated, especially since from my perspective I didn’t have it. I realize now what I was missing almost. And, now I look back and like, is it that I never liked science in middle or high school? And now I wonder, is it that I didn’t like it or did I just never give it a chance? (post interview).

This feeling of wanting elementary students to experience science was supported by her recognition of and appreciation for science being taught in a regular classroom. She shared an example of her prepracticum teacher who worked to support the unit being taught by a classroom specialist. Throughout the semester, Karen came to appreciate the efforts her prepracticum teacher put into supporting the science instruction her students’ received in their science class with a science specialist. She explained that her prepracticum teacher, “tries to put it as much into her classroom as possible, like now
they are doing spring and plants the root, stem, the life cycle of a plant. She is working with Mr. Smith, (the science specialist), it is really great.” Here Karen recognized the importance of a regular classroom teacher supporting the science being taught in the science classroom to enhance student understanding of the content matter.

Karen’s confidence in teaching science grew throughout the semester, contributing this twice to her realization that it was “ok to not know everything” as a science teacher. By the end of the semester Karen admitted that her lack of experience with science as an elementary student could have contributed to her negative attitude in the subject. In the process Karen began to recognize the importance of science being taught at the elementary level. In her post interview, Karen stated that she felt well prepared to teach science and stated content knowledge and her previous experience teaching in the afterschool science club.

Diverse Students, Teaching Strategies and Confidence

At the beginning of the semester Karen’s confidence and interest in teaching diverse students started lower than her peers but demonstrated a stronger growth over the semester ($\Delta=4$, class $\Delta=1.57$). Yet in her interviews she demonstrated no change in emotion starting high and remaining steady throughout the semester, explaining in her preinterview that she liked working with diverse students and “down the road (would) like to work with diverse students”.

Karen maintained this positive outlook for teaching diverse learners throughout the semester. In her post interview she explained that she appreciated diverse students and
“would much rather have a diverse classroom than one where everybody would be the same; that would just be boring to me” (post interview).

At the end of the semester when asked what strategies Karen felt were helpful in teaching English Language Learners, she shared a multitude of ideas that seemed to be based on her experience with the students in her afterschool science group. Strategies Karen mentioned included kinesthetic (active approaches for students during instruction) and providing supplemental materials such as visuals, maps and charts. She also found these strategies helpful in connecting instruction to students, and shared the importance of building rapport with family (See Table 12). She explained, “For English Language Learners I think the word wall was great. If we had more time we would do either a picture or a video clip that was on the word wall so they could see it easily as well, hand motions, speaking slowly . . . clearly, all those small things you almost forget, trying to incorporate that’ (post interview). Karen continued on to explain that the efforts she and her partner put forth were rewarded because, “I felt like we could totally hear the ELL kids changing as the semester went on” (post interview).

Karen also felt that connecting school to her students’ lives was important, speaking about it in both interviews and incorporating it into her instruction in the afterschool program. She described a strategy used by a teacher she once observed feeling that it helped to provide a connection between school and home. “Sometimes, my teacher for her Spanish students takes the students’ homework and gets it translated. She sometimes sends homework home for a few students in Spanish that way their parents can help them with that. That is something I think is really great. Her attitude is
‘now you better do your homework’. But I think of it more, oh that is so great a way to incorporate parents and students.” (post interview).

Karen also expressed a concern for diverse students and their ability to complete homework assignments. She shared an example of how she as a teacher could assist her students as they were working through a problem with resources. Karen said, you want to make sure all these students in your classroom had the resources that you were asking them to be using . . . make sure that all the students are able to go out and do that assignment. And if they can’t take them aside and work out a way to make sure they get that opportunity. A lot of times kids might be shy might not even mention, and a teacher might not notice, like ‘why didn’t you do this?’ and ‘I couldn’t; and it is just that they didn’t have the opportunity to (post interview).

Here Karen demonstrated empathy toward students who may lack resources and or support at home for completing science homework and felt it was the teacher’s role to be aware of her students’ needs and address them. In the following section, Karen’s responses to her interviews and her unit will be reviewed more closely to determine her understanding of strategies to be incorporated to aid diverse student learning.

**Instructional Strategies Discussed and Incorporated in Final Unit**

Throughout the semester, Karen demonstrated tremendous growth in her use of instructional strategies to aid in diverse student learning, see Table 12. Initially, in the preinterview, she only mentioned using student language and connecting science to the student as strategies to help diverse students. In her unit, Karen incorporated nearly all the strategies she discussed in her post interview which included a structured routine,
kinesthetic activities to keep her students active, visuals, word charts, student language, and worked to build rapport with her student’s family through an initial newsletter home to students. Initially, in the preinterview, she only mentioned using student language and connecting science to the student as strategies to help diverse students. However, strategies Karen mentioned in the post interview and further supported by the strategies she incorporated in the final unit, demonstrated tremendous growth. These additional strategies included kinesthetic activities, using visuals in instruction, incorporating maps, word charts, a KWL (What do you know, what do you want to learn, and what did you learn) chart, using student language, connecting science to the students and building a rapport with the family.
Table 11
Karen’s Instructional Strategies for Diverse Learners

<table>
<thead>
<tr>
<th>Strategies for diverse learners</th>
<th>Pre Interview</th>
<th>Post Interview</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured Routine</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Modeling activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Visuals</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maps, word charts, KWL</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Use student language/connect science to student</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Build rapport w/ family</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bring student culture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>x</td>
<td>Classroom Management</td>
<td></td>
</tr>
</tbody>
</table>

Another aspect that demonstrated Karen’s interest in truly meeting the needs of her diverse students was the effort she put into developing student sheets to support their investigations. The student worksheets presented in Karen’s unit worked to scaffold the student’s responses to the investigations and became more student friendly with images and more text as the unit progressed.

By the end of the semester, Karen’s survey scores represented a strong growth in her confidence and interest in teaching diverse students. Karen demonstrated a great willingness to work with diverse students and their families to help them succeed in their learning by sharing multiple instructional strategies. Furthermore, her confidence and the strategies she utilized in her unit to support students increased.

Beliefs About Teaching Science Through Inquiry
At the end of the semester, Karen appeared to be open to incorporating inquiry into her instruction according to the results of her survey and interviews. Specifically on the survey, Karen’s scores indicated that she felt comfortable giving students opportunities to communicate and explain their ideas through discussion. Her initial scores for the discussion factor at the beginning of the semester were comparable with her peers, but Karen showed a stronger growth by the end ($\Delta=3/\text{class} \; \Delta=1.29$). However, for the openness factor, she seemed a bit hesitant to provide students opportunities to explore science content through their own ideas. While Karen started higher than her peers in the presurvey, she demonstrated no growth on the post survey. Here Karen hit a ceiling effect, there wasn’t much room for her to demonstrate growth. The class overall, however, had a slight growth ($\Delta=0/\text{class} \; \Delta=1.09$).

Karen’s survey responses for traditional science increased ($\Delta=1/\text{class} \; \Delta=-1.75$) which on this scale meant that she was moving toward a more traditional lecture and textbook approach, and away from a more inquiry stance of instruction (Table 4). It is important to note, however, that according to Karen’s survey scores, she started and ended the semester much closer to an inquiry stance of instruction than her peers. This meant that in both the pre and post survey, Karen responded to each of the five traditional survey questions indicating that somewhere between sometimes and rarely she would use lectures and textbooks to supplement her science instruction. This was in contrast to her peers who early in the semester, responded for items that would sometimes include lecture and textbooks in their science instruction later moved to between sometimes and rarely selecting lecture and textbooks.
For the inquiry practices factor Karen started at the peek of the scale, higher than her peers and remained steady throughout the semester (Δ=0/class Δ=4.54) indicating she felt prepared to teach using scientific inquiry skills such as asking a question or planning and conducting a simple investigation. Additionally, her interviews indicated that she also demonstrated growth in her acceptance of inquiry as a major contributor to an excellent lesson.

In each of the pre/post interviews Karen was simply asked to describe an excellent lesson. In her preinterview Karen failed to mention any specific type of inquiry-oriented investigation, but she did describe an open, more student led inquiry approach of questioning in her idea of a strong science lesson. She explained, “I guess it would be a class that would allow the students to ask the questions, whereas in a normally based classroom the teachers are asking the questions and the students are raising their hands and asking. So, if it was inquiry-based, it would be based on the students questions and then the teacher formed the lesson based off of that” (preinterview). Here, she also explained the importance of giving students opportunities to be engaged through discussion around an activity.

Karen, however, began her post interview with great enthusiasm as she more clearly described her image of an incredible inquiry-based science lesson often drawing parallels to her own instruction in the afterschool science club. Initially in the post interview, Karen began sharing her idea of an excellent lesson by explaining the teacher’s role as beginning the lesson with essential questions, stating that the students would be working with questions provided by the teacher. She explained, “I guess at the beginning
the teacher should say the essential question’s and the teacher should ask the students questions. Straight up with a nice conversation in all of this” (post interview). However, it is important to note that this is in contrast to the pre-interview where Karen explained that her students would provide initial questions for investigations. This contradiction will be discussed in more detail below.

While Karen discussed many aspects of an excellent inquiry-based science lesson she did not discuss the experimental design portion in her post interview. However, she did describe student led investigations as being a key element of inquiry-based instruction. Karen explained, “inquiry, it is heavily relying on the kids themselves doing the investigation and finding things out for themselves rather than being told what to do so it is a lot more open ended in the sense” (post interview). This belief was further supported by the examples of opportunities she gave her students to work through an investigation independently of the teacher, making discoveries. Here, Karen described an instructional style where despite teacher generated questions, the students would have great freedom to explore and work together to investigate and solve problems.

A science lesson, um, I would feel a lot of interaction between the students themselves and working together to solve the problem at hand the investigation. . . I wouldn’t necessarily be seeing the teacher that much, maybe as an onlooker giving them the scaffolding (for) their learning, giving them ideas or suggestions but really like stepping back. But I know that when we did that that is when the students had the most fun and learned the most. . . There is a lot of, like, talking hands on type stuff, doing the same trial multiple times (postinterview).
Above, Karen also reflected on the impact this type of instruction had on her students’ ability to collaborate and solve problems independently.

Karen continued her description of an excellent inquiry-based science lesson by explaining how she would help students make sense of the data they had collected during the investigation. She described the importance of her students collecting their data by recording their observations through the aid of worksheets distributed by the teacher. She explained that the teacher would probably give students a worksheet that way they could record all their observations. But she would have it set up as much as she could before the students came in . . . and the students would definitely record observations cause I felt like our students would go back and look at their observations. When they were on task they would go back and look at their observations on a good day.

There is a lot of like talking hands on type stuff, doing the same trial multiple times (Postinterview).

The worksheets Karen described above provided a structure for her students to make sense of the data. Karen described how these worksheets helped to keep the students focused on the multiple trials in an investigation and find connections to other investigations. She also saw value in the student recording multiple trials so they could revisit these observations.

As the post-interview progressed, Karen shared her thoughts on the role that questioning played in all aspects of her inquiry-based instruction, rather than only the initial step in an investigation. She explained, “so I would say that I would let kids think
for themselves, rather than being told. We tried to always let students ask questions rather than tell them.” She continued to explain that questioning in her instruction wasn’t “a one-time thing. We tried to keep it standard throughout the entire unit that we did, so they were constantly questioning what they did, and then from the lesson they were going back and questioning what they did previously” (post interview). Here, Karen spoke about her students questioning their results during investigations and continuing to challenge their own understanding.

But even with this enthusiasm for inquiry-based science instruction, Karen still had room to grow in her instruction. Her description of how a teacher would close an excellent lesson grounded in inquiry was a bit vague, stating that the students would have a conversation around the questions at the end of the lesson. Karen explained, “and then at the end of the lesson the teacher would call the kids back where they would have a wrap up where the teacher poses a few essential questions” (post interview). It was difficult to discern whether Karen meant for this section of the lesson to be more structured.

While her discussion of an inquiry-based science lesson during her post interview was quite rich, it became clear that many of the instructional decisions she and her partners made during their lessons for the students were based on a powerful experience from their first lesson. Here she described how the initial lesson was too open, or too student led. She explained,

the first one (lesson) where we left it very open ended that was almost a bit too open ended in the amount of time. But I feel like if we had given more time it
would have been a really, really great science lesson, because they had already learned all the terms we wanted them to have. We introduced it to them we had the word wall, but then it was a great lesson because they were able to experiment and see what worked and didn’t work and learn from their own mistakes as the lesson went along without us telling them yes or no (post interview). Here Karen shared that her first lesson was too student directed at first. She and her partners realized that more scaffolding was needed in order to help the students build the skills to handle the responsibility that comes with a more open ended student directed lesson. The specific instructional changes and strategies Karen implemented in subsequent lessons as a result of this experience teaching the students will be described in the next section.

After Karen’s experience with her first lesson, she found ways to incorporate inquiry at a level she was comfortable with. While in the pre-interview, Karen may have felt that the teacher role was to maintain more control by asking the initial question for the investigation, but then grew to give the students more responsibility with other sections of inquiry as represented in the inquiry chart (Figure 3) including developing a research question, designing the investigation, collecting data, making sense of that data, and constructing explanations and eventually a model.

In summary, by the end of the semester, Karen’s survey responses indicated that she was open to student communicating and explaining their ideas through discussion and questioning. She was slightly more open to using a lecture and or textbook as part of her instruction but still remained closer to the inquiry end of that factor than her peers.

138
However, her high score for inquiry practices meant she felt prepared to teach using scientific inquiry skills such as questioning and designing an investigation. Her final interview supported these findings.

While Karen’s elaborate description of an excellent lesson in the post interview helped to demonstrate her understanding and appreciation for inquiry-based science instruction and her responses throughout the remainder of the interview continued to support her beliefs. Throughout the interview, Karen often supported her beliefs of inquiry-based instruction by sharing specific examples from her own experience teaching the afterschool science club to support her understanding of an inquiry-based science instruction.

She spoke in depth about inquiry-based science instruction highlighting the importance of student questioning, discussion and collaboration, and running multiple trials during an investigation. More importantly, however, Karen demonstrated her ability to recognize shortfalls of a lesson and make strides to scaffold student learning so that students would develop the skills necessary to do inquiry-based investigations.
FIGURE 3: Karen’s Final Unit Plan, Force and Motion Unit for Second Grader
Inquiry Instructional Practice as Represented in the Final Unit

Karen and her partners learned a lesson early in the semester that seemed to have greatly influenced their approach to inquiry-based instruction. In her preinterview, Karen believed that inquiry instruction was guided by student-developed questions. However, it wasn’t until she began to teach that she realized there was a range of inquiry-based science instruction and that with supports and scaffolds students could develop the skills for a more student directed inquiry.

Figure 3 represents the level of inquiry represented in each of the six lessons in Karen’s final science unit entitled Force and Motion. Looking closely at Lesson 1 entitled, “Friction” students were given the following teacher directed question, “Which surface creates the most friction for the ball?” This is a testable question for an investigation. As the teacher, Karen presented the question so Lesson 1 ranked a #1 for the criteria ‘Develop Research Questions or Challenge’. Once again, it is a teacher directed question for the students to investigate. Next, Karen gave the students materials to test at least two surfaces (for example: hardwood floor and shaggy carpet) to determine the impact friction from those surfaces had on balls rolling down a ramp. Students were to select the materials they wanted to test and expected to find an area in the room to set up the investigation. Therefore, for the ‘Design Investigation or Structure’ criteria, the lesson received a #2, students were given most of the variables and controls as well as a model investigation procedure. The students had to set this investigation up themselves, following that model. Students collected most of the data they gathered in the investigation, giving the lesson a #3 in that category. Students were given a worksheet to
help them organize the data they collected. This category received a #1 because the worksheet specifically designed by the teacher contained the specific structure for the students to document their data. And finally, Karen designed a very guided closure with specific questions for the students to answer. The students did not, for example have to formulate their own explanation of the effects of friction on objects. Therefore Lesson #1 received a #1 the criteria, “Construct Explanations and Models”.

As mentioned earlier, Karen described her experience teaching the first lesson in her unit as too open feeling the students had a bit too much freedom to select variables in the investigation. Upon close inspection of the first lesson, however, only one aspect of the lesson seemed to be more student directed than the others, and that was the design of the investigation.

Yet, in the second lesson, students were to rotate among four stations where an energy focused investigation was set to varying heights to test a ball so that it traveled the furthest distance in the fastest amount of time. Rather than giving the students the freedom to select the heights or even select a way to test the question in the second lesson Karen and her partners had developed a teacher directed investigation with fixed variables. However, with each progressive lesson the inquiry represented became more open ended and student directed so that by lesson five of six the lesson was primarily student directed (See Figure 3). By the end of the unit, students were given full reign to design an investigation to explore an aspect of rollercoasters, that takes into account friction, energy, force, gravity, acceleration, speed, slope and height. Data from this investigation would help the students be better prepared to build a fast final rollercoaster.
Looking at Figure 3 it was evident that Karen and her partners pulled back in the earlier lessons offering investigations that while still inquiry-based, represented a more teacher directed inquiry than had been represented in the first lesson. The remainder of the unit however, incorporated a variety of inquiry investigations that became progressively more student directed. Except for the first lesson, many of the earlier lessons were more structured and teacher directed, while the later lessons gave the students more freedom and responsibility in designing their plans and final roller coasters. By the fifth lesson, Karen and her partners had worked up to allowing the students to ask the initial question and select the variables and design they wanted to test with their rollercoaster design. Their sixth and final lesson was the actual construction and testing of the final rollercoaster.

Additionally, as mentioned earlier in the diverse learners strategies section, in response to this pivotal experience, Karen and her partners’ demonstrated great growth throughout the unit in the supports they offered for their students’ responses during the investigations, particularly after the first lesson. Among the many changes they designed a student investigation sheet with more specific with images, space for student comments and data recording. They also began incorporating a word wall that they displayed each class period for students to review and add terms.

In summary, Karen felt that it was important for students to be engaged in inquiry-based investigations and discussing and questioning science and offered examples from her own instruction in the afterschool club to support her statements. The lessons in Karen’s unit also demonstrated her appreciation for inquiry-based science
instruction. After an introductory student directed lesson, Karen and her partners initially pulled back making the lessons more teacher directed. But, as the unit progressed, Karen and her partners gradually worked to give the students more of a role in the investigation by determining which factors to manipulate and eventually which questions to ask and investigate. In the next section I will review Karen’s reflections on the impact this type of methods course had on her as a teacher.

*Final Reflections on the Methods Course Itself*

Reflecting back on the course, Karen had much to share about the impact the experience had on her as a future teacher. Here she explained that she would enjoy teaching science, sharing that she appreciated the interaction she had with her partners and the impact she felt their instruction had on their students. Karen replied, Yeah I do, I really enjoyed our semester w/ the kids, I loved the kids, it was always different, very hands on, I liked to talk to people, I don’t have to have a classroom that is quiet it was a really good experience, I loved working with (my partners) and we worked really well as a team. Like we always were able to bounce ideas off each other. . . It really worked out. . . . I felt like we could totally hear kids changing as the semester went on (postinterview).

Karen continued on describing how much she valued the extended practical experience of teaching her students. Here she explained the importance of incorporating theory by actually teaching students. She explained that it was helpful actually out in the field. I feel like it is really bad when you are teaching and there are no kids around see how they react and see what works and doesn’t work.
Because you can read all the things you want and think you know how things are going to turn out, but necessarily it might not be the case. That is the way it was with science class, there were a lot of things that we weren’t sure of so we tested them out and we saw what worked and what didn’t work we were able to base that on our future lesson plans. Meanwhile, if we were not out in the field, we might have thought like what we did initially was great and we might have just continued doing lessons like that. Never actually having tested the lesson out, you know so I feel like it gave me a chance to learn from your mistakes being out there. That is why I feel this class was beneficial (post interview)

This experience with the students gave Karen and her partners the opportunity to identify problems, research and revise future lessons, and then see their lesson’s impact on student learning. Karen appreciated the opportunity to teach six science lessons because it gave them the opportunity to see the impact of their lessons on student learning. They were able to see the troubles with their approaches and make necessary changes for future lessons. Whereas, in another methods course without the field experience, it was challenging to know whether the lessons developed for a unit were appropriate for student lessons.

Karen also found great support in the course structure where she, her classmates and the instructors would debrief following each science club meeting. I feel like the most beneficial were our days at (the elementary school) where we were actually with the students and we talked at the end what was good. Hearing other people’s (thoughts) what they did and didn’t do. I know we got ideas from other people
ideas for worksheets or different things they do with students. We are all great teachers and it was really beneficial to hear their insight and what they were doing (postinterview).

The reflection portion of the each class held at the elementary school was beneficial for Karen in providing ideas and support for her instruction. This portion of the class immediately followed the science club each week. During this time the preservice teachers shared their experiences, lessons and advice with each other. One last support that Karen valued were the detailed comments her instructors left on her weekly reflections and lesson plans.

And also the comments you and (the professor) gave us in our lessons and reflections, I know it helped (my partners) as well in planning our lessons, and by showing me what you were looking for in a reflection made it easier for me to be thinking about while I was teaching the lesson. So it gave me a place to put my mind. . . . (post interview).

Finally, most importantly, Karen during her post interview directly contributed her confidence in teaching science to her experiences from this science methods course, “I do feel a lot more confident than before. I do feel a lot more than before and I know it is because of this course.”

Summary and Analysis of the Case

Karen’s confidence in teaching science grew throughout the semester. At the end of the semester Karen admitted that her lack of experience with science as an elementary student could have contributed to her earlier negative attitude toward the subject. As the semester progressed, though, Karen began to recognize the importance of science being
taught at the elementary level and come to the understanding that it was ok not to know everything about the science concepts she was teaching. She additionally demonstrated a growing interest in science as a subject important to be taught at the elementary level.

By the end of the semester, Karen’s survey scores also represented a strong growth in her confidence and interest in teaching diverse students. Karen demonstrated a great willingness to work with diverse students in the afterschool club and their families to help them succeed in their learning by incorporating multiple instructional strategies. Furthermore, her confidence and the strategies she utilized in her unit to support students increased.

The content in Karen’s final unit lessons was accurate and grade appropriate receiving high scores in coding. With one exception, the lessons were sequenced appropriately. And finally, the final overarching goal of building a group roller coaster based on the results of the unit investigations provided an excellent conclusion to the unit.

Looking at Karen’s growth throughout the semester, the thing that stood out the most was her growth and understanding in the area of inquiry-based science instruction. Several things seemed to contribute to this growth but much of it seemed to be based on a pivotal experience teaching her students in the afterschool science club. Other indicators that Karen was developing a deeper understanding of inquiry were, a richer view of the role questioning plays in inquiry instruction, the understanding that it was ok to not know everything about science content, and the incorporation of multiple strategies to aid her diverse learners.
Early in the semester, it seemed that Karen accepted inquiry without much question. In her pre interview Karen had this evolving notion of how to put inquiry into practice. She discussed the student’s role as generating the question to be investigated. This understanding was further supported in her post interview by her description of the first lesson she and her partners taught to their afterschool students where the students were given some latitude to select from variables and designs for their investigation. In implementing her initial belief of student-generated and directed investigations, Karen struggled to put it into practice initially. Problems came about with her students. After her encounter with the first lesson Karen began to examine and question her ideas around inquiry-based science instruction.

Karen and her partners experienced the challenges of teaching and working with students in an inquiry environment. Prior to that first lesson in the afterschool science club, Karen did not have any experience teaching or observing inquiry-based science. Teaching all subjects through an inquiry approach, however, was the rule through this university teacher education program. Karen believed in this philosophy and wanted to embrace it. But once she finally received the opportunity to put the theory into practice her instruction was not as effective as she had hoped. It didn’t go as well as it could in part because she didn’t feel enough control over the students and their interactions with the material. But she didn’t step back and stay there. Karen had such a strong belief in inquiry that she reflected on what went wrong and then determined key steps she and her partners needed to do to help their students be better prepared for inquiry-based instruction.
Karen became more cognizant of her students needs for more support and scaffolding in their investigations. Initially, she and her partners pulled back, making the next two lessons more teacher directed, but then her investigations became increasingly more student directed, showing a progressive growth throughout the semester. Among the first changes they incorporated was the decision to take a step backwards and provide more structure for the students. Karen and her partners found a way to teach an inquiry-based science lesson by making it more teacher directed while still giving students a role in the investigation. They didn’t stop there. Karen was a reflective person and kept pushing back to the open ended experience to where by the fourth and fifth lessons she and her partners gave their students much more latitude. She was so strongly sold on inquiry instruction that she was going to bring inquiry back into her science instruction regardless, she just needed some support to do it.

