“Miss, How do you Write Hipótesis?” Learning to Teach Science to English Language Learners While Navigating Affordances and Constraints: A Longitudinal Multiple Case Study

by

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ABSTRACT

Early career science teachers are often assigned to classrooms with high numbers of English language learners (ELL students). As these teachers learn to become effective practitioners, the circumstances surrounding them merit a thorough examination. This study examines the longitudinal changes in Pedagogical Content Knowledge (PCK) and practices of six early career science teachers who taught in urban schools. The teachers participated in the Alternative Support for Induction Science Teachers (ASIST) program during their initial two years of teaching. Our research team followed the participants over a five-year period. This study focuses on data from Years 1, 3, and 5. The data collected included classroom observations and interviews. In addition, classroom artifacts were collected periodically for the purpose of triangulation. The analysis of the data revealed that with the support of the ASIST program, the teachers implemented inquiry lessons and utilized instructional materials that promoted academic language skills and science competencies among their ELL students. Conversely, standardized testing, teaching assignment, and school culture played a role in constraining the implementation of inquiry-based practices. The results of this study call for collaborative efforts among university science educators and school administrators to provide professional development opportunities and support for the implementation of inquiry and language practices among early career science teachers of ELL students.
To my Mom, Dad, Abuela Patricia, Andrew, my friend Dr. Angela Arzubiaga, and to my teachers and mentors, especially to the late Dr. Sandra Abell, who believed in me and provided the inspiration, support, and encouragement that kept me focused throughout this process.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>xiii</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIST OF FIGURES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>xv</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>3</td>
</tr>
<tr>
<td>Theoretical Framework and Related Literature</td>
<td>6</td>
</tr>
<tr>
<td>Rationale for the Study</td>
<td>7</td>
</tr>
<tr>
<td>Limitations</td>
<td>8</td>
</tr>
<tr>
<td>Overview of the Following Chapters</td>
<td>9</td>
</tr>
<tr>
<td>Definitions of Terms</td>
<td>11</td>
</tr>
<tr>
<td>2 REVIEW OF THE LITERATURE</td>
<td>13</td>
</tr>
<tr>
<td>Chapter Overview</td>
<td>13</td>
</tr>
<tr>
<td>Early Career Science Teachers</td>
<td>13</td>
</tr>
<tr>
<td>Teacher Knowledge Research</td>
<td>17</td>
</tr>
<tr>
<td>Studying the Pedagogical Content Knowledge of Experienced and Early Career Science Teachers</td>
<td>20</td>
</tr>
<tr>
<td>Knowledge Development in Early Career Science Teachers of English Language Learner Students</td>
<td>24</td>
</tr>
<tr>
<td>Learning to Teach Science Inquiry to English Language Learner Students</td>
<td>29</td>
</tr>
<tr>
<td>Language Issues in the Science Classroom</td>
<td>30</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Learning to Teach Science as Inquiry</td>
<td>30</td>
</tr>
<tr>
<td>Learning to Teach Inquiry: Case Studies</td>
<td>33</td>
</tr>
<tr>
<td>Learning to Teach Inquiry: Large-scale Professional Development</td>
<td>34</td>
</tr>
<tr>
<td>Strategies for Teaching Science to English Language Learner Students</td>
<td>36</td>
</tr>
<tr>
<td>The Impact of Preservice Preparation on Early Career Teachers’ Knowledge</td>
<td>39</td>
</tr>
<tr>
<td>Induction in Educational Research</td>
<td>41</td>
</tr>
<tr>
<td>The Importance of Early Career Science Teacher Induction</td>
<td>43</td>
</tr>
<tr>
<td>The Importance of Induction Support for Early Career Science Teachers of English Language Learner Students</td>
<td>44</td>
</tr>
<tr>
<td>Teacher Learning through Induction Support</td>
<td>46</td>
</tr>
<tr>
<td>Induction Support for Teachers in Urban Schools</td>
<td>48</td>
</tr>
<tr>
<td>Learning from Mentors</td>
<td>50</td>
</tr>
<tr>
<td>Learning from Reflection</td>
<td>54</td>
</tr>
<tr>
<td>Contextual Factors and Early Career Science Teacher Learning</td>
<td>57</td>
</tr>
<tr>
<td>Areas in Need of Research</td>
<td>58</td>
</tr>
<tr>
<td>Implications</td>
<td>59</td>
</tr>
<tr>
<td>3 METHODOLOGY</td>
<td>61</td>
</tr>
<tr>
<td>Chapter Overview</td>
<td>61</td>
</tr>
<tr>
<td>Sampling</td>
<td>63</td>
</tr>
<tr>
<td>Criteria for Grouping and Selecting Participants</td>
<td>63</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Vocabulary Tiers Rubric..........................82</td>
<td></td>
</tr>
<tr>
<td>Validation of the Language and Inquiry Science Tool ......84</td>
<td></td>
</tr>
<tr>
<td>Validity and Reliability.............................................85</td>
<td></td>
</tr>
<tr>
<td>4 FINDINGS........................................................................87</td>
<td></td>
</tr>
<tr>
<td>Section 1: Teachers with High Percentages of English Language Learner Students ..................................................88</td>
<td></td>
</tr>
<tr>
<td>The Case of Martina......................................................88</td>
<td></td>
</tr>
<tr>
<td>Division of Labor .........................................................89</td>
<td></td>
</tr>
<tr>
<td>School Community .......................................................92</td>
<td></td>
</tr>
<tr>
<td>Teacher Artifacts..........................................................94</td>
<td></td>
</tr>
<tr>
<td>Rules and Regulations..................................................95</td>
<td></td>
</tr>
<tr>
<td>Longitudinal Changes in Martina’s Pedagogical Content Knowledge, Inquiry,and Language Practices .................................................97</td>
<td></td>
</tr>
<tr>
<td>Reported Language and Vocabulary Practices ..............100</td>
<td></td>
</tr>
<tr>
<td>The Case of Kelly ..........................................................105</td>
<td></td>
</tr>
<tr>
<td>Division of Labor .........................................................106</td>
<td></td>
</tr>
<tr>
<td>Rules and Regulations..................................................118</td>
<td></td>
</tr>
<tr>
<td>Longitudinal Changes in Kelly’s Pedagogical Content Knowledge, Inquiry,and Language Practices .............118</td>
<td></td>
</tr>
<tr>
<td>Section 2: Teachers with Moderate Percentages of English Language Learner Students ..................................................122</td>
<td></td>
</tr>
<tr>
<td>CHAPTER</td>
<td>Page</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>The Case of Cindy ........................................................................</td>
<td>122</td>
</tr>
<tr>
<td>Division of Labor .......................................................................</td>