Despite this, Karen’s post survey responses for inquiry were mixed. While Karen does respect the more student led approach to instruction, more even then her classmates, her own personal score moved slightly toward lecture, or teacher led approach to instruction. Meanwhile, the other inquiry factors indicated she was more open to student discussion and utilizing science inquiry skills such as questioning, and planning and conducting simple investigations. The fact that Karen’s view of what was possible to do in a classroom setting went more toward textbook/lecture when virtually everything else for inquiry increased, possibly helped her to be a bit more realistic in the limitations that can exist in a classroom
Describing the role of questioning in inquiry-based science investigations became a main focus in both of Karen’s interviews. As Karen reflected on what inquiry instruction meant to her, it seemed as if Karen was beginning to see the finer details of what science inquiry instruction represents. Questioning took on a much deeper meaning for Karen in the postinterview. No longer feeling that inquiry instruction only represented an initial question, Karen was beginning to see the richness and diversity of inquiry-based science instruction in what appeared to be a direct result based on an experience from their first lesson. Generally, her description of questioning in the post interview had more substance relating to specific ways she incorporated both the student and teacher role in questioning throughout the investigation.

I argue that Karen’s belief around inquiry-based science instruction became more grounded as a result of the significant support she received as she sought to define her ideas, beliefs and her practices.

It was helpful for Karen to be a part of the debriefing sessions learning struggles and interventions strategies that her peers had incorporated into their instruction. The design of the course structure worked for Karen giving her the opportunity to reflect on the process and work to improve the quality of instruction. In other words, Karen could reflect on what she wanted to be and where she wanted to go because it was a safe environment. The experience gave her the confidence to stop and reflect on what was happening with her students. Then she worked back to the inquiry instruction she had initially envisioned at the beginning of the semester.
CASE 4: EMILY - FIELD BASED PRESERVICE TEACHER

This study was conducted while Emily was a junior and enrolled in an Elementary Education program while also pursuing a History major. As a part of the field-based science methods course, Emily designed and taught an eight-week unit on force and motion to second grade students enrolled in an afterschool science club.

Emily had limited opportunities to observe students learning through scientific inquiry in her prepracticum placements and no opportunities to teach science prior to this course. At the time of this study Emily was placed in a kindergarten/first grade classroom for her third of three prepracticums. Emily’s first prepracticum was in a fourth grade class during their science Fridays and her second was in a fifth grade parochial classroom. These placements gave her opportunities to view upper elementary students doing a science unit on electrical circuits and kindergarteners doing a plant unit. However, in her second prepracticum at a local parochial school, Emily’s cooperating teacher described their science program as “you open a book and read from the book” (preinterview). She indicated that she was interested in teaching Kindergarten or first grade once out of school.

As a teacher in the afterschool club, Emily experienced a constant tension throughout the semester wanting to do as the course expected by teaching science with inquiry-based instruction. Yet she valued the lecture based instruction that had served her so well throughout her schooling. One of the few times Emily personally experienced inquiry was as a student in inquiry oriented content course at her university.
Throughout the course, she came to realize that she barely understood physics despite doing well in high school coursework.

Emily’s experience with diverse students was as the social chairperson for students ages 3-21 enrolled in a multiple disabilities school located on campus. Emily indicated that she enjoyed her work with diverse students and felt that each small step they take should be celebrated. This course gave her the opportunity to experience teaching diverse students.

As I present Emily’s case I will describe her tension between lecture based and inquiry-based instruction and the journey she experienced as she and her partner worked with six diverse students in the afterschool science program. In the following sections, I will address Emily’s understanding and confidence in the areas of content knowledge, teaching diverse students, and inquiry teaching.

Content Knowledge and Confidence

Emily began the semester providing mixed messages about her confidence in science content knowledge on her survey and interview despite a strong background in science coursework in high school and a high pre-survey score. Her pre-survey score in physics, the subject area taught in the afterschool curriculum, started at the peek of the scale for physics, higher than her peers, and remained steady throughout the semester. However this only demonstrates that there wasn’t a drop in her score. While Emily’s survey score could not represent further growth in physics from pre to post, she did demonstrate a growth in her understanding and confidence related to physics as represented in her interviews and final unit reflection to be described below. While her
peers’ demonstrated growth in physics ($\Delta=3.43$) few selected the highest score even in the post survey (see Table 5).

On the survey, Emily and her classmates in the field-based methods section, generally demonstrated more confidence related to physics concepts than they did with chemistry, earth science or biology. Both Emily and her classmates growth for Chemistry was slight ($\Delta=1/\text{class } \Delta=2$) and in Earth Science Emily showed a bit more growth than her classmates ($\Delta=3/\text{class } \Delta=.79$). However, her biology score decreased while her peers demonstrated a slight growth ($\Delta=-2/\text{class } \Delta=.75$) (see Table 5). The lower growth Emily and her classmates demonstrated in all subjects except physics was not particularly surprising given that the instructional unit for this methods course section focused on physical science concepts.

Emily came to the science methods course with an extensive background in her high school science courses. In high school she took several science courses including: advanced placement biology, Earth Science, chemistry, physics, and environmental science. At the beginning of the semester, Emily explained the role lecture, memorization, and assistance from family members in the medical field played in her high school science courses. “Lecture was helpful, (I was) really good at memorizing, my parents are both in the medical field and my sister too, so they were good about helping me.” Later in the interview, Emily did however admit having done well in her science coursework, despite not having an understanding of physics. She seemed to accept the fact that she had mastered the art of doing well in science courses without having an understanding of it.
As an undergraduate, however, she took the university’s minimum science requirements for her degree which included a nonmajors physical science course with a lab and a general biology course with no required lab. Despite her significant science coursework in high school, Emily admitted she didn’t understand aspects of physics until she built rollercoasters as part her undergraduate physical science course lab, as evidenced by the quote below:

I didn’t have a lot of science in high school. I really did like Mr. McGovern’s class where he had us build roller coasters. When I took advanced physics in high school I didn’t really understand those properties as much as I could regurgitate them, but when we built those roller coasters, which is such a ridiculous thing to have college students do, but it was really fun and we really got into it, trying to make our ball have the fastest speed (pre interview).

There seemed to be a conflict in Emily’s statement in the above quote, “I didn’t have a lot of science in high school”. Initially it seemed to contradict the five advanced level science courses she described taking as a high school student. But, in looking at the context, if in this case ‘science’ represented inquiry to Emily, the statement could explain her limited experience with inquiry as a high school student.

In the next section, I will review Emily’s unit looking closely at the accuracy of content presented, the sequencing of that content within the unit, and the quality of the overarching goal.
Unit Overview

For their final unit, Emily and her partner designed a six-lesson force and motion unit entitled “Roller Coasters and Motion” for second graders (See Table 12). The final units developed by the preservice teachers provide insight into their understanding of the content and inquiry-based teaching practices. Here I will discuss the content portions of the unit. For purposes of this research, I have referred to the unit as Emily’s alone to simplify language.

At the end of the semester Emily and her partner received a two out of three on the content portion and lesson sequence of their final unit on force and motion, and the highest score for the overarching goal (see Table 13).
<table>
<thead>
<tr>
<th>Lesson #</th>
<th>Lesson Title/Content</th>
<th>Lesson Objective</th>
<th>Lesson Question</th>
<th>Lesson Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Force</td>
<td>Students will identify forces they observe acting on the balls in their experiments.</td>
<td>What makes the ball move?</td>
<td>Discussion, demonstration, and investigation: Students discover different ways to make the ball move. What caused the ball to move and in what direction did it travel? (3 trials designed by students)</td>
</tr>
<tr>
<td>2</td>
<td>Friction</td>
<td>Students will be able to understand the idea that an object at rest will remain at rest until acted on by an outside force.</td>
<td>What role does friction play on the movement of roller coasters?</td>
<td>Discussion, demonstration, and investigation: Students test at least two surfaces (hard floor, shaggy carpet, petroleum jelly) to see how fast and how far the ball rolls. What is causing the differences in how fast and how far the ball rolls?</td>
</tr>
<tr>
<td>3</td>
<td>Energy</td>
<td>Students will explain why some balls did not complete some tracks, while other balls reached the end of other tracks.</td>
<td>What determines how fast a roller coaster goes?</td>
<td>Discussion, demonstration, and investigation: 3 centers Students study a prebuilt roller coaster, predict. Observe ball through 2 different tracks Where does the ball have the most potential energy</td>
</tr>
<tr>
<td>4</td>
<td>Force, friction and energy review</td>
<td>Students will be able to understand that an object at rest will remain at rest until acted on by an outside force.</td>
<td>Have they learned anything new from repeating these experiments?</td>
<td>Discussion, demonstration, and investigation: 3 centers (repeat of previous three lessons)</td>
</tr>
<tr>
<td>5</td>
<td>Thoughtful design of roller coasters</td>
<td>Students will demonstrate their understanding of potential energy and kinetic energy through the effective design of their roller coaster.</td>
<td>Create roller coaster designs and label hills, loops, twirls, most potential energy and kinetic energy</td>
<td>Students come to front of room to draw a sketch or demonstrate concepts. Students work individually to design their roller coaster for the last class by referencing the applications list they made as a group each week.</td>
</tr>
<tr>
<td>6</td>
<td>Building Roller Coasters</td>
<td>Students build their roller coasters using their design, and sc. terms to describe it to the class. If the roller coaster doesn’t work, student should be able to locate problem and fix it.</td>
<td>Testing Roller Coaster Design</td>
<td>Test Time Students build their roller coaster and have teacher come to test it. Have each student share the one thing they think is most crucial in building a roller coaster and explain why. Did your roller coaster make it to the end of the track the first time? If not, what did you have to change?</td>
</tr>
</tbody>
</table>
The content Emily included in her unit to address force and motion was grade level appropriate for second graders consistent with the AAAS benchmark standards. The unit began with an introduction to force and then each lesson consecutively covered friction, energy, a review of the previous three lessons, a rollercoaster design session and then the building of the roller coasters. However, gravity, a key concept for teaching force and motion particularly when preparing to build roller coasters, was only briefly mentioned with friction and not addressed in an activity. If gravity had been included it should have been introduced either before friction or just after.

The majority of the lessons were both conceptually strong and sequenced appropriately because they helped the students gain a deeper understanding of the content and they built upon one another before proceeding. By the fourth week of instruction, though, Emily and her partner sensed that their students were struggling with the content and wanted to give them a second opportunity to grasp the concepts. Their instructional approach for their review session, however, failed to provide new experiences for the children because the centers remained exactly the same as they had been originally taught. Reviewing concepts midpoint in a curriculum can help students gain a richer understanding of the content, if the concepts have varying forms of instruction.

In summary components of the unit were strong, receiving the high scores in coding. With one exception, the unit was sequenced well with accurate content. A student designed and constructed roller coaster served as a strong overarching goal. In
the next section I will discuss Emily’s confidence in teaching science content to
elementary students.

Confidence in Teaching Science Content

By the end of the semester Emily’s confidence in teaching science increased to
the highest level from her pre to post interviews. Emily was hesitant in her preinterview
stating that “the setting of her first teaching position would determine her level of
confidence” (post interview). She was referring whether her future school administrators
and co-teachers accepted and supported inquiry instruction.

In her pre-interview, Emily acknowledged the effort necessary to prepare to teach
a unit on the concepts of energy, force and motion for students enrolled in an afterschool
club that semester saying, “I need to go back and brush up on my knowledge of it
physics.” Furthermore, she anticipated the additional preparation necessary to understand
the content when teaching inquiry-based science instruction rather than lecture. Through
her thoughtful reflection Emily explained,

I think that teaching in that way requires more prep than maybe in another way,
because when you give kids autonomy you need to think about all the different
possibilities that they may do and have a back up plan for new questions that may
come up and may go in different directions which is sort of an organic approach
on their part (pre interview).

Emily appeared to appreciate the challenge of students asking questions of her in class
that she may not have an answer for. Science lessons based in lecture typically offer
fewer opportunities for students to ask such questions. Science lessons that are grounded
in inquiry, however, often provide more opportunities for students to ask questions that may be outside a teachers’ comfort range for content knowledge which can be quite uncomfortable for many, particularly beginning teachers. She indicated that she understood the amount of preparation necessary to be prepared to teach inquiry-based science.

Emily indicated in her post interview that early in the semester she struggled with science content knowledge and the effort necessary to be prepared for science instruction. She valued her experience teaching the students for the model it provided her. She felt that teachers should understand the content in order to accurately teach it, even at the second grade level. In this thoughtful reflection, Emily states:

Just like the kids, we needed to see (experience) it, (teaching) in action, and it is hard to explain something in second grade terms and not have it diluted or confusing if you don’t quite understand it yourself. We were a little worried in the first few lessons that we were wrong. Like we didn’t know the science content, which I also think plays into why the whole force thing was very hard (post interview).

Here Emily acknowledged the struggle she and her partner encountered trying to break down the concepts behind force and motion for younger students without having a solid understanding of the content themselves in the initial weeks of the science club. Hence, she felt that the experience of teaching in the afterschool session helped to model effective science instruction and contribute to her and her partner’s focus on improving the content in their lessons.
Emily also valued the reflection time that followed the preservice instruction in the afterschool science club that was offered as part of the methods class. In her post interview Emily reflected on her initial apprehension of teaching a subject she barely remembered. Below she shared how her confidence in the content grew as the semester progressed due to the valuable resources offered by the course to support her instruction as well as her own growth in pedagogical content knowledge.

I remembered very little about motion despite the fact that I took an entire year of physics in high school. It was scary to think that I was going to instruct students on the principles of motion in January. As the semester continued onward, I gained more confidence in both my knowledge of the content and my ability to teach it. The plethora of sources, support from our professors, and discussions with our peers really gave us many ideas for teaching motion . . . The discussions in class, my partner and I felt really helpful to hear what everyone else was doing” (post interview).

Here Emily acknowledged the value of her classmates’ comments during the methods course weekly discussion and reflection time to help model ways to introduce the content at a grade appropriate level.

Through her teaching in the afterschool club, Emily was able to experience students and their enthusiastic response to inquiry-based science and realize that impact that has on a teacher’s ability to teach the related concepts.

Everything like that I think that as long as I don’t put that mental block up that it is science, science, science, I think I really will enjoy because the kids enjoy it so
much, and when they are into something it is so much easier to teach (post interview).

This statement also implied that even though Emily felt more confident and recognized the value and importance of teaching science she was still somewhat nervous about teaching science and had a certain amount of uncertainty associated with doing science.

In summary, early in the semester, Emily’s strong science background and high grades did provide her with confidence in understanding science content that could be due to the fact that she learned science through a traditional approach. Yet, it wasn’t until she had experienced an inquiry-based lab in an undergraduate physical science lab that she came to have a better sense of the content. She explained, “when I took advanced physics in high school I didn’t really understand those properties as much as I could regurgitate them” (pre interview). Despite her high score, however, she recognized the challenge of adapting that knowledge down to a primary level.

Once in the afterschool classroom Emily quickly realized that she wasn’t sure how to teach that content. Emily recognized that inquiry-based instruction, much more than the lecture-approach, required that teachers understand the content behind force and motion before teaching the concept, especially to younger students. She also demonstrated a typical concern, like most preservice teachers, that she wouldn’t be able to answer all the student’s questions. In both her post interview and final unit reflection, Emily reflected on the effort she invested to learn the content behind force and motion to more accurately represent the physics concepts for younger students. She valued the teaching experience and the class reflection and discussion period that followed each
teaching session. Emily explained that the experience of teaching second grade students coupled with the support from professors, peers and resources contributed to her increased confidence in teaching science despite a bit of hesitancy based on the fact that the subject she is teaching is science.

_Diverse Students, Teaching Strategies and Confidence_

Emily’s confidence and interest in teaching diverse students dropped while her peers demonstrated growth ($\Delta=-4/\text{class } \Delta=1.57$). Her post interview confirmed a drop in her confidence in this area. Yet, as the chair of social events for a campus-sponsored school serving students with multiple disabilities, Emily looked forward to teaching diverse students; exclaiming “I love it!” She spoke of her admiration for diverse students saying, “you have . . . to be able to find joy in unique mini steps, and I think that . . . people focus on them but they focus on why they are diverse and not why they are this unique kid.” Emily also had empathy for the struggles ELL students faced in a classroom. Below she spoke in depth about the challenges ELL students faced trying to navigate between home and the classroom in a culture focused on learning standards.

Second language students often times are incredibly bright, average kids doing incredible things because they are learning two different languages, and they’re translating constantly between home culture and school culture and friend culture and there is so much going on and they could be great teachers to their peers but too many times people think they have to catch up on, catch up to, the standards (pre interview).
Despite this positive outlook, Emily showed a decrease in the post interview related to her confidence in teaching diverse students while other preservice teachers in the field methods course demonstrated no change or growth. For example in her post interview she spoke in depth about the challenges she had with an ELL student in her science club. She explained:

But I think one of our students really proved challenging because she was sort of . . . she didn’t really care so she checked out often, she wanted to be friends, but she didn’t care about the science and she definitely had language issues. I talked to her kindergarten teacher and also her 1st grade teacher, because I was like “how can we support her, is she receiving services?” that kind of thing, and they said that it is just a language processing issue on top of being an ELL. So she was frustrating to work with because we knew how much potential she had (post interview).

Out of concern for her student, Emily took the initiative to seek the diverse ELL’s current and past teachers to learn more about the student. No matter what they tried the student still wasn’t learning, they were just really discouraged.

Despite her disappointment with this particular diverse, ELL student, Emily demonstrated great growth over the semester in her ability to incorporate scaffolding to meet her students’ needs ($\Delta=5$). Emily acknowledged, however, that she and her partner had difficulties initially providing scaffolding and supports for diverse learners through their instruction. But direct experience with the students in their group enabled them to identify and address the needs of their students. Additionally the initial worksheets they
developed to support their instruction were busy with large amounts of information splashed throughout. As the semester progressed, Emily and her partner began to recognize their student’s capacity to learn. With each class the worksheets became more scaffolded and less complex while still working to get content across to their students and they began to incorporate more diverse instructional strategies (See Table 14). As part of her reflection in the final unit, Emily stated:

At the start of this unit, we struggled to integrate strategies that would benefit diverse learners. All of the students in our group were English Language Learners, but we did not incorporate enough supports in the beginning to truly support their needs. Yet as time progressed, “my partner” and I started to use simpler worksheets, a word wall, and more explicit explanations of the science concepts. We consciously tried to tailor our language to their proficiency level and support that level with explicit teaching (Reflection final unit, May 2007).

Emily echoed these thoughts in her post interview, reflecting on ways she and her partner could have better met the instructional needs of the students in their group. Here, she recognized the value of providing visuals like pictures and a word wall earlier in the program to support student learning. Emily indicated that the “written (aspect of science club) was a shortcoming of our design. But also we didn’t think enough in the beginning about supporting them so we should have had the word wall from the beginning used more pictures to support our text all this stuff” (post interview).
In both the pre and post interview and in her final unit, Emily continued to suggest a variety of strategies to use in attending to her diverse students needs and ideas. Throughout her lessons she incorporated videos, an illustrated word wall, other visuals, demonstrations, investigations, and centers.

*Instructional Strategies Discussed and Incorporated in Final Unit*

Prior to teaching in the after school science club, Emily stated that multiple forms of representation particularly the computer would aid diverse student understanding of content. When analyzing Emily’s final unit, Emily’s statements in the post interview strongly supported the strategies found in the lessons (Table 14), in fact strategies and some behavior management strategies found in the unit surpassed those mentioned in the interview.

**Table 13**
*Emily’s Instructional Strategies for Diverse Learners*

<table>
<thead>
<tr>
<th>Strategies for diverse learners</th>
<th>Pre Interview</th>
<th>Post Interview</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured Routine</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Modeling activity</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Kinesthetic</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Visuals</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Maps, word charts, KWL</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Use student language/connect science to student</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Build rapport w/ family</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bring student culture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The science lessons in Emily’s unit demonstrated her growing interest in making the content more accessible for their diverse students by scaffolding their lessons. She developed instructional skills that were generally gained through her experience teaching
the students and through discussions with peers during reflection each week. Generally she began to shorten demonstration time in an effort to give the students themselves more time to explore and investigate with their partners. As described above, a word chart did gain more prominence as the unit progressed. She learned to remove distractions while giving instructions, like holding onto the balls until students understood their role in the lesson. Looking specifically at Emily’s unit lessons, in the third lesson on energy Emily asked students to walk so that they could model or demonstrate where the potential energy was. Students were asked to explain their drawings in words in the review for lesson four. Then in lesson five students generated ideas to design roller coasters, that were reflected back on in lesson six as they built their roller coasters (Table 13).

In the final lesson students were also given steps and procedures to come up with answers for explanations. For example, when having the students test the rollercoasters she gave her students three descriptions of potential outcomes options from which to select and gave them time to discuss the results. Which of the following explanations demonstrate what you just saw, A., B., or C.? Finally Emily asked the students to use vocabulary from the word wall when describing what they experienced in the investigation and commending the students when they did incorporate the science terms into their science report (Table 13).

In summary, despite Emily’s love and appreciation for diverse students and evident growth in designing instruction, the post interview indicated Emily was less comfortable working with diverse students following her experience with the students in the science club. Yet, the unit and her conversations around the unit, highlighted a
preservice teacher who challenged by the experience, continued to think of ways to improve her instruction for diverse students both during the course and after. While she may have been struggling with the experience of teaching a challenging ELL student, it was promising that she was reflecting on ways to improve her instruction with diverse students should she teach them again.

**Beliefs About Teaching Science Through Inquiry**

At the end of the semester Emily’s survey score for discussion indicated that she was comfortable giving students opportunities to communicate and explain their ideas ($\Delta=5/\text{class} \Delta=1.29$), but a bit hesitant to allow them opportunities to explore science content through their own questions ($\Delta=0/\text{class} \Delta=1.09$). It is important to note that this factor demonstrated a small growth across both classes.

Emily experienced positive growth in her understanding of inquiry instruction, through her interviews particularly in the areas of having students develop research questions and giving students opportunities to design at least some piece of their own investigation. In terms of the survey she had the maximum score (20) on the pre survey but her score went down in the post simply because one question was not marked, leaving her with a score of (16) and the growth of the class was ($\Delta=4.54$).

The story for Emily, however, rests in her struggle to balance inquiry with lecture. Emily’s survey responses for traditional science demonstrated growth ($\Delta=4/\text{class} \Delta=-1.75$) which on this scale meant that she was growing toward a more traditional lecture and textbook approach, and away from a more inquiry stance of instruction (Figure 4). Yet, her interviews indicated that she demonstrated growth in her acceptance of inquiry
as a major contributor to an excellent lesson. According to her interview responses, she
had few opportunities in her life to experience inquiry as a student or observe it as a
preservice teacher as most of her science instruction was lecture-based. Initially, in the
preinterview it seemed as if Emily’s vision of inquiry in the elementary classroom was
based on what she felt was acceptable by her science methods instructors. There was
little substance to the inquiry examples she shared, however, which is understandable for
someone with such little experience in inquiry science. Yet, later in the pre-interview she
contradicted herself by indicating that she preferred the lecture-style of teaching and
wondered if the inquiry approach might alienate students like her, stating: “I actually
prefer to be lectured at rather than doing a group activity and I wonder how many kids
feel that way?” Later in the pre interview she continued:

I feel bad saying that sometimes lecturing might be better because it is so against
the current research, and I think for everyone involved sometimes I think
lecturing is ok. Which is not really . . . Like all my professors here are like ‘never
lecture, never lecture’ you don’t have to talk at someone. But like sometimes I
just think that information needs to be presented so that they have some kind of
context when they are doing experiments (pre interview).

Here, Emily was struggling with trying to balance her appreciation for the role that
lecture can play in introducing information connected to an inquiry activity, and the
inquiry focus of her general education courses. This marked the beginning of a tension
that Emily struggled with throughout the semester.
Emily and her teaching partner began the science club acknowledging that they were more comfortable with a lecture style of instruction but understanding that students might do better with a more active inquiry approach to instruction. Here she acknowledges the challenge she anticipated facing in allowing the instruction to be more student directed:

I think that a lot times of teachers do the lecture because they’ve seen it, its very easy, and they’ve done it and they have learned that way, and there is less risk of failure in that lesson, not necessarily on the test. So, I think that it is definitely a challenge. My partner and I were talking about this, it is definitely going to be a challenge for us to step back and build knowledge with the group together as opposed to having an idea of what we want them, . . .we have an idea of what we want them to discover but sort of allowing them to discover other things as they do the experiment as well (pre interview).

Here, Emily acknowledged the challenge she and her partner anticipated experiencing as they try to pull away from their comfort of lecture to teach inquiry-based science. She has taken her understanding of inquiry science and applied it to her expectations of instruction. Emily wants to have the students play a key role in the experimentation, but once again she ultimately has control because she and her partner are the ones who know what the students should discover. This could represent a direct belief in her epistemological view that science always has a correct answer.

By the end of the semester, however, Emily’s post score in inquiry instruction indicated that she still held close to her a more traditional approach to science instruction,
one that was more lecture based and teacher directed. In reviewing Emily and her partner lessons, it is evident they did offer their students more open inquiry-based lessons initially, but gradually grew to lessons that were more teacher directed. Yet, throughout the eight weeks, Emily began to personally recognize the deeper understanding her students’ gained from inquiry-based instruction.