<td>123</td>
</tr>
<tr>
<td>School Community .......................................................................</td>
<td>124</td>
</tr>
<tr>
<td>Rules and Regulations ................................................................</td>
<td>127</td>
</tr>
<tr>
<td>Longitudinal Changes in Cindy’s Pedagogical Content ...................</td>
<td>128</td>
</tr>
<tr>
<td>Knowledge, Inquiry, and Language Practices ................................</td>
<td>136</td>
</tr>
<tr>
<td>The Case of Jim ..........................................................................</td>
<td>137</td>
</tr>
<tr>
<td>Division of Labor .......................................................................</td>
<td>139</td>
</tr>
<tr>
<td>School Community .......................................................................</td>
<td>144</td>
</tr>
<tr>
<td>Longitudinal Changes in Jim’s Pedagogical Content ......................</td>
<td>154</td>
</tr>
<tr>
<td>Knowledge, Inquiry, and Language Practices ................................</td>
<td>157</td>
</tr>
<tr>
<td>Section 3: Teachers with Low Percentages of English Language Learner Students ..................................................</td>
<td>154</td>
</tr>
<tr>
<td>The Case of Alana .......................................................................</td>
<td>161</td>
</tr>
<tr>
<td>Division of Labor .......................................................................</td>
<td>157</td>
</tr>
<tr>
<td>School Community .......................................................................</td>
<td>163</td>
</tr>
<tr>
<td>Teacher Artifacts .......................................................................</td>
<td>164</td>
</tr>
<tr>
<td>Rules and Regulations ................................................................</td>
<td>172</td>
</tr>
<tr>
<td>Longitudinal Changes in Alan’s Pedagogical Content .....................</td>
<td>173</td>
</tr>
<tr>
<td>Knowledge, Inquiry, and Language Practices ................................</td>
<td>173</td>
</tr>
<tr>
<td>The Case of Enid .........................................................................</td>
<td>173</td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>School Community</td>
<td>175</td>
</tr>
<tr>
<td>Rules and Regulations</td>
<td>180</td>
</tr>
<tr>
<td>Teacher Artifacts</td>
<td>181</td>
</tr>
<tr>
<td>Longitudinal Changes in Enid’s Pedagogical Content</td>
<td>182</td>
</tr>
<tr>
<td>Knowledge, Inquiry, and Language Practices</td>
<td>189</td>
</tr>
<tr>
<td>Salient Trends across Cases</td>
<td></td>
</tr>
<tr>
<td>Theme 1: Participants Experienced Changes in Pedagogical Content Knowledge to Student Learning</td>
<td>190</td>
</tr>
<tr>
<td>Theme 2: Pedagogical Content Knowledge Related to Knowledge and Representation of Inquiry Strategies was</td>
<td>197</td>
</tr>
<tr>
<td>Theme 3: When Teachers Implemented Inquiry Strategies, Their Students Engaged in More Language Domains and in the Implementation of Contextualized Vocabulary</td>
<td>200</td>
</tr>
<tr>
<td>Affordances and Constraints Surrounding the Teachers</td>
<td>201</td>
</tr>
<tr>
<td>Theme 4: Teachers who Participated in Alternative Support for Induction Science Teachers and had Access to Inquiry Curriculum Implemented More Inquiry in Their Classrooms</td>
<td>201</td>
</tr>
<tr>
<td>Theme 5: Reform-minded Mentors and Colleagues Played an Important Role in Supporting Professional Teacher Learning</td>
<td>203</td>
</tr>
</tbody>
</table>