I think that even watching what worked with my partner and I’s group, and what didn’t when the kids were actively involved in it and even if they couldn’t articulate what they learned in a really coherent way, knowing what they were trying to say, and like they got it better, they got the concepts that they experimented with and saw in context and manipulated and stuff, much, much better (post interview).

Here, despite her dedication to lecture and text, Emily appeared to be coming to the understanding, that the active approach of inquiry-based science teaching did have a positive effect on her students’ ability to learn the science concepts.

While Emily was limited in her ability to provide details of inquiry in her pre-interview, during her post interview she highlighted her view of how inquiry could be incorporated into specific lessons. In the post interview she became more articulate in her description of inquiry-based lessons and their impact on students by giving a detailed example. She demonstrated growth in both her description and incorporation of inquiry lessons particularly in the areas of giving students opportunities to help develop research questions and play a role in designing investigations (Figure 4). However, she did fail to
mention other components of the inquiry chart which included collecting data, making sense of the data and constructing explanations.

Emily’s descriptions for inquiry-based lessons became more specific and inquiry oriented as the semester passed. Emily’s initial descriptions of an inquiry-based lesson in the preinterview rarely went beyond general explanation of students creating their own questions and designing experiments. Later in the interview she became a bit more specific sharing an example of a marble exploration and the importance of having students focused. Emily explained:

If you do a class experiment like let’s observe these marbles and lets see what we see, and you ask question then it can be a minilesson. But if you have kids go off just exploring they may not necessarily know what they are looking for. I think you need to focus it, focus their inquiry through a mini lesson before you go off and some off to explore because they may not come back knowing what they are looking for. . . like a class experiment (pre interview).

In this hypothetical lesson, Emily seemed comfortable providing a bit more teacher guidance for the students initially, then giving them some freedom to explore with reasonable direction to help focus or assist students in making sense of their experiment. Her explanations, however, failed to have students analyze the data, organize it or construct explanations. While Emily was working to give her students a bit more freedom in their marble exploration, the activity falls more on the teacher directed side of the inquiry chart (Figure 4).
However, in the post interview Emily recognized the deficiency of a circuit lesson she observed where the students were instructed to construct various circuits but as she pointed out, never given the opportunity to create one of their own or light a bulb. Below, Emily described a way the lesson could have been more open or student directed in its inquiry.

When I was in the first grade classroom, and they were doing the circuits, that was interesting that they knew so much more than me and I came in mid week. I didn’t really enjoy that, I don’t know. Even though they were exploring, they didn’t have any creative license to do it. Oh, was it very much lined out, yeah, they had to design specific circuits, they never had to design their own or light up a big light bulb (post interview).

Emily recognized a way to make a teacher directed lesson more inquiry focused, by having the students design their own circuit or even try to light up a light bulb. In this description, her lesson adaptations would allow the students more self-direction by designing their own investigation, i.e. own circuit. However, once again, Emily failed to describe whether the students would collect data, test, or use information to construct explanations.

In the post interview Emily described how the tension between lecture and inquiry played out in their instruction throughout the afterschool science club.

I think that you can tell a difference between our earlier lessons and our later lessons, because my partner and I . . . still felt a little constrained by like our past expectations about how you would teach it, go out and break away from that, so it
took us a while to keep using it for a period…And I think for some people they felt comfortable just saying to the students go do that in your experiment. But for us we didn’t feel that comfortable doing that so we like found a middle ground between designing experiments for them but allowing them to have a hand in how it went and them doing the experiments without a lot of our help, so I think they got that hands on, without that sort of like crazy ‘we’re going to run balls into each other’, thing that they did the first day when we were like, ‘ok, design your own experiment’ (post interview).

Emily shared that she grew throughout the semester in becoming more grounded in her instruction. She was quick to point out that together she and her partner found a ‘middle ground’ or balance as to the amount of guidance they provided their students during investigations, especially after the especially active first lesson in which Emily and her partner gave their students quite a bit of self-direction. The lesson and its impact on Emily and her partners instruction in subsequent lessons as a result of their first teaching experience in the afterschool science club will be described in more detail in the next section.

After teaching in the afterschool program, Emily views on teaching students inquiry-based science had improved. Here, in the post interview, Emily began to reflect on her growing understanding and appreciation for inquiry science instruction.

I still think that the things that they manipulated physically were so the content just stayed in their minds so much more than someone where like showed them the glider
already built and they didn’t have to pick the materials or design it themselves because then they miss that whole step and that is like where the science is (post interview). Interestingly, here Emily described a hypothetical student directed lesson that would have a greater impact on the student learning of content when most of the unit she taught and finalized was teacher directed. Below, Emily’s unit will be reviewed for the quality and level of inquiry represented in each lesson throughout the unit. The introductory lesson is also described in detail below.

_Inquiry Instructional Practice as Represented in the Final Unit_

In the inquiry chart (Figure 4) below, we see Emily’s lessons bouncing back and forth across the chart. In an effort to highlight Emily’s use of inquiry in her unit, each lesson was coded and then mapped out on the inquiry chart to visually represent the level of inquiry of each of her lessons. As Emily explained above, she and her partner went through a transition during the six week teaching experience. Due to the “crazy, ‘we’re going to run balls into each other’, thing that they did the first day when we were like, ‘ok, design your own experiment.’” event Emily described when talking about her first lesson, Emily explained that she and her partner found a middle ground in teaching the remainder of the five lessons. Here she was implying that the first lesson was too open, feeling the students had too much freedom in the investigation. But, upon close inspection of this first lesson, however, the only aspect of this particular lesson that seemed to be more student directed than the others was the design of the investigation. This will be described in more detail below.
Figure 4
Emily’s Final Unit Plan, Rollercoasters for Second Graders
Initially, they wanted to embrace inquiry by giving the students a great amount of self-direction in the introductory lesson. In this lesson on force, students were given a teacher directed question “what makes the ball move?” which ranked a #1 under the heading ‘Develop Research Questions or Challenge’ on the inquiry chart (See Figure 4). Yet, under the ‘Design Investigation or Structure’ heading, her lesson ranked a two because students were asked to design three trials of their own after they observed three demonstration trials of the teachers moving a ball down a ramp, for example, with a breath of air etc. Here students are given some variables and controls (make the ball move) a number three on the chart which is more learner directed. Students were then asked to illustrate each trial indicating what caused the force and what direction the ball traveled. When the learner collected all data, the lesson received a score of four under ‘Collect and Acquire Data’. A four on this chart meant that the collection of data during the investigation was student directed. Emily and her partner then directed the students how to draw their results which placed the lesson at number one, making it a teacher directed section. And finally, students were asked to share their best trial and what they learned from it, which places this lesson at a number two for models. Students at this point played a role in determining their best trial and explaining what they learned from it.

Yet, in her second lesson, in an attempt to provide more structure for the students, Emily and her partner had their students test the effects of friction on a ball in two trials. Rather than give the students an option to select from various materials or determine the set up of the investigation Emily and her partner had developed a teacher directed
investigation with fixed variables. This trend continued. In fact the third and fourth lessons were completely teacher directed with the only student involvement was in data collection. But, finally, in the last lesson, they gave their students more autonomy to develop their final design for their rollercoaster and test it.

Reviewing Emily and her partner’s final unit more closely, it was evident that they began to teach lessons where they as the teachers provided the guiding question and lesson design for their students but did allow the student the opportunity to collect the data they gathered in the investigation. It was also important to note, however, that Emily and her partner did make efforts to provide better scaffolding and supports for their student learning. A word chart was incorporated in their instruction, while they provided structured worksheets for students to help them make better sense of the data. Even in one lesson, they provided three choices for the students to select from to best explain the outcomes of the investigation.

Emily’s interviews demonstrated growth in her views on inquiry-based instruction. However, she continually faced a struggle in trying to find a balance between inquiry-based instruction and lecture, even after personally experiencing student learning and interest related to instruction based in inquiry.

*Final Reflections on the Methods Course Itself*

“This was one of the best classes I have taken at BC because it forced me to put in commitment week in and week out and goes beyond my comfort zone” (final unit reflection, 2007). In her preinterview, Emily had a strong sense of how she felt teachers should be prepared. Emily described the great lengths she had gone through to take the
field-based section so that she could experience the course. She described traditional methods courses as creating an “artificial, huge disconnect between what we learn and what we see.” Emily continued, “I think that any opportunity to work with kids as we are going to do, is a great opportunity, and it is in a place where I know teaching about science in one way but the challenge of teaching in a different way, they are afterschool and extended care, that at this point it is exciting to me. She also felt that this model was the “best way to teach us to teach because for us it is almost like an inquiry practice too, because we are practicing these things and we’re learning methods in class” (Post interview).

From the beginning of the semester, Emily appreciated the structure of the course, feeling that it closely modeled the inquiry-based instruction the course supported. This feeling was reinforced throughout the semester as indicated by her statement in her post interview.

And I think that is very different than what I probably thought at the beginning of the semester, because I had never had any experience with it (inquiry science) so it was all like very theoretical, but like I see now how it could work. So, I think it would definitely be something very hands on with more student led than teacher led and kind of inquiry-based but also like, but I think the discussion a lot of times needs to go first. So you discuss, introduce whatever content you are doing and then you do more inquiry and you go back and you discuss it (post interview)
Here, Emily talks specifically about the importance of having the opportunity to teach inquiry-based science to students. The actual experience helped Emily to see the theory come to life by seeing how inquiry instruction works with students.

*Summary and Analysis of the Case*

Emily was a thoughtful and reflective student. Throughout the semester, she demonstrated growth in her understanding and appreciation of inquiry-based instruction and related instructional strategies for diverse learners throughout the semester demonstrated through her surveys, interviews and final unit. She failed however to show growth in her confidence to teach diverse students and her in content knowledge in physics.

Early in the semester, Emily recognized her hesitancy with science as a subject and contributed at least some of that to her lack of experience with inquiry as a student herself. Emily attributes at least a portion of her understanding of physics to an inquiry experience in one of her college science courses despite her extensive science coursework in High School. While Emily’s content knowledge did not grow on the survey, she did discuss the effort she and her partner invested to learn the content behind force and motion in an effort to more accurately represent it for younger students. Her understanding behind the concepts of force and motion continued to grow due to the struggles Emily and her partner initially encountered in breaking down the concepts in order to introduce the content at a 2nd grade level. They realized the challenges of teaching a concept without having a solid understanding of the content themselves.
By the end of the semester, Emily was not as confident with diverse students despite her previous experience working with that population. Emily demonstrated a drop in her confidence for teaching diverse students which could be due to the struggle she experienced teaching a challenging diverse student. She sought out advice from the diverse student’s current and former teachers, but this information only seemed to discourage her more, feeling that the student was failing to live up to her potential. In working with this student Emily may have realized the difficulties in teaching diverse students in academic settings which could explain why she didn’t show the enthusiasm she showed in the pre interview. Perhaps this experience with her student gave Emily a more realistic view of the challenges present when teaching diverse students, thus making her less confident in her ability to instruct diverse students.

It was promising, though, that she was reflecting on ways to improve her instruction. In the process she became more determined to make the content more accessible for their diverse students by scaffolding their lessons. Despite her previous experience in working with diverse students she had never had any real experience in teaching diverse students. Thus, her teaching was not well grounded in strategies that supported diverse learner understanding of either language or scientific content. Her love of diverse students has potential to still be there, but maybe was somewhat tempered by her experience of trying to teach a challenging diverse student.

Throughout the semester, however, Emily held this tension between lecture based and inquiry-based instruction. Prior to this particular semester, Emily’s only experience with inquiry was in a college lab where she built rollercoasters. Hence, at one level she
acknowledged and respected the inquiry approach to instruction promoted by the science methods course and her general education courses. She acknowledged that that experience contributed to her growing acceptance of inquiry. Emily recognized the challenge of students asking a question she may not have an answer for and made an effort to be prepared. Yet, epistemologically Emily viewed learning as more of a direct transmission of knowledge, which directly reflected how she learned as a student. This belief also appeared to be supported by her post survey score that indicated a growth toward traditional lecture form of instruction.

Looking closely at Emily’s instruction in the afterschool science club highlights how this tension played out. Before the afterschool club, Emily thought that inquiry-based instruction might be challenging and indeed found that to be the case in working with her students in the afterschool science club. Feeling she should incorporate the inquiry philosophy supported by both her general education courses as well as her current science methods course, Emily and her partner started their first lesson giving the students the opportunity to play a role in designing their investigation. But Emily and her partner encountered difficulty translating that theory into practice. Emily and her partner did not feel they had enough control over the students and their interactions with the science materials. The lack of scaffolding and supports for the students led to their off task and mishandling of materials.

This experience set Emily and her partner back a few steps, possibly confirming a bit of their belief in the didactic form of teaching. While they didn’t give up on inquiry as part of their instruction, they were a bit hesitant to reintroduce more student directed
sections of a lesson beyond collecting data gathered during an investigation. Therefore, for a few lessons Emily and her partner found a way to make their instruction a bit more comfortable for themselves by providing a content lecture before each teacher directed investigation. They also incorporated more structure and supports for the students. This intense rigor was maintained throughout much of the unit until the last two lessons where they finally gave the students more autonomy in determining the design and construction of their rollercoaster. This could indicate that she was beginning to develop a more nuanced view of what inquiry represented, that inquiry wasn’t the free for all she had initially experienced at the beginning of the semester. In her post interview Emily acknowledged the value of working with the students and the value of her classmates’ comments during the during weekly discussion and reflection time to help model ways to introduce the content at a grade appropriate level.

Early in the semester, Emily’s teaching beliefs toward inquiry were torn. Emily appeared reluctant to give up her view of didactic teaching because she felt that she lacked the sufficient content background to teach science particularly in the physical sciences. What was particularly interesting was that Emily’s also indicated she had been immersed in the idea of inquiry, going to the point of seeking out a course that would teach through inquiry. While at one level she generally aligned more with a more traditional, didactic view of teaching, another level indicated a much more open view. But, upon closer inspection, she appeared to have a more tilted view of inquiry. She felt that inquiry was always ‘hands-on’ and didn’t appreciate the complexity of inquiry-based teaching and therefore felt the need to lecture before each investigation to ensure the
students understood the purpose behind the it and what the outcome should be. Ultimately, one wonders if Emily felt that science always has a right and wrong answer, a feeling common to new preservice teachers who are uncomfortable with science. She may have also viewed the scientific method as being straightforward and direct and not messy. Yet, as a result of her teaching experience, she gradually began to demonstrate some growth toward inquiry understanding. This tension will be explored more in the cross analysis.
ANALYSIS ACROSS THE TWO CLASSES

In this section, I present a multiple case study analysis exploring the similarities and differences in these four preservice teachers as they compare to the overarching survey results from the two courses they represent. Preparing preservice teachers to be more effective at teaching science once in their elementary classroom is a great concern for our field. This study explored two different approaches to elementary methods for preparing preservice teachers to teach elementary science, a university-based and a field-based methods course. My survey and interview results suggest that each type of instruction has both strengths and weaknesses.

The results are presented in six categories: Science Content Knowledge, Confidence in Teaching Science Content, Confidence in Teaching Diverse Students, Instructional Strategies for Diverse Learners, Beliefs about Teaching Science Through Inquiry, and Inquiry Instructional Practice as Represented in the Final Unit. In each category, the overarching quantitative results from students in both the university and field-based science methods course will first be compared, then the larger case of the four case studies will be explored to determine the affordances and constraints each section of the methods course offers.

Confidence in Teaching Science Content

Looking across the content areas, results from the survey indicated that by the end of the semester the preservice teachers across both courses all had significant increases in their comfort level with physics content. The university group had significant growth in Earth science, biology and physics content scores. Meanwhile the survey results
indicated the field based preservice teachers field based preservice teachers had a significant increase in how well they feel prepared to teach physics and chemistry but not in Earth science or biology. Both groups showed a significant growth in their comfort level with Chemistry content (See Table 15).

Looking more closely at the case studies, the university-based preservice teachers have a significant increase in how well prepared they feel they are to teach chemistry, Earth science, biology and physics. Meanwhile, the survey results indicated the field-based preservice teachers have a significant increase in how well they feel prepared to teach physics and chemistry but not Earth science and biology (See Table 15).
Table 14 *Cross Case Analysis Table*

<table>
<thead>
<tr>
<th>Qualities</th>
<th>Emily – Field-based</th>
<th>Karen – Field-based</th>
<th>Cindy – University</th>
<th>Connie – University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content Knowledge</td>
<td>Increase in physics*, earth science, steady in chemistry* and decrease in biology</td>
<td>Increase in earth science, physics* Chemistry* and steady in Biology</td>
<td>Increase in physics*, earth science*, chemistry*, and biology*</td>
<td>Increase in physics*, Chemistry* and earth science* decrease in biology</td>
</tr>
<tr>
<td>Confidence in Teaching Science Content</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td>Diverse ELL Learners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence in Teaching Diverse Students</td>
<td>Mixed Growth</td>
<td>Increased</td>
<td>Mixed Growth</td>
<td>Increased</td>
</tr>
<tr>
<td>Instructional Strategies for Diverse Learners</td>
<td>Major Growth</td>
<td>Major Growth</td>
<td>Consistently Low</td>
<td>Moderate Growth</td>
</tr>
</tbody>
</table>
Table 15 *Cross Case Analysis Table (continued)*

<table>
<thead>
<tr>
<th>Beliefs about Teaching Science Through Inquiry</th>
<th>Inquiry-based Science Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry Practices*</td>
<td>Increase Discussion*</td>
</tr>
<tr>
<td>Increase</td>
<td>Increase Openness</td>
</tr>
<tr>
<td>Mixed Traditional science*</td>
<td>Slight increase, advocating more structure and scaffolding in instruction</td>
</tr>
<tr>
<td>Had inquiry at some level in all six lessons, fluctuating level of teacher direction.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beliefs about Teaching Science Through Inquiry</th>
<th>Inquiry-based Science Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry Practices*</td>
<td>Increase Discussion*</td>
</tr>
<tr>
<td>Increase</td>
<td>Increase Openness</td>
</tr>
<tr>
<td>Mixed Traditional science*</td>
<td>Slight increase, suggested more structure and scaffolding in instruction</td>
</tr>
<tr>
<td>Had inquiry at some level in all six lessons, fluctuating level of teacher direction.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beliefs about Teaching Science Through Inquiry</th>
<th>Inquiry-based Science Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inquiry Practices*</td>
<td>Increase Discussion*</td>
</tr>
<tr>
<td>Increase</td>
<td>Increase Openness</td>
</tr>
<tr>
<td>Mixed Traditional science*</td>
<td>Decrease More toward inquiry</td>
</tr>
<tr>
<td>Had inquiry at some level in all six lessons, fluctuating level of teacher direction.</td>
<td></td>
</tr>
</tbody>
</table>

*statistical significance
There are a few explanations as to why this could be. It was not surprising that the university-based preservice teachers resulted in a greater increase in their feeling of preparedness to teach a wider range of science content knowledge. These preservice teachers gained more experience with various content through science activities introduced throughout the semester in the methods course, while the field-based preservice teachers spent much of the semester focused on physics both through investigations as part of the methods course and the physics based force and motion unit they taught to the afterschool students. Earth science, biology, and chemistry content were only addressed in the field-based section in the final weeks of the course through investigations and lecture. The university group however spent more time across each of these content areas doing projects such as designing a fast plant investigation, dissections, and field research throughout the semester.

Meanwhile, the qualitative data of the preservice teachers confidence in science content was fairly low. Each of the four preservice teachers demonstrated growth in their confidence of teaching content across the domains in the interviews. The field-based preservice teachers discussed the effort they invested to learn the physics content behind force and motion in an attempt to more accurately represent it for younger students. This struggle to teach a physics focused unit could make the field-based preservice teachers be more conservative in their responses to the survey questions about the other content areas. Yet, the two university-based students had no practical application for their new science knowledge, and therefore had no reason to question whether the content knowledge they gained through the methods course was ample enough to teach a related
unit. Having covered each of the science content areas in the course, it only made sense to respond to the survey that they were prepared to teach each of those areas. Similar to the survey results, these findings support the fact that each content area was covered in the university-based methods course, while the field-based methods course primarily focused on physics due to the force and motion unit being taught to the afterschool science club.

There can be a tendency for the reduced exposure to science content knowledge presented in the field-based science methods course to be pointed out as a weakness. Yet, this may raise issues of quality verses quantity. The field-based preservice teachers were initially intimidated by physics as a subject. But through the afterschool program they were able to delve into physics in their attempt to teach it to primary students and address misconceptions. These teachers gained experience researching a content area by seeking out quality resources and curriculum. In the process these preservice teachers realized their own misconceptions through their research and came to appreciate physics as a subject to challenge their students. Teaching science content in the context of a classroom or afterschool program exposed them to the rigors of teaching where they found multiple ways to represent what they were teaching in an effort to address student misconceptions throughout the six weeks of instruction. The university-based preservice teachers were able to experience quality investigations across the content areas in a laboratory university setting and research specific content to include in a final unit. These teachers received quality instruction and experiences, but their research for the final unit
may not have taken them to the depths of understanding necessary to actually teach that unit to students.

In summary, both methods courses focused on improving preservice teacher confidence in their ability to teach science at the elementary level. The university based preservice teachers demonstrated more confidence across multiple content areas while the field based preservice teachers confidence grew in physics and chemistry, the focus of the unit they taught in the afterschool science club. It is impossible to teach all the science content in any science methods course.

Diverse Learners

Confidence in Teaching Diverse Learners

Overall the survey results for preservice teachers in both sections of science methods course indicated an increase in their confidence to teach diverse learners, including diverse learners (See Table 15). This is not surprising as information and activities to support diverse student learning in science is presented throughout the science methods courses. Additionally, multiple courses in the university education program also highlight strategies for teaching diverse students that preservice teachers may feel they can apply to science instruction as well.

Although there were no significant differences in the survey results, when you look more specifically at the individual case studies, differences in this finding begin to emerge (see Table 15). One of university-based preservice teachers and one of the field-based preservice teachers indicated no change in their interviews and an increase in their survey in their confidence to teach diverse students. Yet, the other two indicated a
decrease on both instruments. Looking more closely at the two preservice teachers who indicated a drop in their confidence to teach diverse students, Cindy, a preservice teacher in the university-based course, raved about her experiences with diverse students she worked with each summer. Yet, her survey scores indicated a decrease in her confidence by demonstrating a concern in not knowing any teaching strategies or ways to monitor diverse student understanding. Also, Emily, a student in the field-based methods course had both her survey and interview scores decrease due to challenging experience teaching a diverse student in her afterschool group. A common trend for field-based preservice teachers like Emily seems to be that teachers leave the program having struggled with diverse students and questioning their effectiveness as teachers. This occurs even when the preservice teacher has had extensive experience working with diverse students. It seems this could be one of the first times the preservice teachers have had to teach and have the students be responsible for what was taught. Although the change in beliefs was similar for both classes in the next section we see a difference in practice.

*Instructional Strategies for Diverse Learners*

This category highlighted great differences between preservice teachers in the two methods sections. Both classes grew in terms of their beliefs for teaching diverse learners and they grew significantly. There were no differences. However, where you begin to see a difference is when you begin to identify the specific strategies the preservice teachers mentioned in their post interviews and incorporated in their final science units. University-based preservice teachers demonstrated little to moderate growth, while the field-based preservice teachers demonstrated great growth from the
strategies they identified from pre to post interview and then the strategies they incorporated in their final unit.

Looking closely at the diverse related instruction in both sections; preservice teachers in each of the two sections received the same lecture and related activities toward the design of experiences for teaching diverse learners. Both the field-based and university-based preservice teachers also had time dedicated to discuss instructional strategies for diverse learners as part of investigations.

Yet, as stated before the key difference between the two sections of the methods course is that preservice teachers in the field-based methods course designed and taught curriculum to students, many of which are diverse, in an afterschool program. The more practical experience with students may have led these preservice teachers to integrate more strategies to support diverse student learning. In wanting to meet the needs of their students both field-based preservice teachers sought outside resources to find alternative approaches both for the content as well as the instructional strategies. These resources included but were not limited to peer and professor suggestions during the reflection and discussion time that follows each afterschool teaching, former teachers of the diverse student, journal reflection/responses, and related lectures and activities presented as part of the methods course.

In the university-based methods course, however, preservice teachers only interaction with students that particular semester was through a one day a week prepracticum assignment where little or no science was taught. Cindy from the university-based course demonstrated a slight growth from the strategies she mentioned.
in the interviews to the final science unit she developed. She had no opportunity to test her science lessons on students or experience the impact her suggested daily PowerPoint lectures would have on second graders attention span or interest. She saw no need to challenge herself to incorporate many other strategies in her final unit. However, Connie, also from the university-based course, only mentioned two strategies in each of her interview, but just two weeks after the post interview went on to incorporate several more strategies in her final unit. One factor that could have contributed to this growth was that Connie searched several high quality science curriculums to develop her unit on matter. These curriculum resources could have contributed to the moderate growth in the strategies she incorporated into her final unit. It is difficult to determine whether Connie just copied lesson ideas from the curriculum to her unit or whether she has actually internalized the strategies.

It was possible that seeing their student needs pushed the field-based preservice teachers to find strategies to enhance their understanding of the content being introduced. There was a purpose to apply the strategies they had been exposed to throughout the semester. The university-based science methods course however was structured in a way that may not be as conducive for preservice teachers to design diverse learner supported instruction for a science inquiry unit. As indicated by Cindy’s case, her beliefs were based more on her prior experience than on what she had been exposed to in her science methods class. She could talk the theory but when she applied her beliefs to practice it didn’t play out. She struggled to bridge the theory introduced in class into practice. This
can be a strong mismatch for instruction. In the case of Connie, however, she struggled to share a range of strategies in her interviews, but incorporated several in her final unit.

Inquiry-based Science Instruction

Beliefs About Teaching Through Inquiry

The survey results from the field-based course demonstrated a greater growth in terms of the inquiry practices and discussion category than the university-based course (Table 15). And while they didn’t have greater growth in terms of openness there was a ceiling effect and they did end up with a more inquiry view of science. ‘Inquiry practices’ in this study indicated preservice teachers who felt prepared to teach using scientific inquiry skills. This means that the field-based preservice teachers felt comfortable to ask students scientific oriented questions, plan and conduct a simple investigation using simple equipment, and use data to construct and communicate a reasonable explanation.

It is worth noting that the field-based preservice teachers scored higher initially, possibly indicating a selection effect. This could mean that more inquiry oriented preservice teachers may have signed up for the field-based science methods course. As for the openness factor they didn’t show an increase because there was a ceiling effect, which indicates the instrument was limited in what we could determine.

In the next sections I will explore how the preservice teachers related to using structures and scaffolding in their instruction including textbooks, worksheets, homework and how they applied the theory of inquiry science to practice in their final unit.

Traditional Science
This factor had a surprising result; the scores from the pre/post interviews indicated that the university-based preservice teachers demonstrated a growth toward inquiry-based instruction while the field-based preservice teachers demonstrated a growth toward traditional science. Once again, an increase in traditional science represents a preservice teachers’ comfort with textbooks, lecture, worksheets and homework. Initially, this was hard to understand especially when taking into consideration the large growth in inquiry represented in the field-based preservice teachers final unit. But, after reviewing the case studies, a very different understanding came to light.

The field-based preservice teachers taught their first lesson in the afterschool science club incorporating inquiry-based science the way they had always believed it to be. But as we saw in the case studies they quickly realized the challenges and restrictions of doing student led science inquiry in an actual classroom setting. In their first lesson, both field-based teachers introduced an open, student led inquiry-based lesson and experienced students inability to stay on task and handle the science materials properly. Both field-based preservice teachers realized that there needed to be more scaffolding and structure for their students before they could be prepared to handle such responsibility as student led inquiry. This indicates that the field-based preservice teachers were advocating more scaffolding and support in their responses on the survey.

The idea that science based inquiry is all open ended and student directed is a popular misconception for preservice teachers. Until, as this case illustrates, preservice teachers get the opportunity to teach inquiry-based science to students and realize the challenges it can present if not approached carefully. The field-based preservice teachers
initially thought structure wasn’t necessary, until their first experience teaching made them more cognizant of their students’ needs. They learned that structure was necessary to do the inquiry.

Therefore, it is possible that the university-based preservice teachers traditional science score moved towards open inquiry-based instruction because they support the idea of inquiry-based instruction as supported by the majority of their education courses including the science methods course. Yet, without an opportunity to teach inquiry there was nothing to challenge these preservice teachers’ idea of inquiry as being open ended and student directed. While they felt it was the right way to teach, they lacked the understanding of the support and scaffolding necessary to support student learning in this manner. I believe that once preservice teachers do have an opportunity to teach science based inquiry to students one would see more of a shift toward structure in their science instruction as well. A closer look into the preservice teachers final science unit will help to further highlight the preservice teachers understanding and beliefs around inquiry-based science instruction.

_Inquiry Instructional Practice as Represented in Final Unit_

Upon close analysis of the preservice teachers final science unit, two trends became clear. One half of the university-based preservice teachers lessons included no inquiry, while the other half was very structured and teacher directed except for the data collection portion of several lessons. Whereas, both field-based preservice teacher units have inquiry at some level in all six lessons, with a fluctuating level of teacher directed lessons.
Therefore the field-based preservice teachers resulted in greater representation of inquiry-based instruction in their final units. There are a few potential reasons why. It is possible that the authentic teaching experience provided during the field-based course provided the preservice teachers an opportunity to teach science using inquiry while receiving support via weekly journal reflections, weekly lesson planning, and whole class discussions following each lesson taught. The university-based preservice teachers received an opportunity to team teach one science lesson and receive peer and instructor feedback on the lesson prior to and following the instruction. However, they did not have opportunities to engage elementary students in scientific inquiry. These findings suggest that if preservice elementary teachers are to learn to teach inquiry-based science they must have experience in teaching science to students.

A closer look at the field-based science methods course highlights the benefits those preservice teachers experienced. Both of the field-based preservice teachers’ ideas around inquiry science became more realistic as they became aware that their students needed a bit more support to gain the skills necessary for a more student directed lesson. This change in understanding experienced by each of the preservice teachers is noted in Figure 5. The experiential nature of the course provided the field-based preservice teachers an opportunity to try to teach inquiry as they understood it. But more importantly, the supportive environment of the course may have helped these preservice teachers stick with it after a rather disappointing first attempt. Neither of these teachers gave up. Rather, they with the support of peers and instructors found ways for their students to participate in investigations while still maintaining control over key areas of
an inquiry-based science lesson. Then, as they built their confidence and found their students building key skills to participate in inquiry-based investigations, they began to design lessons that allowed for more student direction. One field-based preservice teacher did this notably sooner than the other.

When comparing the cases from the two sections for this category there were a few similarities. When reviewing the inquiry charts, both groups of preservice teachers felt comfortable giving their students full control over ‘collecting and acquiring data’, even when all else was teacher directed. Additionally, both groups often failed to incorporate the criteria of ‘making sense of the data’ and ‘constructing explanations’ into their lessons. It is often a challenge for preservice teachers to incorporate these criteria due to time limitations, concerns of unanswerable student questions that may arise, and simply a lack of understanding of how to approach this. This is disappointing as these two criteria are the most important in helping students come to understand the science behind the investigation. This indicates a great need for area of improvement in both sections.

Summary

My research suggests two trends in the findings. When comparing the two sections of science methods course, preservice teachers in the field-based section developed a more inquiry view of science, yet smaller growth in confidence in their overall content understanding except for physics. The field-based preservice teachers also demonstrated a greater understanding of strategies that could assist diverse learner understanding.
The university-based preservice teachers finished the course with less inquiry-based views overall but more confidence in other science content areas. Yet, these teachers had more trouble bridging theory into practice to support diverse learner understanding of science content.
CHAPTER 5: DISCUSSION AND IMPLICATIONS

This study sought to examine the strengths and weaknesses that both a field-based science methods course and a traditional university-based science methods course have on preservice teachers’ preparedness for teaching inquiry-based science in a diverse elementary classroom. This final chapter will summarize the findings of this study and connect them to the existing literature on the experiences of both approaches as part of teacher preparation. I will then share some of the limitations of this study, identifying where these limitations highlight directions for future research. Finally, I will end with a discussion of the implications of this work on teacher preparation.

DISCUSSION AND IMPLICATIONS

Four interesting trends emerged from this analysis across a field-based and a university-based science methods course including:

1. The university-based preservice teachers experienced greater growth in their confidence in teaching content across the fields.

2. The field-based preservice teachers experienced more growth in the amount of diverse learner strategies represented in their lessons while the university-based demonstrated little growth in those areas.

3. The field-based course promoted the development of preservice teachers’ ability to design inquiry-based instruction for elementary students.

4. The field based preservice teachers experience of teaching in a diverse afterschool science club, may compensate for their lack of experience with language or culture, important factors for working with diverse learners, particularly ELLs.
5. Neither the field-based nor university-based preservice teachers’ inquiry-based lessons in their final unit worked with students to use evidence to support claims or construct explanations.

Build scaffolds support bilingual background experience with language and culture

These trends will be described in more detail below.

*University-based Course Support Greater Confidence in Content Understanding*

Previous research of Eick, Ware, and Williams (2003) have found that preservice teachers who experience teaching science to students in supportive environments increases their confidence. This study expands these findings by drawing comparisons to a more traditional based science methods course to suggest that a broader survey of content needs to be better represented.

Not surprisingly, preservice teachers in the university-based science methods course resulted in greater growth in confidence in their science content knowledge. There are a few explanations as to why this could be. The depth verses breadth problem highlights the tradeoff of time that occurs when incorporating a field-based component to a science methods course. As stated above, preservice teachers in the field-based science methods section spent much of the semester focused on the physics based unit that they taught to the afterschool students. Earth science, chemistry, and biology content were only addressed in the final weeks of the field-based science methods course through activities and lecture. However, the strength of university-based course as indicated on the preservice teacher surveys and in their interviews was that they became more
comfortable across the content over the semester because they were more exposed to a wide range of content. These preservice teachers spent more time with these content areas doing projects such as designing a fast plant investigation, dissections, and field research throughout the semester. This concurs with Appleton’s research (2002) found that after preservice teachers in his science methods course experienced a physics oriented unit the ones who had previously experienced success in learning science content did become more confident in their instruction.

However, Appleton warned that it was important for science educators not to confuse confidence with competence, which offers some perspective on the findings from this research. In this case, it is something to consider. It is possible, that the university-based preservice teachers’ confidence in science content may be misrepresented. They experienced growth in their understanding of content based on the data we gathered, but that may be limited. It is possible that the field-based preservice teachers may have gained a deeper understanding of the content knowledge necessary to teach by doing just one content area.

The actual experience of teaching students in the field, may have played a positive role in the field-based preservice teachers understanding of what it means to teach science content to elementary students. By teaching a physics based unit in such depth, the field-based preservice teachers may have realized how much content knowledge was necessary to teach elementary students and in the process realized how little they understood. In the interviews, the field-based preservice teachers explained how in the initial lessons they struggled to break down the concepts behind force and motion when
they didn’t have a solid understanding of the content themselves even though both had had high-level physics as high school students.

Zembal-Saul, Blumenfeld, & Krajcik,(2000) found similar results in their year long study. While investigating how their elementary preservice teachers apply their content knowledge to plan, teach and reflect, they found that in the first of two teaching cycles, had accurate content representations in their plans, but had too many topics that weren’t sequenced well. Their preservice teachers struggled to help students make connections between the topics in their unit. In the second cycle, however, the preservice teachers preformed much stronger by being more selective in their content representations and were better able to connect the topics for their students.

These findings suggest that the wide range of content based instruction and investigations offered through the university course provided those preservice teachers with greater confidence in their ability to teach science at the elementary level. However, the preservice teachers in the field-based course gained a much different experience through teaching a unit based in one content area that made them discover the amount of knowledge necessary to understand the concepts enough to teach them.

*The field-based preservice teachers experienced more growth in the amount of diverse learner strategies represented in their lessons*

Both the field-based and university-based preservice teachers demonstrated growth throughout the semester in their beliefs for teaching science to diverse learners. Yet, when lessons in the units were analyzed the field-based preservice teachers
integrated more strategies to aid diverse learners while the university-based preservice teachers demonstrated little growth in those areas.

The growth in beliefs represented by both groups of preservice teachers is not surprising as the focus of the School of Education is dedicated to preparing preservice teachers to teach diverse students. Issues of diversity are quite integrated throughout their teacher education program. At least one of the preservice teachers’ prepracticum assignments must be held in a diverse, urban school. Additionally, preservice teachers are assigned a semester long read ‘aloud program’ with one diverse student per prepracticum placement. In this program, a preservice teacher works closely with one diverse student from the prepracticum classroom to help them develop reading and language skills.

As the instructors, our individual extensive experiences teaching diverse students at the elementary to middle school may also contribute to this finding. Bryan and Atwater’s (2002) research indicates that we have a great potential to be more effective in our instruction to preservice teachers in supporting their understanding and experience with diverse learners.

Yet, the differences represented by the strategies discussed in the interviews and later integrated in the final units indicated that the field-based preservice teachers had a better grasp of interventions to aid diverse student learning in science. The field-based preservice teachers developed lessons that incorporated instructional strategies to enhance diverse student learning. While the university-based students spoke highly of their interest in teaching diverse students, but only incorporated a moderate to low
amount of instructional strategies in their final units. A critical evaluation of these lessons plans seems to suggest that preservice teachers’ readiness to teach inquiry to diverse students may be more subtle than looking at beliefs alone. There are a few reasons for the strong growth represented in the field-based preservice teachers’ beliefs for teaching diverse students.

This may indicate, as Bryan and Abel (1999) research described, that our university-based preservice teachers experienced a disconnect between their beliefs and understanding around diverse student learning. They may have never had reason to question their beliefs. Yet, similar to the elementary preservice teacher in Bryan and Abel’s research our field-based preservice teachers, particularly Emily, struggled to balance her beliefs and understanding on what it meant to teach science to diverse students.

According to the weekly reflective journals that the field-based preservice teachers in our field-based methods course turn in each week in response to their teaching had greater potential to influence their beliefs in teaching diverse students because Tillema’s (2007) research suggests it is based upon their own teaching experience rather than a hypothetical situation.

In our field-based methods course, weekly debriefing sessions that followed each teaching session provided opportunities for preservice teachers to share, analyze and determine best instructional strategies with their peers and instructors for future instruction for their diverse students. Preservice teachers additionally handed in weekly reflection journals that also included the past and often future lesson to be taught. This
gave the instructors the opportunity to provide specific diverse learner strategies. Despite a science methods course rich in cultural education by the end of the semester Southerland and Gess-Newsome, (1999) found their elementary preservice teachers held fixed categories, high and low, for their diverse students. Students representing the high group would be exposed to more investigations and those in the low group would receive more traditional, teacher-focused lessons. The researchers felt that a few interventions would help preservice teachers move past this image that supported the findings from this study. They recommended that after coming to know their diverse students, preservice teachers should gain an understanding of the students’ knowledge and understanding of science, which in our courses we call our misconception interviews. The researchers saw value in having preservice teachers continue to work with diverse students with the support of instructors encouraging the strength of inclusive science teaching through class discussions, specific diverse learner feedback on lessons and focus on diverse learner interventions during discussions, feedback, and assignments. Both science methods courses supported our preservice teachers’ beliefs about supporting diverse learners in science but the field-based preservice teachers integrated more key instructional strategies to enhance diverse learner understanding of the content. The support structure offered by the field-based methods course may have contributed to the preservice teacher growth and helped them to translate their beliefs into practice.

*Field-Based Course Supported More Inquiry-based Instruction*
Each of the four preservice teachers' beliefs in inquiry-based instruction as reported through the interviews demonstrated growth throughout the semester and were quite comparable. However, the surveys for each of the field-based preservice teachers show greater overall growth in inquiry than their peers in the university-based course. But a critical evaluation of the inquiry level represented in each of the lessons in their units seems to suggest otherwise. It became clear that the two groups had very different ideas about inquiry-based science instruction. In this study the field-based preservice teachers introduced more lessons incorporating inquiry into their final units than the university-based preservice teachers. Additionally, both field-based preservice teachers experienced growth to differing degrees in their integration of inquiry-based investigations and inquiry views.

Furthermore, the field-based preservice teachers did not demonstrate a smooth transition between the stages represented in the inquiry continuum. As a result of taking this course, the field-based preservice teachers' lesson development mapped onto the inquiry continuum as a jagged developmental process. Notice that their first lessons moved toward the open, student-guided side of the inquiry continuum of the chart (see Figure 3 and Figure 4). In fact, the lessons in the unit did not represent a gradual movement from one end of the spectrum to the other end of the spectrum, rather more of a back and forth movement while the field-based preservice teachers were trying to figure out what they were doing, experimenting and really thinking. However, I didn’t see this inquiry exploration in the university course. The lessons of the university-based preservice teachers followed a much more static growth following nearly the same
teacher guided path for each of their inquiry lessons (see Figure 1 and Figure 2). Each lesson represented a teacher guided question, and designed investigation, student gathering of data, and teacher guided discussion of making sense of the data and constructing explanations.

Whereas, university-based Cindy incorporated inquiry into less than 50% of her lessons in her final unit. She consistently described science inquiry-based teaching in both her pre and post interview as being hands on. This aligned closely with preservice teachers in Abell, Bryan and Anderson’s (1998) and Windschitl’s (2003) who by the end of the semester despite an inquiry focused university-based science methods course still had preservice teachers who viewed inquiry as fun or hands on. Similar to preservice teachers in Davis’s (2006) research Cindy discussed how the inquiry was a great way to keep student interest rather than understanding and appreciating its value in science instruction. Cindy’s perspective was further supported by the lessons she developed for her final unit.

This research indicates that there were a few factors offered by our field-based science methods course which promoted the growth represented by field-based preservice teachers inquiry understanding. The reasons for this may be twofold. This study suggests that the authentic experience of teaching students science in the context of a classroom type setting coupled with an supportive environment appears to have had a positive influence on preservice teacher understanding and incorporation of inquiry-based science (Eick & Reed, 2002) and instructional strategies to enhance diverse student learning (Southerland & Gess-Newsome, 1999) into their final unit. This research
closely aligns with Sherin’s (2002) findings which suggest that the act of learning and teaching comes from teachering and in that process the teaching can lead to improved pedagogical instruction while also developing a deeper understanding of content and how to design and sequence instruction to support student learning. Therefore, from Sherin’s perspective, if beginning elementary teachers are to learn to teach science they must have experience in teaching science to students. These findings suggest that our field-based science methods course provides preservice teachers authentic experience of teaching science to real students and in the process develop their inquiry-based instruction.

Consistent with the work of Mulholland and Wallace (2001) and Eick (2002) this study found that once the field-based teachers encountered student management issues with their students during their first inquiry-based lesson, they pulled back making the next lesson more teacher directed. However, unlike the pre and inservice teachers in their studies who consistently resorted to making their science instruction more teacher directed, the field-based preservice teachers in this study were later able to reincorporate more student directed inquiry due to the supports and structure they incorporated with each lesson. Rather than retreating further and further away from inquiry-based instruction, they had the supports of the course to help them reflect on the experience and learn strategies to help them gradually build back to the guided and later student directed inquiry they had initially envisioned for their instruction. These supports included a team of instructors, including a dynamic elementary science specialist from the school that hosted the afterschool science club, dedicated to inquiry-based instruction for diverse students, a partner to coteach, reflect, plan etc, peers to reflect with during weekly
debriefing sessions, weekly journal reflections with professor feedback, and the comfort of knowing they were not doing this alone.

The field-based teachers demonstrated growth in their inquiry instructional practice because each of their lessons in their final units represented some level inquiry. However, their inquiry beliefs also indicated an understanding that inquiry instruction requires a certain amount of structure and scaffolding in order for it to be effective for student learning. This finding aligns closely with Fradd and Lee (1999)’s work. In their long term study with diverse 4th grade students and teachers in an urban school, they found that the teachers became more comfortable with teaching science once they began to incorporate more structured guided inquiry investigations. Then, gradually as the students began to gain the appropriate skills the teachers made the investigations more open ended giving the students more of a role in the investigation. In the process their students were able to learn the process of science.

Bianchini & Cavazos’ (2007) research aligns closely with findings from this study. Their research indicates that providing a supportive, non-threatening environment for preservice teachers to practice inquiry-based teaching with diverse students seems to be a significant factor to in helping teachers experience and build confidence in it. Having constant data and feedback from real elementary students motivated the field-based preservice teachers to seek assistance and information from multiple sources. The extensive supports available through the field-based science methods course offered the field-based preservice teachers multiple avenues to seek strategies for their instruction. These supports ranged from the instructors (a professor, assistant and classroom science
specialist), peers, debriefing sessions, weekly journal reflections with professor feedback, and the comfort of knowing they weren’t doing this alone. These supports may have very well been a factor that helped to keep the field-based preservice from giving up on the idea of guided of open ended inquiry-based science instruction and helped them to bridge theory into practice.

Wilson’s (1996) research found that preservice teachers needed to practice inquiry-based instruction in non-threatening, nurturing environments, such as an afterschool program. In this setting our pairs of preservice teachers were completely in charge of their students. The urban afterschool setting provided a safe environment for these preservice teachers to explore and experiment while teaching inquiry-based lessons to students. This opportunity to teach in an authentic setting and then reflect helped them to indentify inconsistencies between their initial beliefs and practice (Bryan & Abell, 1999) and come to a better understanding of what it means to teach inquiry (Crawford, 1999) to diverse elementary students. The university-based preservice teachers didn’t have these opportunities to challenge their beliefs and therefore despite their indication of strong beliefs for inquiry-based science instruction and diverse learners, incorporated inquiry into only half of their lessons and integrated fewer instructional strategies than the field based preservice teachers for diverse learners into their lessons.
The field based preservice teachers experience of teaching in a diverse afterschool science club, may compensate for their lack of experience with language or culture, important factors for working with diverse learners, particularly ELLs.

Bilingual research shows that teachers who have a background experience of being immersed in a culture other than their own can be more effective in teaching diverse students (Villegas & Lucas, 2002). The field based model represented in this study has potential to help preservice teachers gain a bit of that background experience through their teaching, and may help to fill a void so many white, Caucasian teachers experience when entering diverse classrooms. Through the supportive environment of the field based course, conversations held immediately following the preservice teacher helped the preservice teachers to work together to find ways to challenge the diverse learners to learn the concepts behind physics while learning how to make roller coasters work. This helps diverse learner understanding in two ways, one the physics based roller coaster unit provided a concept for the diverse students to make connections to while helping to build their skills and scaffold their learning. Garcia’s (1991) found that thematic instruction provides more support for diverse learners than solely skills focused instruction. Additionally, the preservice teachers continually sought ways to introduce each related physics concept with an investigation and related discussion to challenge the diverse students thinking rather than watering down the content. Gerstein (1996) found that ELL students learned best when teachers scaffolded learning for the students and asked higher order thinking questions without watering down the curriculum. Field based preservice teachers in this study came to discover the necessity for scaffolding the
learning for their diverse students after initial attempts to give their students a bit more direction in investigations than the students were prepared for.

*Preservice teachers from neither course developed lessons for students to gain skills in using evidence to support claims or construct explanations.*

Despite the promising findings related to the field-based preservice teacher growth in inquiry-based instruction, we found a disappointing trend in the level of inquiry represented in each of the four preservice teachers lessons

Figure 5 *Continuum for Teaching Science*

<table>
<thead>
<tr>
<th>Traditional Based</th>
<th>Activity Based</th>
<th>Investigation Based</th>
<th>Evidence Based</th>
<th>Argument Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Didactic Based Science Tradebook Focus with simple science art project</td>
<td>Fun, hands-on activities designed to motivate and keep students actively engaged</td>
<td>Abilities to engage in inquiry (NRC, 1996); ask testable questions and design fair tests; focus on collecting data</td>
<td>Need to support claims with evidence; evidence is not questioned in terms of quality, coherence, etc.</td>
<td>Argument construction is central; coordinating evidence and claims is viewed as important; emerging attention to considering alternatives</td>
</tr>
</tbody>
</table>
The figure above is adapted from Zembal-Saul’s (2009) *Continuum for teaching science as argument*. Zembal-Saul sees many of her preservice teachers enter her science methods course comfortable with teaching science in a more activity based method of instruction. As the semester continues the preservice teachers gradually begin to moving more into investigations, eventually working their way toward constructing an argument. In my experience I feel that some of our preservice teachers experience an earlier, even more traditional step in their understanding of science inquiry, where preservice teachers may lecture, do a read aloud of a science related literature book or use a related science art activity that fails to challenge the students cognitively. Therefore, we added an additional level at the beginning of the continuum to represent a stage demonstrated by our preservice teachers entitled, *Traditional Based*.

When mapping the preservice teachers unit lessons onto this continuum a trend was seen across both courses. Similar to the preservice teachers in Windschitl’s research (2003) lessons developed by each of the four preservice teachers fell at different places on this continuum, but rarely if ever made it to the evidence or argument stage. Even the two field-based preservice teachers who experienced a stronger growth toward inquiry-based instruction, based on the level of inquiry represented in their final unit lessons, barely made it to these final two stages.

A trend was seen across both courses. Similar to the preservice teachers in Windschitl’s research (2003) lessons developed by each of the four preservice teachers fell at different places on this continuum, but rarely if ever made it to the evidence or argument stage. Even the two field-based preservice teachers who experienced a stronger
growth toward inquiry-based on the level of inquiry represented in their final unit lessons barely made it to the final two stages. The field-based preservice teachers and university-based preservice teacher Connie asked questions, gave students opportunities to design the lessons, and collect data but they often fail to have students make sense of the data, construct explanations and arguments. This supports Crawford’s (2007) research that suggests preservice teachers start from where they are comfortable to teach. It is important to note however, that students at the elementary level may have a harder time initially with the explanation and argumentation stages of inquiry. But with scaffolding and supports have the opportunity to begin to build these skills.

LIMITATIONS AND FUTURE DIRECTIONS FOR RESEARCH

While this study provides some evidence of how a field-based science methods course has the potential to influence preservice teacher understanding of inquiry-based instruction for diverse learners, the research clearly has limitations.

Please note that my claims are tempered by the fact that learning to teach is complex and preservice teachers in any given semester of their program have multiple experiences that contribute to their learning and growth. It would be difficult for me to identify the effects of our program alone and to attribute any true changes in belief or understanding through a one semester course. With that in mind however, the research does offer some points that are important to consider when developing a science methods course.

The study only closely followed four preservice teachers in the qualitative portion of my research. While this is a small sample group of participants, each preservice
teacher represented a wide range of experience, ideas and beliefs around science inquiry instruction for diverse learners. However, it is important to note that the preservice teachers in this class were homegenous from the same university so wide generalizations are unwarranted. For example, I didn’t draw comparisons to other field-based or university-based programs. Furthermore, these preservice teachers cannot represent the full range of responses to the two instructional approaches. Larger scale studies examining preservice teacher performance in other field-based inquiry science programs might provide additional information regarding their ability to design inquiry-based instruction for diverse learners.

Another limitation of this study and suggestion for further research was that I didn’t do formal observations of the preservice teachers’ instruction or analysis of their student learning as a result of their teaching. Therefore, I do not know how closely their instruction matched the lessons that they wrote, how students responded to their instruction, or how the preservice teachers may have responded to student misconceptions and struggles to understand the content. This may have further illuminated our findings related to the field-based preservice teachers understanding of inquiry-based instruction for diverse students. This could have provided more information to aid our work as teacher educators.

A third limitation is not knowing how much the preservice teachers change in beliefs will influence their thinking and future instruction. The lack of follow up to see how the preservice teachers would teach inquiry science to diverse learners as student teachers and their initial years of teaching greatly hinders our understanding of the
effectiveness of this intervention. Further research into this would offer science educators more insight into how durable or transferrable the experiences of the field-based course really are into real settings. This is especially important because the work of Ackerson and her team (2006) found limitations on how much a change in beliefs influences thinking. She found that preservice students in her highly reflective science methods course demonstrated growth in understanding the Nature of Science from pre to post interviews and surveys, but then showed a regression five months later. Similarly, in Zembal-Saul, Krajcik, & Blumenfeld’s (2002) research the preservice teachers who had demonstrated such growth during a year long experience in a cycle of teaching found that only one of the two preservice teachers was able to still maintain the content representations in science once in their student teaching placements. However, Eick and Ware’s (2003) similar field-based course for secondary science teachers found that the practical knowledge and developing abilities were gained through what they call coteaching. In their model, preservice teachers teach students with a partner, the support of the instructor and with the cooperating teacher. His findings indicated that this experience in his field methods course methods course did help to ease the preservice teachers’ transition into student teaching. While our model didn’t have a cooperating teacher at all times our school based science specialist, the instructor and an assistant were rotating continually throughout the afterschool classrooms during the preservice teachers instruction. Other than the presence of a cooperating teacher at all times, the course supports listed earlier in this chapter closely aligned with the ones Eick and Ware reported to support preservice teachers.
The impacts of deeply learning how to teach one subject as opposed to a survey of all science content areas could be better understood. A longitudinal study following these preservice teachers would help determine how durable these changes in beliefs are as these preservice teachers enter the classroom as student teachers and later become classroom teachers.

Another limitation involves the role that inquiry-based college level science content courses play on preservice teachers readiness to integrate inquiry and content into their instruction for a field-based science methods course. Both the field-based preservice teachers Emily and Karen had university level science courses that incorporated inquiry-based investigations. Connie had switched out of a biology major into education during her sophomore year.

**IMPLICATIONS**

Building on this research there are few things to take into consideration regarding this study. The findings from this study have several implications for elementary science teacher preparation programs. In considering designed based research I am using the data to reinform the design of the course at our university. This study implies that we need to have more authentic opportunities for our preservice teachers to teach inquiry-based science to diverse students in supportive environments.

Yet it is important to point out that there is value in both course approaches. Both have strengths. The university-based science methods course offers preservice teachers a greater exposure and thus confidence to teach a variety of science content at the elementary level. However, it is important to consider that the field-based university
allowed the preservice teachers more opportunity explore and test their understanding, beliefs and ideas to design inquiry-based learning for diverse students. But there are the challenges, so based upon your goals of the new structure if you want preservice teachers to gain a broader experience around teaching science to diverse students explore further into a field-based science method course model. In order to address the limitations of preservice content growth in this course a beneficial step is to build bridges with the Arts and Science Department to develop cross department science courses so that they help preservice teachers develop their content understanding during lecture, while seeing ways to bring that content into an elementary classroom through investigations done as part of the lab.

If you want preservice teachers to gain a broader content knowledge you would want to teach at university-based science methods course. There are additional instructional strategies that could be incorporated into a university based methods course should the university not have access to a school or similar setting for the preservice teachers to teach. These strategies could include but are not limited to: video case studies of classrooms with accompanying student work for preservice teachers to analyze and make recommendations for student interventions and determine whether student growth is demonstrated, and doing case studies of students preservice teachers encounter in their practicum placements. This can help to bring as much of the authenticity to the course as possible.

Druva and Anderson’s (1983) meta-analysis of K-12th grade teacher research found a small but significant relationship between the science training of the teacher and
their teaching effectiveness with their students. Yet, Enochs and his colleagues found that the number of college science courses taken and the number of years of high school science taken were negatively correlated with the elementary preservice teachers self-efficacy to teach science. This indicates the inadequacy of traditional science instruction (Enochs, Scharmann, & Riggs, 1995). However, Palmer’s (2006) research demonstrated that teachers who engaged in inquiry-based learning as part of his science methods course had an increased efficacy or belief in their ability to teach science and mathematics which remained high even 9 months later while teaching science in a primary classroom.

These findings align with Tobin and Fraser (1990) who found that content knowledge and ability to teach resulted in more inquiry-based instruction opposed to those teachers less knowledgeable who used more traditional, text based instruction for disseminating content knowledge.

Even though a portion of a science methods course focuses on content, it is important for preservice teachers to take science courses in addition to the science methods course. Requiring preservice teachers to take separate courses that focus specifically on the content would allow a field-based science methods course such as this provide the opportunity for preservice teachers to apply their knowledge content in the context of inquiry-based teaching. Our university currently has two science content courses in the arts and science department that integrate inquiry into the labs. Windschitl, (2003) long term study found that the few preservice teachers who incorporated guided or open, student directed inquiry into their instruction were the ones who had had experienced long term research experience prior to coming to the university, not the ones
who had practiced inquiry in teaching experiences. Since previous experience is shown to have a significant influence on preservice teacher behaviors it is important that the college level science content courses incorporated inquiry so that the preservice teachers gain that experience and see how inquiry builds off the content. That would allow more time to be focused on developing pedagogical content knowledge (Shulman, 1986) once preservice teachers enter the science methods course.

Based upon this work I recommend that elementary science methods courses work to incorporate as part of their course more authentic field-based teaching experiences for their preservice teachers. These preservice teachers receive the opportunity to integrate their pedagogical and content knowledge (Shulman, 1986) through developing and teaching an inquiry-based unit and to personally experience their students learning. The supportive nature of the course gave them confidence to challenge their beliefs and try new approaches such as inquiry-based science in their instruction. Their field-based experience allowed them to work through any challenges they encountered. This supportive, non-threatening environment for preservice teachers to apply theory into practice while developing, and revising an inquiry-based unit they taught diverse students seems to be a significant factor to in helping teachers experience and build confidence in it. Most importantly though, little can take the place of the motivation this authentic teaching experience provided the field-based preservice teachers when they saw the student learning in response to the unit they continuously developed, taught, revised, and taught. Finally, this research indicates the importance of elementary preservice teachers taking content courses designed specifically to highlight
strategies to break down the university level content to students at the elementary level. This could have the potential to address the weaknesses of content knowledge in the field based methods course.
APPENDIX A: Preservice Science Teacher Survey (continued)
Spring, 2007
Student Eagle ID#: ______________________
Section: Ed10901 or ED10902

**Pre-service Science Teachers Survey**

We thank you for participating in this research study to help us to better understand how to support pre-service science teachers. We would appreciate it if you could take approximately 30 minutes to complete these questions. This survey is broken up into 3 sections:

1) Background Information – This section is to help us know who you are.
2) Your Science Teaching – This helps us identify how often you anticipate you will do certain activities in the classroom.
3) Your Teaching Philosophy – Your perceptions on what is an effective teaching style.

1. Are you:  
   - ○ Male  
   - ○ Female

2. Ethnicity – Are you:  
   - ○ American Indian or Alaskan Native  
   - ○ Hispanic or Latino  
   - ○ Not Hispanic or Latino  
   - ○ Black or African-American  
   - ○ Native Hawaiian or Other Pacific Islander  
   - ○ White  
   - ○ Other

3. Race- Are you: (Choose one or more.)  
   - ○ Asian

4. Are you:  
   - ○ Freshman  
   - ○ Sophomore  
   - ○ Junior  
   - ○ Senior  
   - ○ Master’s Program

5a. What science courses did you take in High School?  
   a. Life Science/Biology  
   b. Earth/Space Science  
   c. Chemistry  
   d. Physics/Physical Science  
   e. Environmental Science  
   f. Advanced Placement

5b. List your Science Course #  
   (list semester e. Fall 2005)

6. Prepracticum Experience

Locations

Grade levels (Darken all ovals that apply.)  
- ○ 1st  
- ○ 2nd  
- ○ 3rd  
- ○ 4th  
- ○ 5th  
- ○ 6th  
- ○ 7th  
- ○ 8th  
- ○ 9th  
- ○ 10th  
- ○ 11th  
- ○ 12th

7. Which grade levels do you want to teach? (Darken all ovals that apply.)  
- ○ 1st  
- ○ 2nd  
- ○ 3rd  
- ○ 4th  
- ○ 5th  
- ○ 6th  
- ○ 7th  
- ○ 8th  
- ○ 9th  
- ○ 10th  
- ○ 11th  
- ○ 12th

Sections 1 & 2 were adapted from the Local Systemic Change through Teacher Enhancement instrument (1999) by Horizon Research, Inc., funded by NSF. Section 2 was also adapted from Ritter, Boone & Robbs, (2001) SEBEST (Self-Efficacy Beliefs about Equitable Science Teaching and Learning). Section 3 was adapted from the Teachers Survey of the Teaching, Learning and Computing Project by Becker and Anderson (1998) funded by NSF and DoE.
APPENDIX A: Preservice Science Teacher Survey (continued)

Section 2: Your Science Teaching
8. Please provide your opinion about each of the following statements. 
   (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>No Opinion</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I enjoy teaching science.</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. I will be able to teach science to children whose first language is not</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. I have the ability to teach science to children from economically</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>disadvantaged backgrounds.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. I can do a great deal as a teacher to increase the science achievement</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of children who do not speak English as their first language.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. I will be able to meet the learning needs of children of color when I</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>teach science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. I do not know teaching strategies that will help children who are</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English Language Learners achieve in science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. I can help girls learn science at the same level as boys.</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. I do not know how to teach science concepts of children who speak</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English as a second language.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. I will be effective in teaching science in a meaningful way to girls.</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. I will have the ability to help children from low socioeconomic</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>backgrounds be successful in science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. I will be able to successfully teach science to Native American</td>
<td>✅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>children.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)
Section 2: Your Science Teaching
8. Please provide your opinion about each of the following statements. (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>No Opinion</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>l. I will not be able to teach science to children who speak English as a second language as effectively as I will to children who speak English as their first language.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>m. I cannot help girls learn science at the same level as boys.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>n. I will be able to effectively monitor the science understanding of children who are English Language Learners.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>o. I will not be able to successfully teach Asian children.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>p. I will be able to successfully teach science to children of color.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>q. I will be able to help girls learn science.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>r. I will not be able to teach science successfully to White children.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

9. In the left section, please rate each of the following in terms of its importance for effective science instruction in the grades you plan to teach. In the right section, please indicate how prepared you feel to do each one:

<table>
<thead>
<tr>
<th>Importance</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not important</td>
<td>Some-what prepared</td>
</tr>
<tr>
<td>Some-what important</td>
<td>Fairly well prepared</td>
</tr>
<tr>
<td>Fairly important</td>
<td>Very well prepared</td>
</tr>
<tr>
<td>Very important</td>
<td>Not prepared</td>
</tr>
<tr>
<td></td>
<td>Some-what prepared</td>
</tr>
<tr>
<td></td>
<td>Fairly well prepared</td>
</tr>
<tr>
<td></td>
<td>Very well prepared</td>
</tr>
</tbody>
</table>

a. Provide concrete experiences before abstract concepts.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○

b. Develop students’ conceptual understanding of science.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
c. Take students’ prior understanding into account when planning curriculum and instruction.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
d. Make connections between science and other disciplines.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
e. Have students work in cooperative groups.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
f. Have students participate in appropriate hands-on activities.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
g. Engage students in inquiry-oriented activities.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
h. Have students prepare project/laboratory/research reports.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
i. Have students use computers.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
j. Engage students in applications of science in a variety of contexts.  
   Importance: ○ ○ ○ ○ ○  
   Preparation: ○ ○ ○ ○ ○ ○ ○ ○ ○
APPENDIX A: Preservice Science Teacher Survey (continued) (continued) 9. In the left section, please rate each of the following in terms of its **importance** for effective science instruction in the grades you plan to teach. In the right section, please indicate how **prepared** you feel to do each one:

<table>
<thead>
<tr>
<th>Importance</th>
<th>Preperation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not important</td>
</tr>
<tr>
<td>k. Use performanc e-based assessment</td>
<td>☐</td>
</tr>
<tr>
<td>l. Use informal questioning to assess student understanding</td>
<td>☐</td>
</tr>
<tr>
<td>m. Provide graphical images to enhance text</td>
<td>☐</td>
</tr>
<tr>
<td>n. Introduce student vocabulary as part of activity</td>
<td>☐</td>
</tr>
<tr>
<td>o. Meet the needs of ethnically and linguistically diverse students</td>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

10. Within science, many teachers feel better prepared to teach some topics than others. How well prepared do you feel to teach each of the following topics at the grade levels you plan to teach? (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Not adequately prepared</th>
<th>Someewhat prepared</th>
<th>Fairly Well Prepared</th>
<th>Very Well Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Earth Science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Earth’s features and physical processes</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. The solar system and the universe</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3. Climate and weather</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>b. Biology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Structure and function of human systems</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Plant biology</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3. Animal behavior</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4. Cells</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5. Interactions of living things/ecology</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6. Genetics</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>c. Chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Structure of matter and chemical bonding</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Properties and states of matter</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3. Chemical reactions</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4. Energy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>d. Physics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Forces and motion</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Energy and heat</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3. Light and sound</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4. Electricity and magnetism</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5. Modern physics (e.g. special relativity)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>e. Environmental and resource issues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Pollutions, acid rain, global warming</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
(continued) 10. Within science, many teachers feel better prepared to teach some topics than others. How well prepared do you feel to teach each of the following topics at the grade levels you plan to teach? (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>f. Scientific inquiry skills</th>
<th>Not adequately prepared</th>
<th>Some-what prepared</th>
<th>Fairly Well Prepared</th>
<th>Very Well Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ask a question about objects, organisms, and events in the environment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Plan and conduct a simple investigation.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Use simple equipment and tools to gather data.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Use data to construct a reasonable explanation.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. Communicate investigations and explanations.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

11. Please indicate how well prepared you feel to do each of the following. (Darken one oval on each line.)

<table>
<thead>
<tr>
<th></th>
<th>Not adequately prepared</th>
<th>Somewhat prepared</th>
<th>Fairly Well Prepared</th>
<th>Very Well Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Lead a class of students using investigative strategies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Manage a class of students engaged in hands-on/ project-based work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Help students take responsibility for their own learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Recognize and respond to student diversity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Encourage students’ interest in science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Use strategies that specifically encourage participation of females and minorities in science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Involve parents in the science education of their children.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

12. Please rate the effect you anticipate each of the following will have on your science instruction.
   (Darken one oval on each line.)

<table>
<thead>
<tr>
<th></th>
<th>Inhibits effective instruction</th>
<th>Somewhat inhibits</th>
<th>Neutral or mixed</th>
<th>Some-what encourages</th>
<th>Encourages effective instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. State and/or district curriculum frameworks.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>b. State and/or district testing policies and practices.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>c. Quality of available instructional materials.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>d. Access to computers for science instruction.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>e. Time available for teachers to plan and prepare lessons.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>f. Time available for teachers to work with other teachers.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>g. Importance that the school places on science.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Appendix A: Preservice Science Teacher Survey

13. About how often do you anticipate you will do each of the following in your science class? (Darken one oval each line.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Never</th>
<th>Rarely (a few times a year)</th>
<th>Sometimes (once or twice a month)</th>
<th>Often (once or twice a week)</th>
<th>All or almost all science instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Use inquiry-based instructional materials as the basis of science lessons.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Introduce content through formal presentations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Demonstrate a science-related principle or phenomenon.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Teach science using real-world contexts.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Arrange seating to facilitate student discussion.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Use open-ended questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Require students to supply evidence to support their claims.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Encourage students to explain concepts to one another.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Encourage students to consider alternative explanations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Allow students to work at their own pace.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Help students see connections between science and other disciplines.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Use assessment to find out what students know before or during a unit.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. Use assessment to give students a grade.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. Use assessment to provide me with data on student understanding and how to change my instruction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o. Use assessment to redesign my instruction.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p. Embed assessment in regular class activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q. Assign science homework.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r. Read and comment on the reflections students have written in their notebooks or journals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s. Lecture on science content.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

14. About how often do you anticipate STUDENTS in your class will take part in each of the following types of activities? (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Never</th>
<th>Rarely (a few times a year)</th>
<th>Sometimes (once or twice a month)</th>
<th>Often (once or twice a week)</th>
<th>All or almost all science instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Participate in student led discussions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Participate in discussions with the teacher to further science understanding.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Work in cooperative learning groups.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Make formal presentations to the class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Read from a science textbook in class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Read other (non-textbook) science related materials in class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Answer textbook/worksheet questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Review homework/worksheet assignments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Work on solving a real-world problem.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. Share ideas or solve problems with each other in small groups.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. Engage in hands-on science activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Follow specific instructions in an activity or investigation.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. Design or implement their own investigations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. Design objects within constraints (e.g., egg drop, toothpick bridge, aluminum boats).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o. Work on models or simulations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p. Work on extended science investigations or projects (a week or more in duration).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>q. Participate in field work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r. Record and represent data.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s. Analyze data.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t. Write reflections in a notebook or journal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>u. Prepare written science reports.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v. Use mathematics as a tool in problem solving.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w. Use computers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x. Take short answer tests (e.g., multiple choice, true/false, fill-in-the-blank).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>y. Take tests requiring open-ended responses (e.g., descriptions, explanations).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>z. Engage in performance tasks for assessment purposes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

Section 3: Your Teaching Philosophy

15. The following paragraphs describe observations of two teachers’ classes, Mrs. Hill’s and Mr. Jones’. Answer each question below by checking the box under the column that best answers that question for you.

Mrs. Hill was leading her class in an animated way, asking questions that the students could answer quickly; based on the reading they had done the day before. After this review, Ms. Hill taught the class new material, again using simple questions to keep students attentive and listening to what she said.

Mr. Jones’ class was also having a discussion, but many of the questions came from the students themselves. Though Mr. Jones could clarify students’ questions and suggest where the students could find relevant information, he couldn’t really answer most of the questions himself.

<table>
<thead>
<tr>
<th>Question</th>
<th>Definitely Ms. Hill’s</th>
<th>Tend towards Ms. Hill’s</th>
<th>Tend towards Mr. Jones’</th>
<th>Definitely Mr. Jones’</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Which type of class discussion are you more comfortable having in class?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Which type of discussion do you think most students prefer to have?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. From which type of class discussion do you think students gain more knowledge?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. From which type of class discussion do you think students gain more useful skills?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
### APPENDIX A: Preservice Science Teacher Survey (continued)

16. Indicate how much you disagree or agree with each of the following statements about teaching and learning.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Teachers know a lot more than students; they shouldn’t let students muddle around when they can just explain the answers directly.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>b. A quiet classroom is generally needed for effective learning.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>c. Students are not ready for meaningful learning until they have acquired basic reading and math skills.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>d. It is better when the teacher – not the students - decides what activities are to be done.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>e. Student projects often result in students learning all sorts of wrong “knowledge”.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>f. Homework is a good setting for having students answer questions posed in their textbooks.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>g. Students will take more initiative to learn when they feel free to move around the room during class.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>h. Students should help establish criteria on which their work will be assessed.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>i. Instruction should be built around problems with clear, correct answers, and around ideas that most students can grasp quickly.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
<tr>
<td>j. How much students learn depends on how much background knowledge they have – that is why teaching facts is so necessary.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)

17. Different teachers have described very different teaching philosophies to researchers. For each of the statements, check the box that best shows how closely your own beliefs are to each of the statements in a given pair. The closer your beliefs to a particular statement, the closer the box you check. Please check only one box for each set.

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. “I mainly see my role as a facilitator. I try to provide opportunities and resources for my students to discover or construct concepts for themselves.”</td>
<td>“That’s all nice, but students really won’t learn the subject unless you go over the material in a structured way. It’s my job to explain, to show students how to do the work, and to assign specific practice.”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. “The most important part of instruction is the content of the curriculum. That content is the community’s judgment about what children need to be able to know and do.”</td>
<td>“The most important part of instruction is that it encourages ”sense-making” or thinking among students. Content is secondary.”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. “It is useful for students to become familiar with many different ideas and skills even if their understanding for now, is limited. Later, in college, perhaps they will learn these things in more detail.”</td>
<td>“It is better for students to master a few complex ideas and skills well, and to learn what deep understanding is all about, even if the breadth of their knowledge is limited until they are older.”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. “It is critical for students to become interested in doing academic work - interest and effort are more important than the particular subject-matter.”</td>
<td>“While student motivation is certainly useful, it should not drive what students study. It is more important that students learn the history, science, math and language skills in their textbooks.”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. “Science curriculum should be seen as a resource from which you can determine one’s own science instruction.”</td>
<td>“In order for students to learn important concepts, it is important for you to follow the science curriculum carefully and in the order provided.”</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX A: Preservice Science Teacher Survey (continued)
Survey Addendum: Language experience

ED 109
Spring, 2007
Open Response Questions

1. Do you have previous experiences with diverse populations? _________
   If so, in what context?

2. What courses have you taken related to languages? What languages do you speak?

3. What courses have you had where you were introduced to English Language Learner strategies?
APPENDIX B: Interview Protocol

Pre-service Teacher Interview Protocol

Thank you for agreeing to participate in this study designed to better understand your needs and how to support your growth as a teacher. This interview will take approximately thirty minutes. Although I have a set of questions I am going to ask, please feel free to ask me questions and share any thoughts you might have. Please keep in mind that there are no right or wrong answers, we are simply looking for your thoughts on these issues. Do you mind if I tape this session? It will help me to stay focused on our conversation and it will ensure I have an accurate record of what we discussed.

Beliefs about Science Teaching
1. Imagine you observed another teacher’s classroom who conducted what you believe to be an excellent science lesson. What types of things would you have expected to see?
   a. What was the teacher doing?
   b. What were the students doing?
   c. Why do you consider this an excellent science lesson?
   d. Do you feel prepared that you could teach in this way?

2. What is your understanding of inquiry-based science teaching?
   a. How do you feel it will play out in your classroom?
   b. Do you feel prepared to teach this way?

Diverse/Urban (ELL) Context
1. How do you feel about working with diverse students?

2. How do you feel diverse students learn best?

3. Can you describe the strategies you would use in a science lesson to support diverse students?

Educational Opportunities
4. What opportunities have you had to observe/teach science being taught to elementary students? Can you describe your experience?

5. What opportunities have you had to teach lessons using these strategies?

Content Understanding
6. How confident do you feel about teaching science in your future elementary classroom?
   a. Do you think you will enjoy it?
   b. How prepared do you feel to guide student learning of this content?
   c. What opportunities have you had to learn about this particular content area?
   d. How helpful were these opportunities?
7. As you have taken other methods courses here at Boston College what activities or resources have best supported your growth and helped you develop good teaching practice? Why? Can you recall any specific instances?

APPENDIX B: Interview Protocol

9. In the diagram below the ‘teacher’ box in the circle represents a full time teacher. At this point in your degree here at Boston College, please place an X where you feel you are in your preparation toward becoming a full time teacher.

Thank you for your time. If I have any additional questions or need clarification, how and when is it best to contact you?

Sections adapted from Horizon Research Inc. Inside the Classroom Teacher Interview Protocol and ILF
APPENDIX C: Student Misconception Interview (Field-based Science Methods Course)

Student Misconception Interview

Rationale
Students are inquisitive people, and as such, they are constantly trying to construct meaning out of their experiences and observations. Unfortunately, in science many phenomena are often counterintuitive. For example, consider the notion that the Earth goes around the Sun. From the perspective of someone on the Earth, it sure looks like the Sun goes around you! This may sound far fetched, but a 1988 survey conducted by the Public Opinion Laboratory at Northern Illinois University determined that only 45% of United States adults could correctly state that the Earth orbited the Sun and that it took one year to complete the trip. Furthermore, even some of the best students can give the right answers, but are only using correctly memorized words. When questioned more closely, these students reveal their failure to understand fully the underlying concepts. Research has shown that students' existing understandings (often called misconceptions or alternative conceptions) are resilient to instruction. That is, even after instruction students will often rely on their previous understandings to answer questions. Research has shown that it is important that as teachers we take into account students’ misconceptions when designing our instruction. If we are not aware of students' existing understanding, it is likely that our students will leave our classrooms with the same misconceptions that they held before entering our classrooms.

The purpose of this assignment is to help you to better understand the type and structure of students' understandings of various natural phenomena. You will design a misconception interview around the concepts of force, motion, and energy, which you will conduct with the students at Eisenhower Elementary.

Creating the Get to Know You Activity and Interview Protocol

- The first 10 minutes of your initial meeting with your student (or students) should focus on a ‘get to know you’ activity. You will be working with these students for the next 7 weeks so you want to get to know your students and start to build relationships with them.
- The next 25-30 minutes should focus on the misconception interview. There are some websites listed at the end of this sheet that describe common student misconceptions for force, motion, and energy. You should use these to help you create appropriate questions.
- Develop an interview protocol that will help you explore a student’s understanding of these science concepts. You should start with some easy questions and gradually probe
more deeply. You may want to use additional hands on materials depending on the science topic, such as balls, ramps, toy cars, etc. There are a couple of sample interview protocols below.

• You will hand in a draft of your ‘get to know you’ activity and interview protocol on Thursday, Feb. 1 on WebCT in your dropbox.

**Appendix C: Student Misconception Interview (Field-based Science Methods Course)**

• We will post our comments on your assignment by Sunday so you can be ready to interview the students on Tuesday. Revise the interview protocol based on any feedback that you receive from us.

**Conducting the Interview**

• When you interview the student, take your time. Allow the student plenty of time to respond to each question. Provide the student with minimal help, but remain supportive and positive. Vary your questioning according to the responses the student is making. Your aim is to find out as much as possible about what they think. After they respond to a question if it seems unclear, you might want to prompt them by saying something like – “Tell me more about ______” or “Explain what you mean by ___.” But if the student appears lost, do not press for higher level answers.

• If interviewing more than one student, give each student ample time to answer each question with his or her own ideas. Also, try alternating the student with whom you start each question.

• You should have a pen or pencil and take notes of the students’ ideas during the interview. You may want to also have students make drawings possibly with labels in which case you should collect them. After the interview, it can be helpful to make your own comments on the student drawings using post its while the interview is still fresh.

**Write-up for Student Misconception Interview**

• Include your final interview protocol that you used with students.

• If the student produced any drawings, include them.

• You should write an approximately 2-page paper that includes: 1) the student’s responses to the questions and 2) your own reflections.

  o Student responses. You should use a pseudonym to protect the student’s identity (e.g. if the student’s name is Jane refer to her as Mary). Tell the age, grade level and background of the student. Describe how the student responded to each of your questions. We do not need a detailed transcript, but rather a summary of the main ideas or concepts the student provided for each question.

  o Reflection. You should also provide a reflection about your own thoughts about interviewing the student that addresses the following questions: 1) What surprised you
about the student’s responses? Why? 2) Do you think the student’s responses were
typical of most individuals his or her age? Why or why not? 3) In planning to teach
about this science topic, how will the student’s responses inform your instruction? What
specific strategies or activities might you try to address these misconceptions?

Useful Websites:

Children’s Ideas in Science

*Benckmarks* (AAAS, 1993), Chapter 15 provides a description of student misconceptions
organized by the chapters in the rest of the book. If you scroll down to the bottom of the
page, **Appendix C: Student Misconception Interview (University Science Methods
Course)**
**Appendix C: Student Misconception Interview (Field-based Science Methods
Course)**

you will see a list of the chapters. If you click on the different chapters, it describes
common student conceptions.
http://www.project2061.org/publications/bsl/online/ch15/ch15.htm

Science myths in K-6 textbooks and popular culture
http://www.amasci.com/miscon/miscon.html#links%20
APPENDIX C: Student Misconception Interview (Field-based Science Methods Course)

Sample Interview Protocol

Introduction
(Before you start the interview, you should describe what it is you will be doing – there is an example below).

Thank you very much (name of student here) for agreeing to be interviewed. This interview is not for a grade, but is intended to help me to learn how to teach better. There is no right or wrong answer to the questions I am going to ask you. I just want to understand what you think about the question. I have pieces of paper and pens and pencils for you to draw anything that you want to help explain your ideas and thoughts. This interview will take about 25-30 minutes. Do you have any questions about this interview? Ok, ready?

Sample Questions

(Earth Science) The Earth in space
1. What sort of shape do you think the Earth is?
2. Have you heard people say that the Earth is round? Do you think they mean like a football, or flat like a CD?
3. Draw what you think the Earth is like.
4. Draw some people standing on the Earth.
5. Can you draw another person standing on the other side of the Earth (in Australia)?
6. Why don’t the people fall off?
7. What do you think gravity is? Where does it come from?
8. Is there gravity on the space shuttle? Why or why not?

(Chemistry) Chemical Reactions (Have a glass of vinegar, a glass of water and baking soda for this interview)
1. Explain to the student that you have a glass of vinegar, a glass of water and baking soda. What do you think will happen when I combine the baking soda and vinegar? Why?
2. Put a spoonful of baking soda in the vinegar. What happened when I combined the vinegar and baking soda? Why did this happen?
3. Draw what you think happened with the vinegar and baking. Explain your drawing.
4. What do you think will happen when I combine the baking soda and water? Why?
5. Put a spoonful of baking soda in the water. What happened when I combined the baking soda and water? Why did this happen?
6. Why did something different happen when I used the vinegar compared to when I used
water?
7. If the student does not bring up the idea of chemical reaction, ask him or her if they know what a chemical reaction is.
8. Why do chemical reactions occur?
9. What are other examples of everyday chemical reactions? Why are these chemical reactions?
APPENDIX D: Student Misconception Interview (University-based Science Methods)

Student Misconception Interview

Rationale

Students are inquisitive people, and as such, they are constantly trying to construct meaning out of their experiences and observations. Unfortunately, in science many phenomena are often counterintuitive. For example, consider the notion that the Earth goes around the Sun. From the perspective of someone on the Earth, it sure looks like the Sun goes around you! This may sound far fetched, but a 1988 survey conducted by the Public Opinion Laboratory at Northern Illinois University determined that only 45% of United States adults could correctly state that the Earth orbited the Sun and that it took one year to complete the trip. Furthermore, even some of the best students can give the right answers, but are only using correctly memorized words. When questioned more closely, these students reveal their failure to understand fully the underlying concepts. Research has shown that students' existing understandings (often called misconceptions or alternative conceptions) are resilient to instruction. That is, even after instruction students will often rely on their previous understandings to answer questions. Research has shown that it is important that as teachers we take into account students’ misconceptions when designing our instruction. If we are not aware of students' existing understanding, it is likely that our students will leave our classrooms with the same misconceptions that they held before entering our classrooms.

The purpose of this assignment is to help you to better understand the type and structure of students' understandings of various natural phenomena.

Creating the Interview Protocol

• Select a topic that you are interested in interviewing a student about (e.g. light and shadows). You might want to consider what topic you would like to focus on for the lesson you are going to teach and your final curriculum unit. This can be a great way to start exploring this content area.
• There are some websites listed at the end of this sheet that describe common student misconceptions. You should use these to help you select a topic and create appropriate questions.
• Develop an interview protocol that will help you explore a student’s understanding of the science concept. The interview should take about 25-30 minutes. You should start with some easy questions and gradually probe more deeply. You may want to use additional materials depending on the science topic (i.e. you if your topic is astronomy you may want some balls to help the students model the Earth-Moon-Sun system). There are a couple of sample interview protocols below. You will hand in a draft of your interview protocol on January 31.
• Revise the interview protocol based on any feedback that you receive from us.

**Conducting the Interview**
• If you are currently in your pre-practicum, ask your supervising teacher to help you select a student to interview. You should also share your interview protocol with your
APPENDIX D: Student Misconception Interview University-based Methods

supervising teacher. If you are not currently in a classroom, talk to us and we can help you find a student to interview. Check with the student to make sure he or she is willing and agrees to be interviewed.

• When you interview the student, take your time. Allow the student plenty of time to respond to each question. Provide the student with minimal help, but remain supportive and positive. Vary your questing according to the responses the student is making. Your aim is to find out as much as possible about what they think. After they respond to a question if it seems unclear, you might want to prompt them by saying something like – “Tell me more about ______” or “Explain what you mean by ___. ” But if the student appears lost, do not press for higher level answers.

• You should have a pen or pencil and take notes of the students’ ideas during the interview. You may want to also have students make drawings in which case you should collect them. After the interview, it can be helpful to make your own comments on the student drawings using post its while the interview is still fresh.

Write-up for Student Misconception Interview

• Include your final interview protocol that you used with students.
• If the student produced any drawings, include them.
• You should write an approximately 2-page paper that includes: 1) the student’s responses to the questions and 2) your own reflections.
  o Student responses. You should use a pseudonym to protect the student’s identity (e.g. if the student’s name is Jane refer to her as Mary). Tell the age, grade level and background of the student. Describe how the student responded to each of your questions. We do not need a detailed transcript, but rather a summary of the main ideas or concepts the student provided for each question.
  o Reflection. You should also provide a reflection about your own thoughts about interviewing the student that addresses the following questions: 1) What surprised you about the student’s responses? Why? 2) Do you think the student’s responses were typical of most individuals his or her age? Why or why not? 3) If you were teaching a class about this science topic, how would the student’s responses inform your instruction? What specific strategies or activities might you try to address these misconceptions?

Useful Websites:
Children’s Ideas in Science

Benchmarks (AAAS, 1993), Chapter 15 provides a description of student misconceptions organized by the chapters in the rest of the book. If you scroll down to the bottom of the page, you will see a list of the chapters. If you click on the different chapters, it describes
common student conceptions.
http://www.project2061.org/publications/bsl/online/ch15/ch15.htm

Science myths in K-6 textbooks and popular culture
http://www.amasci.com/miscon/miscon.html#links%20
APPENDIX D: Student Misconception Interview (University-based Science Methods)

Sample Interview Protocol

Introduction
(If you haven't met the student before introduce yourself and describe your role in their classroom. To help the child feel more comfortable, you may want to share a bit about yourself and ask the student a question or two about themselves. Before you start the interview, you should describe what it is you will be doing – there is an example below).

Thank you very much (name of student here) for agreeing to be interviewed. This interview is not for a grade, but is intended to help me to learn how to teach better. There is no right or wrong answer to the questions I am going to ask you. I just want to understand what you think about the question. I have pieces of paper and pens and pencils for you to draw anything that you want to help explain your ideas and thoughts. This interview will take about 25-30 minutes. Do you have any questions about this interview? Ok, ready?

Sample Questions
(Earth Science) The Earth in space
1. What sort of shape do you think the Earth is?
2. Have you heard people say that the Earth is round? Do you think they mean like a football, or flat like a CD?
3. Draw what you think the Earth is like.
4. Draw some people standing on the Earth.
5. Can you draw another person standing on the other side of the Earth (in Australia)?
6. Why don’t the people fall off?
7. What do you think gravity is? Where does it come from?
8. Is there gravity on the space shuttle? Why or why not?

(Chemistry) Chemical Reactions (Have a glass of vinegar, a glass of water and baking soda for this interview)
1. Explain to the student that you have a glass of vinegar, a glass of water and baking soda. What do you think will happen when I combine the baking soda and vinegar? Why?
2. Put a spoonful of baking soda in the vinegar. What happened when I combined the vinegar and baking soda? Why did this happen?
3. Draw what you think happened with the vinegar and baking. Explain your drawing.
4. What do you think will happen when I combine the baking soda and water? Why?
5. Put a spoonful of baking soda in the water. What happened when I combined the baking soda and water? Why did this happen?
6. Why did something different happen when I used the vinegar compared to when I used water?

249
7. If the student does not bring up the idea of chemical reaction, ask him or her if they know what a chemical reaction is.
8. Why do chemical reactions occur?
9. What are other examples of everyday chemical reactions? Why are these chemical reactions?
APPENDIX E: Curriculum Evaluation Field-based Methods

Curriculum Evaluation

Rationale
Print texts dominate classroom instruction (King and O’Brien, 2002). In particular in science classrooms, the instructional materials (both the student textbook and teacher materials) play a major role in the teaching and learning (Kesidou and Roseman, 2002). Project 2061’s review of science textbooks concluded that none of the nine programs they examined were likely to result in students learning the targeted national science standards. Their critique concluded that the materials covered many topics at a superficial level, focused on technical vocabulary, did not take into account students’ prior knowledge, lacked coherent explanations of real-world phenomena, and did not provide students with opportunities to develop explanations of phenomena (Kesidou and Roseman, 2002).

When you are teaching, it is important to evaluate the textbook and other curriculum materials that you are using to assess their strengths and weaknesses. This can help you to decide whether or not to use those materials and if you do decide to use them how you might adapt them to compensate for any weaknesses.

Science in a Nutshell: Energy & Motion
You will critique the Science in a Nutshell: Energy & Motion curriculum guide. You and your partner will be receiving one of these kits for your teaching in the Gardner afterschool program. These kits are a great resource providing materials and some great ideas for activities, but there are also weaknesses to the curriculum as well. You will use the Project 2061 criteria to help you think about the strengths and weaknesses of the curriculum and how you might want to adapt them for your own teaching.

Write-up of Curriculum Evaluation
Your final curriculum review should include the following components:

1. Brief Description of Curriculum Materials
   - Title, publisher, date of publication, Authors, Specific Subject, and Grade

2. Unpack the key Standard or Benchmark
   - Use the Benchmarks or Standards to choose a standard that aligns with the key learning goal addressed in your target lesson. You should then unpack that standard or benchmark by addressing the following two questions:
     1) What does the standard mean?
     2) What misconceptions might students have?
APPENDIX E: Curriculum Evaluation Field-based Methods

• For the student misconceptions, you might want to check some of the websites on WebCT (Webpages ➔ Misconception Webpages). If you do use these websites, make sure that you reference them appropriately in your write-up.

3. Critique of the Curriculum – 8 subcategories
• Use the simplified Project 2061 textbook evaluation criteria from class to determine if the materials will help students develop an understanding of the specified Benchmark or Standard. You can use the table that we filled out in class or you can choose a different format, such as paragraphs. There is a word version of the table available for download on WebCT (Assignments ➔ Curriculum Evaluation). Regardless of the format, you should provide a rating for all 8 subcategories and include evidence for those ratings. You and your partner can work together to complete the critique of the curriculum. Please indicate on your paper who your partner is that you worked with.

4. Overall judgment and reflection about the materials
• Now that you have analyzed the curriculum materials across the 8 subcategories, provide your overall judgment of the materials and how you might adapt them. You should provide an approximately 1-2 page discussion that addresses the following questions. You should write your overall judgment and reflection of the materials independently (i.e. it should not be the same as your partner).
  1. Do you think these materials would help students learn the target learn goal? Why or why not?
  2. What are the strengths and weaknesses of the materials?
  3. How do you think you might adapt or modify the curriculum materials to improve student learning? Why do you think these modifications might be helpful?
APPENDIX F: Curriculum Evaluation University-based Methods

Curriculum Evaluation

Rationale
Print texts dominate classroom instruction (King and O’Brien, 2002). In particular in science classrooms, the instructional materials (both the student textbook and teacher materials) play a major role in the teaching and learning (Kesidou and Roseman, 2002). Project 2061’s review of science textbooks concluded that none of the nine programs they examined were likely to result in students learning the targeted national science standards. Their critique concluded that the materials covered many topics at a superficial level, focused on technical vocabulary, did not take into account students’ prior knowledge, lacked coherent explanations of real-world phenomena, and did not provide students with opportunities to develop explanations of phenomena (Kesidou and Roseman, 2002).

When you are teaching, it is important to evaluate the textbook and other curriculum materials that you are using to assess their strengths and weaknesses. This can help you to decide whether or not to use those materials and if you do decide to use them how you might adapt them to compensate for any weaknesses.

Selecting a Curriculum/Textbook
You will select and critique materials from one curriculum project or textbook using a simplified version of the American Association for the Advancement of Science (AAAS) textbook evaluation criteria. You will do an analysis similar to the one we did in class around the Science in a Nutshell: Energy & Motion curriculum guide. The length of the materials you critique should be similar to the guide we looked at in class. Since many curriculum are longer, you should pick one section or chapter of the curriculum to critique.

Write-up of Curriculum Evaluation
Your final curriculum review should include the following components:

1. Copy of Targeted Lesson and Any Relevant Intro Materials
   • You should make a photocopy (or you can scan it) of the curriculum materials (e.g. section or lesson) that you analyze. If you photocopy the materials, you will need to hand this in during class and not use WebCT.

2. Brief Description of Curriculum Materials
   • Title, publisher, date of publication, Authors, Specific Subject, and Grade

3. Unpack the key Standard or Benchmark
• Use the *Benchmarks* or *Standards* to choose a standard that aligns with the key learning goal addressed in your target lesson. You should then unpack that standard or benchmark by addressing the following two questions:
  1) What does the standard mean?
  2) What misconceptions might students have?

APPENDIX F: Curriculum Evaluation University-based Methods

• For the student misconceptions, you might want to check some of the websites on WebCT (Webpages  Misconception Webpages). If you do use these websites, make sure that you reference them appropriately in your write-up.

4. Critique of the Curriculum – 8 subcategories

• Use the simplified Project 2061 textbook evaluation criteria from class to determine if the materials will help students develop an understanding of the specified *Benchmark* or *Standard*. You can use the table that we filled out in class or you can choose a different format, such as paragraphs. There is a word version of the table available for download on WebCT (Assignments  Curriculum Evaluation). Regardless of the format, you should provide a rating for all 8 subcategories and include evidence for those ratings. If you want to, you can work with a partner to critique the same curriculum. Please indicate on your paper who your partner is that you worked with.

5. Overall judgment and reflection about the materials

• Now that you have analyzed the curriculum materials across the 8 subcategories, provide your overall judgment of the materials and how you might adapt them. You should provide an approximately 1-2 page discussion that addresses the following questions. If you worked with a partner to complete the critique, you should write your overall judgment and reflection of the materials independently (i.e. it should not be the same as your partner).

4. Do you think these materials would help students learn the target learn goal? Why or why not?

5. What are the strengths and weaknesses of the materials?

6. If you were going to use them in your classroom, how might you adapt them or modify them to improve student learning? Why do you think these modifications might be helpful?
APPENDIX G: Reflection Assignment Field-based Methods

**Teaching Reflection**

This should be an approximately 1-2 page reflection on your teaching and your plans for the next week’s teaching at Gardner. You should also include a draft of the lesson plan that you just taught either as an Appendix or as a separate document.

At the beginning of your reflection, include who was the lead teacher and who was the secondary teacher.

**Reflection on this Week’s Teaching**

Your reflection on your teaching should address the following questions:

- What did you think went well during the lesson? Why did you think that went well?
- What do you think did not go as well? Why do you think it did not go well?
- Do you feel like you met the needs of all of the learners in your group? Why or why not?

Some aspects that you might want to consider:

- Student learning of science content, student learning of scientific inquiry, developmental appropriateness, formative assessment, connections to literacy, connections to math, motivation and engagement, connections to previous and future lessons, connections to students’ everyday experiences and students’ misconceptions.

**Plan for Next Week’s Teaching**

Your plan for next week should address the following questions:

- What are you planning on doing next week at Gardner (science content learning goals, inquiry learning goals, demonstrations, activities, etc.)?
- How does your plan connect to what you have previously done and what you think you will be doing in the future?
- Do you have any questions for Kate or Anne? (It is ok if you don’t have questions.)

**Lesson Plan**

You should also include a draft of your lesson plan that you used when you taught. This will provide us with a sense of what you did during this past lesson, which will help us as we provide you with feedback. The lesson plan will also provide you with a record that you can then add more detail to for the final unit plan.

**Naming of Files**

You should name your reflection file as: lastname_reflect_.doc. For example, if Kate and her partner were teaching their first lesson, she would name the file as: McNeill_reflect_1.doc
If you hand in your lesson plan as a separate file (versus an appendix), name the lesson plan file as: lastname_lesson_#.doc. For example, if Kate and her partner were teaching their first lesson, she would name the file as: McNeill_lesson_1.doc
APPENDIX H: Reflection Assignment University-based Methods

Teaching a Lesson and Reflection

Description
An important aspect of teaching science is using available resources to design instruction. You and a partner will develop a thirty-minute lesson to teach a science topic of your choice (e.g. motion) for a grade level of your choice (e.g. 1st grade). For the one group of three, you will teach a forty-five minute lesson. You will then teach that lesson to ED109 and we will act as your students. All partners should actively participate in the teaching. After you teach your lesson, we will then spend fifteen minutes as a class discussing the lesson and providing you with feedback.

Lesson Plan
You will hand in a detailed lesson plan for the lesson you teach in class. The detailed lesson plan can be identical to your partner’s lesson plan. The detailed lesson plans should include: purpose, time required, age of students, materials needed, materials management, student misconceptions, national or state standards, instructional objectives or learning outcomes, detailed description of instructional activities (demonstrations, lectures, experiments, discussions), and any references you used to develop the lesson. You should include any visuals you would use such as PowerPoint slides, pictures, science trade books, or student handouts. See example Lesson from Flight unit – What determines how fast something falls?

Final Write-up for Teaching and Reflection
One week after you receive the video for your Lesson you will post on WebCT your lesson plan and a reflection on your teaching from watching the videotape. The reflection on your teaching should be written independently and should be approximately 2 pages. This reflection should stem from both the class discussion of your lesson after you presented and from watching the videotape of yourself teaching.

The reflection should address the following questions and any other insights you had from the experience:

• What did you think went well during the lesson? Why did you think that went well?
• What do you think did not go as well? Why do you think it did not go well?
• Do you feel like your lesson would meet the needs of diverse learners? Why or why not?
• If you were going to teach this lesson again, how might you change it to make it more effective? Why would that make it more effective?

Some aspects that you might want to consider in your reflection:
• Student learning of science content, student learning of scientific inquiry, developmental appropriateness, formative assessment, connections to literacy, connections to math, motivation and engagement, connections to previous and future lessons, connections to students’ everyday experiences and students’ misconceptions.
APPENDIX I: Final Curriculum Unit Assignment (Field-based Methods)

Final Curriculum Unit Design

Rationale
As a teacher, you develop lessons and entire units to help support your students in learning science. The final project for this class will be to design a curricular unit that lasts 6 days and targets a specific science content area. We view teaching as a design activity (Brown, 2004; Simon, 1996) where teachers use and adapt numerous resources to create their own classroom instruction. Our expectation is not that you will invent this unit from scratch, but rather you will use different resources (e.g. textbooks, online resources, books) to adapt and develop your own unit. We also recommend that you consider the Project 2061 curriculum evaluation criteria as you develop your unit.

Format
You will develop an instructional sequence for 6 days (approximately 45-60 minutes a day) of instruction that includes detailed lessons for all 6 days including any student handouts, powerpoints, or other materials you would use if you were teaching this in your class. This should provide the reader a sense of the instructional sequence over time and how it will help the students achieve the target learning goals.

In terms of the format of the lessons and unit plans, there are many different formats and templates out there. We would like you to use a format that you are comfortable with. However, your unit should include the following components:

1. Unit Introduction
   • This should include the target grade level (e.g. 3rd grade). It should describe the unit purpose, describe how the unit will engage and motivate students (Project 2061 - IA), and provide a justification for the lesson sequence (Project 2061 – IC).

2. Science Background
   • Science Standards - You should list the science content and inquiry standards that the unit addresses. You may choose to either use the national standards (AAAS Benchmarks or NRC Standards) or the state standards (Mass curriculum frameworks).
   • Elaboration on the Standards - The standards tend to be fairly succinct statements. You should unpack the standards and describe the target science content for the unit in more detail. What are the big science ideas that you want the elementary students to understand? What are some different ways that you might talk to the elementary students about the science content?
   • Possible student misconceptions – What are the typical misconceptions that students have regarding the content to be covered in this unit?

3. Detailed lessons for 6 days of instruction
   • All six lessons should be detailed “lesson plans” that provide a picture of what your teaching looked like during your time at Eisenhower Elementary.
The detailed lesson plans should include: purpose, time required, age of students, materials needed, materials management, student misconceptions, national or state standards, instructional objectives or learning outcomes, detailed description of instructional activities (demonstrations, lectures, experiments, discussions), and
APPENDIX I: Final Curriculum Unit Assignment (Field-based Methods)

- any references you used to develop the lesson. You should include any visuals you would use such as PowerPoint slides, pictures, or student handouts. See example Lesson from Flight unit – What determines how fast something falls?
- Student work - You should hand in copies of the students’ work that they created during the lessons at Eisenhower.

4. Assessment
- You will develop an assessment to evaluate students’ understanding of the science content and inquiry targeted in this unit. This should be a culminating assessment you would use at the end of the unit. The student assessment can take a variety of forms such as a test, presentation, lap report, performance assessment or other written assignment. You should include both the student version of the assessment as well as a rubric or key that you would use to assess student learning.

5. References
- Provide the references for all of the resources that you used to develop this unit (urls, books, etc).
- Provide references for at least five science trade books that you could use in the unit and what lesson they could connect to.

6. Reflection (INDEPENDENT)
- Everyone should write an individual reflection.
- Your reflection on your unit should be approximately 2 pages and should address the following questions:
  1. Explain the process you went through to develop your unit (e.g. Where did your ideas come from? How did you make decisions about what to include?)
  2. What is the one main thing that you hope the Eisenhower students got out of the unit? Why?
  3. Do you feel like your unit meets the needs of diverse learners? Why or why not?
  4. Is this a unit you would feel comfortable teaching in your future elementary classroom? Why or why not?
  5. In your future elementary classroom, do you think science will be a part of your classroom instruction? If so, to what extent? Why or why not? (We are looking for honesty – so if the answer is “No” that is totally fine. We just want to know why.)

7. Extensions (INDEPENDENT)
- You will also need to include three extensions to the unit. You and your partner should not have the same three extensions.
- Each extension should be approximately ½ page. They should describe how they connect the learning goals in the unit, but push the learning goals even farther either by going more in depth or connecting to related content (e.g. unit is on growth of plants. The extensions are about animals).
- The extensions could be descriptions of three additional lessons that you are summarizing instead of writing in depth. Or they could be a little less traditional, like a description of a field trip (e.g. visit to Darwin exhibit at Museum of Science with related pre and post discussion, project, and/or activity) or more long term project (e.g. testing water quality
in the Charles River) that you can imagine doing as a next steps. **Final Curriculum Unit**  
**Due – Monday, May 7**
APPENDIX J: Final Curriculum Unit Assignment University-based Methods

Curriculum Unit Design

Rationale
As a teacher, you develop lessons and entire units to help support your students in learning science. The final project for this class will be to design a curricular unit that lasts 6 days and targets a specific science content area. We view teaching as a design activity (Brown, 2004; Simon, 1996) where teachers use and adapt numerous resources to create their own classroom instruction. Our expectation is not that you will invent this unit from scratch, but rather you will use different resources (e.g. textbooks, online resources, books) to adapt and develop your own unit. We also recommend that you consider the Project 2061 curriculum evaluation criteria as you develop your unit.

Format
You will develop an instructional sequence for 6 days (approximately 45-60 minutes a day) of instruction that includes detailed lessons for all 6 days including any student handouts, powerpoints, or other materials you would use if you were teaching this in your class. This should provide the reader a sense of the instructional sequence over time and how it will help the students achieve the target learning goals.

If you choose to design your curriculum unit with a partner, steps 1 - 5 below should be identical. You will need to independently write your reflection. You will also need to independently develop three extensions to the unit discussing possible next steps (each about ½ page long).

In terms of the format of the lessons and unit plans, there are many different formats and templates out there. We would like you to use a format that you are comfortable with. However, your unit should include the following components:

8. Unit Introduction
   • This should include the target grade level (e.g. 3rd grade). It should describe the unit purpose, describe how the unit will engage and motivate students (Project 2061 - IA), and provide a justification for the lesson sequence (Project 2061 – IC).

9. Science Background
   • Science Standards - You should list the science content and inquiry standards that the unit addresses. You may choose to either use the national standards (AAAS Benchmarks or NRC Standards) or the state standards (Mass curriculum frameworks).
   • Elaboration on the Standards - The standards tend to be fairly succinct statements. You should unpack the standards and describe the target science content for the unit in more detail. What are the big science ideas that you want the elementary students to understand? What are some different ways that you might talk to the elementary students about the science content?
• Possible student misconceptions – What are the typical misconceptions that students have regarding the content to be covered in this unit?

10. Detailed lessons for 6 days of instruction

APPENDIX J: Final Curriculum Unit Assignment University-based Methods

• All six lessons should be detailed lesson plans. This is the same format as the lesson that you taught in ED109. If the lesson that you taught in ED109 fits into the content and sequence in your final unit, you are welcome to use this as one of your 6 lesson plans.
• The detailed lesson plans should include: purpose, time required, age of students, materials needed, materials management, student misconceptions, national or state standards, instructional objectives or learning outcomes, detailed description of instructional activities (demonstrations, lectures, experiments, discussions), and any references you used to develop the lesson. You should include any visuals you would use such as PowerPoint slides, pictures, or student handouts. See example Lesson from Flight unit – What determines how fast something falls?

11. Assessment
• You will develop an assessment to evaluate students’ understanding of the science content and inquiry targeted in this unit. This should be a culminating assessment you would use at the end of the unit. The student assessment can take a variety of forms such as a test, presentation, lap report, performance assessment or other written assignment. You should include both the student version of the assessment as well as a rubric or key that you would use to assess student learning.

12. References
• Provide the references for all of the resources that you used to develop this unit (urls, books, etc).
• Provide references for at least five science trade books that you could use in the unit and what lesson they could connect to.

13. Reflection
• Everyone should write an individual reflection. If you are working with a partner on your unit design, the reflection should be independent.
• Your reflection on your unit should be approximately 2 pages and should address the following questions:
  1. Explain the process you went through to develop your unit (e.g. Where did your ideas come from? How did you make decisions about what to include?)
  2. If you were teaching this unit in your elementary classroom, what is the one main thing that you would hope the students would get out of the unit? Why?
  3. Do you feel like your unit would meet the needs of diverse learners? Why or why not?
  4. Is this a unit you would feel comfortable teaching in your future elementary classroom? Why or why not?
  5. In your future elementary classroom, do you think science will be a part of your
classroom instruction? If so, to what extent? Why or why not? (We are looking for honesty – so if the answer is “No” that is totally fine. We just want to know why.)

14. Extensions (Only for people working with a partner – to be written independently)
APPENDIX J: Final Curriculum Unit Assignment University-based Methods

• If you are writing the unit with a partner, you will also need to include three extensions to the unit. You and your partner should not have the same three extensions.
• Each extension should be approximately ½ page. They should describe how they connect the learning goals in the unit, but push the learning goals even farther either by going more in depth or connecting to related content (e.g. unit is on force and motion. The extensions are about energy).
• The extensions could be descriptions of three additional lessons that you are summarizing instead of writing in depth. Or they could be a little less traditional, like a description of a field trip (e.g. visit to Darwin exhibit at Museum of Science, with related pre and post discussion, project, and/or activity) or more long term project (e.g. testing water quality in the Charles River) that you can imagine doing as a next steps.

Timeline

Outline – Wednesday, March 14
• If you decide to work with a partner, this should be identical and indicate who you are working with (you can hand in one copy).
• Include a draft version of the target content and inquiry standards.
• Include a draft of your lesson sequence. This should include your initial ideas for each day of the unit in terms of the content that you will target and the activities that you are thinking of doing. The activities do not need to be described in depth, but should give a sense of what you are currently thinking.
• If you have particular questions or concerns about your sequence that you would like feedback on, you can include those as well.
• In terms of length, this document should be approximately 2-4 pages.

One Lesson – Wednesday, March 28
• If you are working with a partner, these should not be identical. Each partner should take the lead on one lesson; therefore, you should hand in separate lessons. But you can include both lessons in your final unit.
• When you write up this lesson, follow the directions under #3 in terms of format.

Student Assessment – Wednesday, April 18
• If you decide to work with a partner, this should be identical and indicate who you are working with (you can hand in one copy).
• Include a draft of your science background (standards, elaborations, misconceptions).
• Include what you envision the culminating assessment for your unit to be including both the student version as well as the rubric or answer key that you would use.

Final Curriculum Unit – Monday, May 18
APPENDIX K Factors for Survey

Science Content

_Biology_
\[ b_{10b4} + b_{10b7} + b_{10b6} + b_{10b1} + b_{10b3}. \]

10. Within science, many teachers feel better prepared to teach some topics than others. How well prepared do you feel to teach each of the following topics at the grade levels you plan to teach? (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Not adequately prepared</th>
<th>Some-what prepared</th>
<th>Fairly Well Prepared</th>
<th>Very Well Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Biology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Structure and function of human systems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Animal behavior</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Cells</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. Genetics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. Evolution</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>c. Chemistry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Structure of matter and chemical bonding</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Properties and states of matter</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Chemical reactions</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Energy</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

_Chemistry_
\[ b_{10c2} + b_{10c3} + b_{10c4} + b_{10c1}. \]
**Physics**

\[b_{10d1} + b_{10d2} + b_{10d3} + b_{10d4} + b_{10d5}\]

<table>
<thead>
<tr>
<th>d. Physics</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Forces and motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Energy and heat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Light and sound</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Electricity and magnetism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Modern physics (e.g. special relativity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Diverse Learners**

Overall

b8b, b8c, b8d, b8e, b8f, b8g, b8h, b8i, b8j, b8k, b8l, b8m, b8n, b8o, b8p, b8q, b8r, b11d, b11f, b9oa, b9ob

8. Please provide your opinion about each of the following statements.

<table>
<thead>
<tr>
<th>Total points</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>No Opinion</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>b. I will be able to teach science to children whose first language is not English.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. I have the ability to teach science to children from economically disadvantaged backgrounds.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. I can do a great deal as a teacher to increase the science achievement of children who do not speak English as their first language.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. I will be able to meet the learning needs of children of color when I teach science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. I do not know teaching strategies that will help children who are English Language Learners achieve in science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. I can help girls learn science at the same level as boys.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. I do not know how to teach science concepts of children who speak English as a second language.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. I will be effective in teaching science in a meaningful way to girls.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j. I will have the ability to help children from low socioeconomic backgrounds be successful in science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. I will be able to successfully teach science to Native American children.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. I will not be able to teach science to children who speak English as a second language as effectively as I will to children who speak English as their first language.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

269
m. I cannot help girls learn science at the same level as boys.

<table>
<thead>
<tr>
<th></th>
<th>Not adequately prepared</th>
<th>Some-what prepared</th>
<th>Fairly Well Prepared</th>
<th>Very Well Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. Recognize and respond to student diversity</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>f. Use strategies that specifically encourage participation of females and minorities in science.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>n. I will be able to effectively monitor the science understanding of children who are English Language Learners.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>o. I will not be able to successfully teach Asian children.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>p. I will be able to successfully teach science to children of color.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>q. I will be able to help girls learn science.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>r. I will not be able to teach science successfully to White children.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

11. Please indicate how well prepared you feel to do each of the following.

**Diverse Learners** (the real thing)

b 8b, b 8d, b 8f, b 8h, b 8l, b 8n, b 9oa, b 9ob

8. Please provide your opinion about each of the following statements.

<table>
<thead>
<tr>
<th>Total points</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>No Opinion</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>b. I will be able to teach science to children whose first language is not English.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>d. I can do a great deal as a teacher to increase the science achievement of children who do not speak English as their first language.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>f. I do not know teaching strategies that will help children who are English Language Learners achieve in science.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>h. I do not know how to teach science concepts of children who speak English as a second language.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>i. I will not be able to teach science to children who speak English as a second language as effectively as I will to children who speak English as their first language.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
<tr>
<td>n. I will be able to effectively monitor the science understanding of children who are English Language Learners.</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>
9. In the left section, please rate each of the following in terms of its importance for effective science instruction in the grades you plan to teach. In the right section, please indicate how prepared you feel to do each one:

<table>
<thead>
<tr>
<th>Importance</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not important</td>
<td>Not adequately prepared</td>
</tr>
<tr>
<td>Somewhat important</td>
<td>Some-what prepared</td>
</tr>
<tr>
<td>Fairly Important</td>
<td>Fairly Well Prepared</td>
</tr>
<tr>
<td>Very Important</td>
<td>Very Well Prepared</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0. Meet the needs of ethnically and linguistically diverse students.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not important</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Race and Gender

b8r + b8p + b8k + b8m + b8e.

8. Please provide your opinion about each of the following statements.

<table>
<thead>
<tr>
<th>Total points</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>r. I will not be able to teach science successfully to White children.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p. I will be able to successfully teach science to children of color.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>k. I will be able to successfully teach science to Native American children.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. I cannot help girls learn science at the same level as boys.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. I will be able to meet the learning needs of children of color when I teach science.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

b13h + b13f + b13i + b14a +b13g.

13. About how often do you anticipate you will do each of the following in your science class?
14. About how often do you anticipate **STUDENTS** in your class will take part in each of the following types of activities?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Never</th>
<th>Rarely (a few times a year)</th>
<th>Sometimes (once or twice a month)</th>
<th>Often (once or twice a week)</th>
<th>All or almost all science instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. f. Use open-ended questions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. g. Require students to supply evidence to support their claims.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. h. Encourage students to explain concepts to one another.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. i. Encourage students to consider alternative explanations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 a. Participate in student led discussions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Openness**

b15c + b15d + b15b.

15. The following paragraphs describe observations of two teachers’ classes, Mrs. Hill’s and Mr. Jones’. Answer each question below by checking the box under the column that best answers that question for you.

Mrs. Hill was leading her class in an animated way, asking questions that the students could answer quickly; based on the reading they had done the day before. After this review, Ms. Hill taught the class new material, again using simple questions to keep students attentive and listening to what she said.

Mr. Jones’ class was also having a discussion but may of the questions came from the students themselves. Though Mr. Jones could clarify students’ questions and suggest where the students could find relevant information, he couldn’t really answer most of the questions himself.

<table>
<thead>
<tr>
<th>Question</th>
<th>Definitely Ms. Hill’s</th>
<th>Tend towards Ms. Hill’s</th>
<th>Tend towards Mr. Jones’</th>
<th>Definitely Mr. Jones’</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Which type of discussion do you think most students prefer to have?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. From which type of class discussion do you think students gain more knowledge?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
d. From which type of class discussion do you think students gain more useful skills?

<table>
<thead>
<tr>
<th></th>
<th>□</th>
<th>□</th>
<th>□</th>
<th>□</th>
</tr>
</thead>
</table>

Inquiry

b10f1 + b10f5 + b10f2 + b10f3 + b10f4.

10. Within science, many teachers feel better prepared to teach some topics than others. How well prepared do you feel to teach each of the following topics at the grade levels you plan to teach?

<table>
<thead>
<tr>
<th>Total points</th>
<th>Not adequately prepared</th>
<th>Some–what prepared</th>
<th>Fairly Well Prepared</th>
<th>Very Well Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>f. Scientific inquiry skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Ask a question about objects, organisms, and events in the environment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Plan and conduct a simple investigation.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Use simple equipment and tools to gather data.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Use data to construct a reasonable explanation.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. Communicate investigations and explanations.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Traditional view of science

e14e, e14g, e13b1, e16f, e14h

1,2,3,4,5

14. About how often do you anticipate STUDENTS in your class will take part in each of the following types of activities? (Darken one oval on each line.)

<table>
<thead>
<tr>
<th>Total points</th>
<th>Never (a few times a year)</th>
<th>Rarely (once or twice a month)</th>
<th>Sometimes (once or twice a week)</th>
<th>Often (once or twice a week)</th>
<th>All or almost all science instruction</th>
</tr>
</thead>
</table>

273
13. About how often do you anticipate you will do each of the following in your science class?

(Darken one oval each line.)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Never</th>
<th>Rarely (a few times a year)</th>
<th>Sometimes (once or twice a month)</th>
<th>Often (once or twice a week)</th>
<th>All or almost all science instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>e. Read from a science textbook in class.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>g. Answer textbook/worksheet questions.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>h. Review homework/worksheet assignments.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

16. Indicate how much you disagree or agree with each of the following statements about teaching and learning.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>f. Homework is a good setting for having students answer questions posed in their textbooks.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX L

Coding Preservice Teacher Interviews

Codes

1a. Imagine you observed another teacher’s classroom who conducted what you believe to be an excellent science lesson. What types of things would you expect to see?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/1</td>
<td>Used the term inquiry</td>
<td></td>
</tr>
</tbody>
</table>

1b.

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/1</td>
<td>Used the term ‘Hands on’</td>
<td>Preservice teacher describes class as being hands on, doing science.</td>
</tr>
</tbody>
</table>

1c. Observing Inquiry

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification (if response bridges two categories, select the more structured category.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Criteria</strong></td>
<td></td>
</tr>
<tr>
<td>1c1.</td>
<td>Develop Research Questions or Challenge</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Learner poses a question independently.</td>
<td>Learner selects among questions or poses new questions with support from teacher.</td>
</tr>
<tr>
<td></td>
<td>Learner designs investigation including choosing variables and controlling variables.</td>
<td>Learner provided variables and controls as well as a model investigation procedure or structure from teacher, curriculum or other materials.</td>
</tr>
<tr>
<td>1c2.</td>
<td>Design Investigation or Structure</td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Learner designs investigation including choosing variables and controlling variables.</td>
<td>Learner provided variables and controls, but designs investigation procedure or structure.</td>
</tr>
<tr>
<td></td>
<td>Learner collects all data.</td>
<td>Learner collects majority of data, but given some data.</td>
</tr>
</tbody>
</table>

275
<table>
<thead>
<tr>
<th>1c4. Make Sense of Data</th>
<th>Learner determines how to organize data (e.g. graph, table, drawing)</th>
<th>Learner provided guidance on how to organize data (e.g. create a graph).</th>
<th>Learner told how to organize data (e.g. make a line graph with heights of plants on the y-axis and time on the x-axis).</th>
<th>Learner given specific structure or scaffold to organize data (e.g. line graph with x and y axis already labeled and just fills in data).</th>
<th>No Response</th>
</tr>
</thead>
</table>

**More**--------------------------**Amount of Learner Self Direction**--------------------------**Less**

**Less**--------------------------**Amount of Direction from Teacher or Material**--------------------------**More**

| 1c5. Construct explanations and models | Learner formulates explanations or models using evidence from their investigation and reasoning (including appropriate scientific concepts). | Learner guided in including evidence and reasoning to formulate their explanation or model. (e.g. write a conclusion using evidence from your investigation. Explain why the evidence supports your conclusion). | Learner given context specific prompts or examples to use evidence and reasoning to formulate their explanation or model. (e.g. Write a claim that more friction either causes a car to go faster or slower. Use the speed of the car from your experiment as evidence. Explain why you think friction influences the speed). | Learner given explanations or models to choose from. (e.g. provided with three possible models about how we see object and the student has to circle one of the models considering what he/she found in their investigation). | No Response |

1d. Why do you consider this an excellent science lesson?
<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1d1. 0/1</td>
<td>Experience as a K-12 student</td>
<td>Preservice teacher’s experience as a K-12th grade student/ Positive or negative</td>
</tr>
<tr>
<td>1d2. 0/1</td>
<td>Methods course</td>
<td>Preservice teacher’s learning from science methods course or other methods course (inquiry)</td>
</tr>
<tr>
<td>1d3. 0/1</td>
<td>Students are discussing science</td>
<td>Students are having conversations around science, students are working or interacting w/ each other.</td>
</tr>
<tr>
<td>1d4. 0/1</td>
<td>Real world science problem/activity</td>
<td>Science activity has connections to real world problems or connect to student lives.</td>
</tr>
<tr>
<td>1d5. 0/1</td>
<td>Students engaged</td>
<td>Students are engaged (interested, motivated) in their work and discussion. Exciting</td>
</tr>
<tr>
<td>1d6. 0/1</td>
<td>Deeper understanding/ beyond memorization</td>
<td>Students demonstrate a deeper understanding of science students understand science beyond memorization of terms</td>
</tr>
<tr>
<td>1d7. 0/1</td>
<td>Inquiry</td>
<td>WHY? Preservice teacher discusses at least one aspect of the scientific inquiry from the table in terms of why it is important to incorporate inquiry into their instruction. e.g. Say or imply that it is important to have kids design questions, design an investigation, collect and/or analyze data</td>
</tr>
</tbody>
</table>

2a. Do you feel prepared to teach this way?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/1/2</td>
<td>No/ Maybe(do and don’t)/Yes</td>
<td>Maybe or do and don’t represents someone who feels prepared but needs more experience</td>
</tr>
</tbody>
</table>

2b. Why?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2b1. 0/1</td>
<td>Previous experience</td>
<td>In Prepracticum, methods course, summer camp, afterschool program or simply a lack of experience</td>
</tr>
<tr>
<td>2b2. 0/1</td>
<td>Content (hard/easy)</td>
<td>comfort level in science strong or weak. + or -</td>
</tr>
<tr>
<td>2b3. 0/1</td>
<td>Behavior management</td>
<td>Feel they need to have a better grasp of it or already have a grasp of BM + or -</td>
</tr>
<tr>
<td>2b4. 0/1</td>
<td>Loudness</td>
<td>Classroom noise level due to activity is acceptable or not. + or -</td>
</tr>
<tr>
<td>2b5. 0/1</td>
<td>Management of materials</td>
<td>Gathering, preparing, distributing, managing, or cleaning up of materials. + or -</td>
</tr>
</tbody>
</table>
2b6. 0/1 Structure of the classroom
Preservice teacher is willing or unwilling to allow students freedom to use inquiry strategies in their classroom, comfortable with a lack of structure in the classroom, “chaos”. + or -

2b7. 0/1 Emotional
Relating to past experiences/ good or bad. Ex. “I know I have a hard time.” “It worked for me.” + or -

3. What is your understanding of inquiry based science teaching?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="https://example.com/table.png" alt="Table of Inquiry-Based Science Teaching Criteria" /></td>
</tr>
</tbody>
</table>

3a. Develop Research Questions or Challenge
Learner poses a question independently.

3b. Design Investigation or Structure
Learner designs investigation including choosing variables and controlling variables.

3c. Collect and Acquire data
Learner collects all data.
| 3d. Make Sense of Data Representations (e.g. drawings, graphs) | Learner determines how to organize data (e.g. graph, table, drawing). | Learner provided guidance on how to organize data (e.g. create a graph). | Learner told how to organize data (e.g. make a line graph with heights of plants on the y-axis and time on the x-axis). | Learner given specific structure or scaffold to organize data (e.g. line graph with x and y axis already labeled and just fills in data). | No Response |
| 3e. Construct explanations and models | Learner formulates explanations or models using evidence from their investigation and reasoning (including appropriate scientific concepts). | Learner guided in including evidence and reasoning to formulate their explanation or model. (e.g. write a conclusion using evidence from your investigation. Explain why the evidence supports your conclusion). | Learner given context specific prompts or examples to use evidence and reasoning to formulate their explanation or model. (e.g. Write a claim that more friction either causes a car to go faster or slower. Use the speed of the car from your experiment as evidence. Explain why you think friction influences the speed). | Learner given explanations or models to choose from. (e.g. provided with three possible models about how we see object and the student has to circle one of the models considering what he/she found in their investigation). | No Response |

More------------------Amount of Learner Self Direction-----------------------------Less
Less------------------Amount of Direction from Teacher or Material------------------More
4a. Diversity, How do you feel about working w/ diverse students?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Excited, confident,</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td>Optimistic</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Comfortable</td>
<td>Neutral</td>
</tr>
<tr>
<td>1</td>
<td>Cautious</td>
<td>Negative Slightly concerned Worried/nervous</td>
</tr>
</tbody>
</table>

4b. (Both Questions) How do you feel diverse students learn best? Can you describe the strategies you would use in a science lesson to support diverse students?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>4b1.</td>
<td>0/1 Structured routine</td>
<td>Students w/ ADHD for example work better when there is a routine that is consistent.</td>
</tr>
<tr>
<td>4b2.</td>
<td>0/1 Kinesthetic</td>
<td>A physical representation of concepts beyond text. Example: “Um keeping it all very physical, so for example exploring potential or kinetic energy w/ words that she could show it and label it. I feel like in science they are so handicapped by this language barrier, by all the lang based activities, allowing them to show us and that kind of thing gave them confidence and from there we worked on from getting the vocabulary once they new that they had it. “</td>
</tr>
<tr>
<td>4b3.</td>
<td>0/1 Visuals</td>
<td>Photos, objects</td>
</tr>
<tr>
<td>4b4.</td>
<td>0/1 Semantic maps, charts, word charts, KWL</td>
<td>Graphic organizers</td>
</tr>
<tr>
<td>4b5.</td>
<td>0/1 Use student language in introducing terms</td>
<td></td>
</tr>
<tr>
<td>4b6.</td>
<td>0/1 Connect the science instruction to student’s background</td>
<td></td>
</tr>
<tr>
<td>4b7.</td>
<td>0/1 Build rapport with the students’ family</td>
<td>In an effort to make the student feel valued.</td>
</tr>
</tbody>
</table>
4b8. 0/1 Bring students cultural heritage into the classroom? Students share their background and heritage through stories, music, food etc.

5a. (Both Questions) What opportunities have you had to observe/teach science being taught to elementary students? Can you describe your experience? What opportunities have you had to teach lessons using these strategies?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>5a1. 0/1</td>
<td>Prepracticum placement</td>
<td>Preservice teacher taught lesson while assigned to a prepracticum training.</td>
</tr>
<tr>
<td>5a2. 0/1</td>
<td>Afterschool, summer camp, alternative settings</td>
<td>Preservice teacher taught in setting outside of the classroom.</td>
</tr>
</tbody>
</table>

5b. Level of preservice teacher participation in lesson observed/taught.

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>5b1. 0/1</td>
<td>Taught</td>
<td>Preservice teacher taught a science lesson they created.</td>
</tr>
<tr>
<td>5b2 0/1</td>
<td>Led</td>
<td>Preservice teacher taught a prepared lesson from another source</td>
</tr>
<tr>
<td>5b3 0/1</td>
<td>Assisted</td>
<td>Preservice teacher assisted cooperating teacher in teaching a science lesson</td>
</tr>
<tr>
<td>5b4 0/1</td>
<td>Observed</td>
<td>Preservice teacher observed a science lesson being taught.</td>
</tr>
<tr>
<td>5b5 0/1</td>
<td>No Experience</td>
<td></td>
</tr>
</tbody>
</table>
5c-5f. Level of inquiry in lesson preservice teacher observed/taught.
5c. Taught, 5d. Led, 5e. Assisted, 5f. Observed

<table>
<thead>
<tr>
<th>Level Criteria</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0 (didn’t do)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level Criteria</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0 (didn’t do)</td>
</tr>
<tr>
<td>5c-5f1. Develop Research Questions or Challenge</td>
<td>Learner poses a question independently.</td>
<td>Learner selects among questions or poses new questions with support from teacher.</td>
<td>Learner sharpens or clarifies question provided by teacher, materials, or other sources.</td>
<td>Learner engages in question provided by teacher, materials, or other sources.</td>
<td>No Response</td>
</tr>
<tr>
<td>5c-5f2. Design Investigation or Structure</td>
<td>Learner designs investigation procedure or structure including choosing variables and controlling variables.</td>
<td>Learner provided variables and controls, but designs investigation procedure or structure.</td>
<td>Learner provided variables and controls as well as a model investigation procedure or structure from teacher, curriculum or other materials.</td>
<td>Learner given entire investigation procedure or structure by teacher, curriculum, or other sources.</td>
<td>No Response</td>
</tr>
<tr>
<td>5c-5f3. Collect and Acquire data</td>
<td>Learner collects all data.</td>
<td>Learner collects majority of data, but given some data.</td>
<td>Learner given the majority of data, but collects some.</td>
<td>Learner given all data.</td>
<td>No Response</td>
</tr>
<tr>
<td>5c-5f4. Make Sense of Data</td>
<td>Learner determines how to organize data (e.g. graph, table, drawing).</td>
<td>Learner provided guidance on how to organize data (e.g. create a graph).</td>
<td>Learner told how to organize data (e.g. make a line graph with heights of plants on the y-axis and time on the x-axis).</td>
<td>Learner given specific structure or scaffold to organize data (e.g. line graph with x and y axis already labeled and just fills in data).</td>
<td>No Response</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>5c-5f5. Construct explanations and models</td>
<td>Learner formulates explanations or models using evidence from their investigation and reasoning (including appropriate scientific concepts).</td>
<td>Learner guided in including evidence and reasoning to formulate their explanation or model. (e.g. write a conclusion using evidence from your investigation. Explain why the evidence supports your conclusion).</td>
<td>Learner given context specific prompts or examples to use evidence and reasoning to formulate their explanation or model. (e.g. Write a claim that more friction either causes a car to go faster or slower. Use the speed of the car from your experiment as evidence. Explain why you think friction influences the speed).</td>
<td>Learner given explanations or models to choose from. (e.g. provided with three possible models about how we see object and the student has to circle one of the models considering what he/she found in their investigation).</td>
<td>No Response</td>
</tr>
</tbody>
</table>

More------------------------Amount of learner Self Direction------------------------Less
Less------------------------Amount of Direction from Teacher or Material----------------More

284
6a. How confident do you feel about teaching science in your future elementary classroom?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Excited, confident, Optimistic</td>
<td>Positive</td>
</tr>
<tr>
<td>2</td>
<td>Comfortable</td>
<td>Neutral</td>
</tr>
<tr>
<td>1</td>
<td>Cautious</td>
<td>Negative Slightly concerned</td>
</tr>
</tbody>
</table>

6b. Why?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>6b1</td>
<td>0/1  Previous experience</td>
<td>In Prepracticum, methods course, summer camp, afterschool program or simply a lack of experience</td>
</tr>
<tr>
<td>6b2</td>
<td>0/1  Content (hard/easy)</td>
<td>comfort level in science strong or weak. + or -</td>
</tr>
<tr>
<td>6b3</td>
<td>0/1  Behavior management</td>
<td>Feel they need to have a better grasp of it or already have a grasp of BM + or -</td>
</tr>
<tr>
<td>6b4</td>
<td>0/1  Loudness</td>
<td>Classroom noise level due to activity is acceptable or not. + or -</td>
</tr>
<tr>
<td>6b5</td>
<td>0/1  Management of materials</td>
<td>Gathering, preparing, distributing, managing, or cleaning up of materials. + or -</td>
</tr>
<tr>
<td>6b6</td>
<td>0/1  Structure of the classroom</td>
<td>Preservice teacher is willing or unwilling to allow students freedom to use inquiry strategies in their classroom, comfortable with a lack of structure in the classroom, “chaos”. + or -</td>
</tr>
<tr>
<td>6b7</td>
<td>0/1  Emotional</td>
<td>Relating to past experiences/ good or bad. Ex. “I know I have a hard time.” “It worked for me.” + or -</td>
</tr>
</tbody>
</table>

7. In the diagram below the ‘teacher’ box in the circle represents a full time teacher. At this point in your degree here at Boston College, please place an X where you feel you are in your preparation toward becoming a full time teacher. Explain why you placed the X there.

[Diagram with a circle and an X]
| nonteacher |  |
APPENDIX M: Consolidation Codes for Interviews

Code 1: Excellent Lesson

Code #1c: Observing – Inquiry

Code #1d: Why a great lesson?

Code #3: Inquiry

Code #5 Opportunities to observe/teach

Code #5c-f: Level of Inquiry (N/A if should not be coded)

Code #4 Diversity

Code #2: Prepared to teach?

6a. Confidence teaching science
APPENDIX N – Sample lesson plan for unit coding

Lesson 1: Why things move: An Introduction to Force

Purpose:
What makes roller coasters fun? The purpose of this lesson is to introduce students to force. It is designed to be the first lesson in the unit. This lesson will not introduce specific forces like gravity or friction, which will be included later in the unit. In the next lesson, the students will conduct experiments to understand one force that will influence roller coasters: friction. Ultimately, this series of lessons will end in students designing roller coasters in which they draw upon the concepts they learned, including force.

Time:
45 minutes

Age of students:
2nd grade

Materials needed:
• 3 ramps
• white balls
• worksheets
• pencils

Materials management:
When students enter, all the materials will be left on the table out of the view so that they are not distracted. In part one, I will utilize one of the ramps and one ball so that the students see the demonstration using the materials they will utilize in their experiments. In part two, students will receive a ball, a ramp, a worksheet and a pencil. Before receiving these materials, students will be reminded to the way to treat materials appropriately and respectfully. After the activity and before the discussion students will return the materials to the table so that they do not distract them during the discussion.

Student Misconceptions
1. Because you cannot see ‘forces’ they do not exist.
2. There are no forces acting upon an object when it is at rest.
3. Only when you see something push or pull a ball is there a force.
4. Things stop because they run out of force.

AAAS Benchmarks
1. Motion (K-2): The way to change how something is moving is to give it a push or a pull.
2. Motion (K-2): Things move in many different ways, such as straight, zigzag, round and
round, back and forth, and fast and slow.
3. Values and Attitudes (K-2): Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out.

**Learning Objectives:**
1. Students will predict what objects move after watching a demonstration.
2. Students will draw on their prior knowledge to raise questions and make predictions.
3. Students will define forces as a push or a pull
4. Students will identify the forces they observe acting on the balls in their experiments by drawing and speaking about them both on a worksheet and in discussion.
5. Students will explain how the direction and strength of the force impact the movement of the object.

**Instructional Activities**

**Part 1: Teacher Demonstration and Discussion**
1. Connect to students’ prior knowledge and everyday experience
   - Are roller coasters fun because they stand still? No! They are fun because they twist, loop, zig-zag, and go fast. Today we are going to talk about what makes roller coaster move.
   - You all use balls in PE. What do you use balls for? When you throw the ball up make a basket, what makes the ball go up? Close your eyes and imagine that you are about to pass a basketball or soccer ball to one of your friends. What makes the ball move? Can you see the ball move toward your friend? How fast does it move? Did you kick/throw it hard? Does that matter?
   - What do you think makes something move? Have students brainstorm about what they think makes something move. Record their answers on the white board.
2. Hold a ball up for the students’ observation. Ask students to observe what happens with the ball. Place a ball on a flat, smooth surface and push it with one finger towards the partner teacher.
   - Ask students to share their observations about what made the ball move and how the ball moved.
   - Write on the white board key words that they mention when describing the motion. Create a word wall using these words. Refer to them as ‘motion words’ that the students can use in their reflections.
3. Place the ball on the smooth, flat surface. Tell the students that you are going to blow on the ball. Ask them to predict what will happen to the ball. Record student predictions on the white board in the third column.
   a. Complete the blowing demonstration. Ask students to check if their predictions were right. Students will then locate from where the force originated.
4. Discussion
   a. Engage students in a discussion about why the ball moved each time what the forces was and how the ball moved each time. Refer back to the motion words, predictions, and
other student comments to guide discussion.

• What made the ball move in the first demo?  (repeat if necessary)
• What made the ball move in the second demo?
• How did the ball move?  Why?
• Guide students to discuss that the ball moved because it was pushed or blew on.  It did not move because of its own volition.
• Define the word force as a push or pull.  Ask students to discuss how force relates to our demonstrations.

Part 2: Student Investigation

1. Introduction
• Now have students discover different ways to make the ball move using the ramps or their body.  Students must identify what the force was and why the force moved the way it did as a result of that force.
• Pass out the student sheet for part 2 and a pencil.  Fill out the sheet with the class for the demonstration so that the students understand what they should do to fill out the sheet.  Tell the students that their challenge is to design three new experiments that make the ball move in a certain way and explain why.

2. Students design and conduct investigations using worksheets.
• Utilizing the student sheet for Part 2, students will first conduct the three guided experiments and record their results.  These results should include what caused the ball to move and what direction the ball moved.
• Students should then design three trials of their own.  These trials should make the ball move in new ways that did not occur in the first three trials.
• Circulate among the students to keep them on track.  If students become off track but are still experimenting, ask them what they are trying to determine through this specific experiment.  If students are not participating, ask them to show you their creative experiments.
• Provide feedback on trials.  Ask students to clarify their reasoning for designing certain trials verbally.  Provide feedback on those answers.
• Make sure that students illustrate their three trials on the worksheet.  They should draw all the materials they used, what caused the force and what direction the ball traveled.
• When students are finished with their trials or it is time to discuss, collect the balls, ramps, and pencils.
• Ask students to sit quietly and think about what they learned about why the balls moved from their experiments.  Ask them to come up with two creative thoughts to share with the class about their trials.

Part 3: Closure and Review

1. Ask students to share their trials and illustrations.
• Have each student present his or her best trial and what he or she learned from it.  Discuss any similarities between this trial and other student trials.

2. Ask students what they learned about our original question – What makes something move?
• Forces act on objects to make them move or stop moving.
• A force is a push or pull. You cannot always see forces.
• The strength of the force and the direction of the force determine how the ball moved.

3. Connections to prior knowledge
• Ask students to think back to when they imagined throwing/kicking a ball. Did they learn anything new about what happened to the ball? Why do they think the ball moved?
• Connect to any other examples the students offered at the start of the lesson. Connect to the trials they created.

4. Connections to the next lesson
• Ask the student to think about when they pushed the ball or blew on it. Did the ball keep going forever? What made the ball stop? Return to the idea that there are specific types of forces that are very important to think about when designing a rollercoaster, but also in everyday life. Tell students that in the next lesson we will explore a specific type of force that makes real-life rollercoaster’s stop and slow down.

References:

Changing Motion: Starting Things Moving and Changing Direction. Motion, Lesson 5. Project 2061 Benchmarks online.
**Worksheet**

Name: _____________________

**How do things move?**

Next to the writing in the box, describe what happened to the ball after you did each action. Please show the way that you pushed, rolled or dropped the ball using arrows. In the empty boxes, create your own movement for the ball and describe what happened.

**Example**

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throw the ball at your partner</td>
<td></td>
</tr>
<tr>
<td>Do not touch the ball</td>
<td></td>
</tr>
<tr>
<td>Roll the ball down the ramp</td>
<td></td>
</tr>
<tr>
<td>Throug the ball up in the air</td>
<td></td>
</tr>
<tr>
<td>Bounce the ball</td>
<td></td>
</tr>
</tbody>
</table>
**APPENDIX O:** Coding Preservice Teacher Units

### Part 1. Unit Introduction  Code 1a. Term Usage

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0/1</td>
<td>Used the term inquiry</td>
<td>Preservice teacher uses inquiry in the opening statement</td>
</tr>
</tbody>
</table>

### 1b. Level | Criteria | Clarification |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0/1</td>
<td>Used the term ‘Hands on’</td>
<td>Preservice teacher describes class as being hands on, doing science.</td>
</tr>
</tbody>
</table>

**Code 2. Structure of unit/Conveying a sense of purpose**

**DEPTH NOT DETAIL!!!!!**

### 2a. Unit conveys overarching goal or purpose

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Overarching goal clear initially and throughout</td>
<td>Each lesson in the unit contributes to the overarching goal or purpose. Material conveys an overall sense of purpose and direction that is understandable and motivating to students. Unit clearly states that students will work toward or accomplish a goal. A unit that conveys an overarching goal by the end of the unit could state something like the following: “Each aspect of the content was grounded by our ultimate objective: to have students design and build their very own roller coaster” Additionally the unit as a whole works to help the student achieve the goal. Look at the lesson objectives, are they supportive of the students moving toward that goal? (How do the lessons help the students achieve their goal?)</td>
</tr>
<tr>
<td>1</td>
<td>½ of lessons contributes to goal</td>
<td>1. The unit has a final goal but it is difficult to see progression along the way to help students reach that goal, or the unit builds strongly toward a goal but the goal is</td>
</tr>
</tbody>
</table>

294
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>never realized. OR At least ½ of the lessons contributes to the overarching goal or purpose. Material occasionally conveys an overall sense of purpose and direction that is understandable and motivating to students</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Lessons fail to contribute to a goal which may or may not be present.</td>
<td>0. The unit fails to offer some type of overarching goal for the students. Lessons in the unit fail to contribute the overarching goal or purpose. Material doesn’t convey an overall sense of purpose and direction that is understandable and motivating to students.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Sequencing appropriate</strong></td>
<td>2. The sequencing of lessons develops a strong foundation of experiences for students and allows concepts to build in complexity. The material involves students in a logical or strategic sequence of activities that are connected. i.e. a student can’t understand how a plane flies before they understand gravity.</td>
</tr>
<tr>
<td>1</td>
<td>½ lessons demonstrate a logical sequence of activities</td>
<td>1. At least ½ of the lessons appear to build a strong foundation of experiences for students and allows concepts to build in complexity. The material may attempt to involve students in a logical or strategic sequence of activities that are connected but the connections are not strong.</td>
</tr>
<tr>
<td>0</td>
<td>Lessons fail to be logical in sequencing.</td>
<td>0. Unit represents just a collection of activities that neither build in complexity or offer logical or strategic sequence of activities.</td>
</tr>
<tr>
<td>2c</td>
<td><strong>Accuracy of content presented</strong></td>
<td>Is the content accurate? Especially look at the <em>unpacking of the standards</em> section. MAYBE DUMP?</td>
</tr>
<tr>
<td>2d.</td>
<td>2</td>
<td><strong>Depth of content</strong> challenges students appropriately</td>
</tr>
<tr>
<td>------</td>
<td>----</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>At least ½ of lessons challenge students appropriately</td>
<td>At least ½ of the content presented in lessons is appropriate for student’s age, grade level, and knowledge base. The content may have sections that are too high or too low for students to grasp concepts.</td>
</tr>
<tr>
<td>0</td>
<td>Lessons fail to be appropriate</td>
<td>Lessons in the unit fails to be appropriate for student’s age, grade level, and knowledge base. The content is too high or too low for students to grasp concepts.</td>
</tr>
</tbody>
</table>

Part II Lessons

**Code 3. Accessing Prior Knowledge/ Taking Account of Student Ideas**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Specific lesson</th>
<th>Clarification</th>
</tr>
</thead>
</table>

296
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| **3a.** 0/1 | **Discussion**  
Frames prior knowledge or experiences through discussion/May use a pic or slide to facilitate discussion | Preservice teacher accesses student’s prior knowledge about the concept verbally. And/or Preservice teacher displays a picture or a slide that connects the concept to prior knowledge. Do not assume discussion when a question is being asked. Informal discussion around activity preparation, the doing of etc. Preservice teacher must explicitly indicate that students will explain ideas, or have a discussion around the topic. |
| **3b.** 0/1 | Frames prior knowledge or experiences in **writing/drawing/building** | Preservice teacher accesses student’s prior knowledge about the concept in writing and/or drawing. Students may be given opportunity to write (possibly prediction). Indicate if it is an example done by teacher to support students. |
| **3c.** 0/1 | Students personally experience how topic connects to everyday life. | Preservice teacher provides opportunity for students to personally experience how the topic connects to their everyday life. Example: students go to the playground to experience the effects of slope on a slide. |
Make note if the above approaches are only done initially.

**Code 4. Supporting Diverse Learners**

**4a. Supports for Diverse Learners**

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Specific lesson</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Provided <strong>supports</strong> for Diverse Learners throughout unit</td>
<td>5 Lessons or more provide supports for diverse learners</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Occasionally Provided Supports</td>
<td>At least 2 lessons provided supports for diverse learners.</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Did Not Provide Supports</td>
<td>Unit does not provide any supports for diverse learners.</td>
<td></td>
</tr>
</tbody>
</table>

**If so . . . Code 4. (continued) Strategies described in science lessons to support diverse students?**

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>4b.</td>
<td>0/1 Structured routine</td>
<td>Students w/ ADHD for example work better when there is a routine that is consistent.</td>
</tr>
<tr>
<td>4c.</td>
<td>0/1 Kinesthetic</td>
<td>A physical representation of concepts beyond text. Example: “Um keeping it all very physical, so for example exploring potential or kinetic energy w/ words that she could show it and label it. I feel like in science they are so handicapped by this language barrier, by all the language based activities, allowing them to show us and that kind of thing gave them confidence and from there we worked on from getting the vocabulary once they new that they had it. “ Students act out or teachers demonstrate.</td>
</tr>
<tr>
<td>4d.</td>
<td>0/1</td>
<td>Visuals</td>
</tr>
<tr>
<td>4e.</td>
<td>0/1</td>
<td>Semantic maps, charts, word charts, KWL</td>
</tr>
<tr>
<td>4f.</td>
<td>0/1</td>
<td>Use student language in introducing terms</td>
</tr>
<tr>
<td>4g.</td>
<td>0/1</td>
<td>Build rapport with the students’ family</td>
</tr>
<tr>
<td>4h.</td>
<td>0/1</td>
<td>Bring students’ cultural heritage into the classroom and/or connect the science instruction to student’s background</td>
</tr>
</tbody>
</table>

### 5. Structure of student materials provided for student. Did it support diverse learners? . . . support inquiry?

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>5a.</td>
<td>1/0</td>
<td>Materials available for students</td>
</tr>
</tbody>
</table>

### 5b. Scaffolding in student worksheets
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
| 2 | **Strong scaffolds incorporated to support student use of language** | Suggestions may be offered for how to write the sentence through possibly through sentence starters. A picture maybe provided to support the text. Space exists to encourage students to write their own ideas that moves beyond simple fill in the blank, multiple choice, and short answer.  
*See Sample of well designed sheet for second language learners.* |
| 1 | **Scaffolds are acceptable** | Simple fill in the blank, multiple choice, and short answer seems to dominate the worksheets. Little variation in tasks asked of the students. Students may have space to draw but may |
| 0 | **Scaffolds are missing** | **Lacking scaffold support**  
No major concept is being reinforced. Direction to draw a picture w/o specific support around the lesson concept. Large amount of text w/ little or no support for students in the way of illustrations, room to draw and comment etc. |
<table>
<thead>
<tr>
<th>Code</th>
<th>Level</th>
<th>Criteria</th>
<th>Specific lesson</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>5c.</td>
<td>1/0</td>
<td>Multiple ways to represent knowledge.</td>
<td>Do student materials support the students in using their own words (language) drawings. Students could be given a (microphone, computer, song, poem). Open-ended student work allows students to draw a picture or write an essay demonstrating connection to the lesson concept and/or summarizing the main idea. If this and closed type of questions are offered then select this, Indicate if teacher reviews how to fill in worksheet.</td>
<td></td>
</tr>
<tr>
<td>5d.</td>
<td>1/0</td>
<td>Knowledge is applied to new situation</td>
<td>Do materials push students to think about material in a new situation. Opportunities for students to summarize and apply knowledge. The main idea is open ended where students apply knowledge through writing or drawing to address a new situation.</td>
<td></td>
</tr>
</tbody>
</table>

**Code 6. Lesson Structure**

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
<th>Specific lesson</th>
<th>Clarification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Open ended student generated</td>
<td>Lesson provides little structure giving students the opportunity to generate the project. Students may pose a question independently, design an investigation, collect and organize the data, and provide explanations.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Structured Inquiry</td>
<td>Lesson offers a structured inquiry lesson where teachers provide a question, investigation, at least some of the data, guidance to organize the data and explain the data. Students are involved through problem solving, discussion, and/or inquiry based projects.</td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Clarity Score</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Diadatic - teacher driven</td>
<td>Lesson is presented by the teacher with little or no student contribution.</td>
<td></td>
</tr>
</tbody>
</table>

**Code 7. Do one for each lesson.**

**INQUIRY (see chart below for clarification) List which level the activity falls under.**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Clarity Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>7a-e</td>
<td>Lessons 1-6. Develop Research Questions or Challenge</td>
<td>0-4</td>
</tr>
<tr>
<td>7a-e</td>
<td>Lessons 1-6 Design Investigation or Structure</td>
<td>0-4</td>
</tr>
<tr>
<td>7a-e</td>
<td>Lessons 1-6 Collect and Acquire Data</td>
<td>0-4</td>
</tr>
<tr>
<td>7a-e</td>
<td>Lessons 1-6 Organizing (Making Sense of Data)</td>
<td>0-4</td>
</tr>
<tr>
<td>7a-e</td>
<td>Lessons 1-6 Construct Explanations and Models</td>
<td>0-4</td>
</tr>
<tr>
<td>Level Criteria</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>----------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1-6v. - Develop Research Questions or Challenge</td>
<td>Learner poses a question independently.</td>
<td>Learner selects among questions or poses new questions with support from teacher.</td>
</tr>
<tr>
<td>1-6w. Design Investigation or Structure</td>
<td>Learner designs investigation including choosing variables and controlling variables.</td>
<td>Learner provided variables and controls, but designs lab protocol.</td>
</tr>
<tr>
<td>1-6x. Collect and Acquire data</td>
<td>Learner collects all data.</td>
<td>Learner collects majority of data, but given some data.</td>
</tr>
<tr>
<td>1-6y. Organizing Data</td>
<td>Learner determines how to organize data (e.g. graph, table, drawing)</td>
<td>Learner provided guidance on how to organize data (e.g. create a graph)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>1-6z. Construct explanations and models</td>
<td>Learner formulates explanations or models using evidence from their investigation and reasoning (including appropriate scientific concepts). (e.g. draws conclusions).</td>
<td>Learner guided in including evidence and reasoning to formulate their explanation or model. (e.g. draw conclusions).</td>
</tr>
</tbody>
</table>

**More-------------------Amount of Learner Self Direction-------------------Less**

**Less-------------------Amount of Direction from Teacher or Material---------More**
References