x
CHAPTER

Theme 6: Teachers who Taught a Single Subject in Middle School Settings in Year 1 Implemented More Inquiry Than Their High School Counterparts ...................................204

Theme 7: District and School Assessments Impacted the Implementation of Inquiry .................................................................205

5 DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH........208

Discussion ................................................................................................208

Discussion of Teachers’ Longitudinal Changes in Pedagogical Content Knowledge and Practices .....................209

Discussion of Affordances and Constraints .................................214

Implications and Directions for Future Research .................................221

REFERENCES ....................................................................................................225

APPENDIX

A ARIZONA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD APPROVAL FORM .................................................................236

B ARIZONA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD APPLICATION .................................................................238

C SUBJECT CONSENT FORM ..................................................................245

D OBSERVATION PROTOCOL ..........................................................248

E END OF THE YEAR REVIEW ..........................................................254
F  PEDAGOGICAL CONTENT KNOWLEDGE INTERVIEW:

    CODING MAP ...................................................................................... 257

G  MONTHLY INTERVIEW ........................................................................... 261

H  LIST INQUIRY RUBRIC ....................................................................... 269
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Characteristics of Participants</td>
<td>65</td>
</tr>
<tr>
<td>2.</td>
<td>Data Collection Schedule</td>
<td>74</td>
</tr>
<tr>
<td>4.</td>
<td>Martina: Longitudinal Changes in Pedagogical Content Knowledge</td>
<td>99</td>
</tr>
<tr>
<td>5.</td>
<td>Martina: Reported Language Domain Implementation</td>
<td>100</td>
</tr>
<tr>
<td>8.</td>
<td>Kelly: Longitudinal Changes in Pedagogical Content Knowledge</td>
<td>120</td>
</tr>
<tr>
<td>9.</td>
<td>Kelly: Reported Language Domain Implementation</td>
<td>121</td>
</tr>
<tr>
<td>10.</td>
<td>Cindy: Longitudinal Changes in Pedagogical Content Knowledge</td>
<td>129</td>
</tr>
<tr>
<td>12.</td>
<td>Cindy: Observed Practices</td>
<td>134</td>
</tr>
<tr>
<td>13.</td>
<td>Cindy: Reported Language Domain Implementation</td>
<td>135</td>
</tr>
<tr>
<td>15.</td>
<td>Jim: Reported Language Domain Implementation</td>
<td>151</td>
</tr>
<tr>
<td>17.</td>
<td>Alana: Longitudinal Changes in Pedagogical Content Knowledge</td>
<td>164</td>
</tr>
<tr>
<td>19.</td>
<td>Alana: Observed Practices</td>
<td>169</td>
</tr>
<tr>
<td>20.</td>
<td>Enid: Longitudinal Changes in Pedagogical Content Knowledge</td>
<td>183</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>22. Enid: Reported Language Domain Implementation</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>23. Number of Observed Inquiry Lessons per Participant</td>
<td>202</td>
<td></td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Diagrammatic Representation of Integrated Theoretical Frameworks</td>
<td>235</td>
</tr>
</tbody>
</table>
CHAPTER 1

Introduction

“All-right guys, today I want you to use your knowledge of classification to come up with a sequence of organisms and events showing the evolutionary history of life on earth.” Martina¹, whose class I am observing one last time, has been a participant of the Persistent, Enthusiastic Relentless: Study of Induction Science Teachers (PERSIST) for the past five Years. She is introducing today’s lesson to her 10th grade Honors Biology class.

“We will try to figure out the evolution of life on earth. Each of you will receive a laminated card with a picture of an organism. As a class you will come up with a hypothesis about the order in which the organisms in the cards first appeared on earth.” “Miss, how do you write hypótesis?” asks a young man seated at a lab station with two other classmates.

Good ear, Carlos! The word *hypothesis* is very similar in Spanish and English. You say *Hy-po-the-sis*, and you write it like this.”

Martina proceeds to write the word on the whiteboard. The students are copying the word in their science journals. The tone of Martina’s voice is friendly, and she enunciates every word in a clear and calm tone. (Martina’s classroom, final observation April 6, 2010)

Five Years ago, Martina, like many first-year science teachers, found

¹ The participants’ names have been changed to protect their anonymity.
herself in an urban classroom with students whose first language was not English and who were mastering science content and academic language skills simultaneously. Unfortunately, most beginning teachers do not have the academic preparation and experience to teach students science content in a manner that teaches them to speak, read, and write in a new language. Unlike many of her colleagues, Martina participated in a science-specific induction program for early career science teachers during her first two years in the classroom. As part of the induction program, she worked with mentors who were content specialist. She also participated in monthly workshops that focused on the design and implementation of science inquiry. In addition, her district provided professional development specifically designed for content teachers who had English Language Learners (ELL students) in their classrooms. By her fifth year in the classroom, she had obtained an English-as-a-Second-Language (ESL) endorsement, and was close to finishing a Master’s degree in ESL.

Martina, like other new teachers, is learning how to teach. This process is not always a linear or even progressive process, and for this reason, there is much to learn about this time in a teacher's life. By studying the learning trajectory of new teachers, mentors, teacher educators, school and district administrators can learn about supporting early career specialists who need to develop the competencies needed to become successful, effective teachers in urban schools. Studies of this kind will allow those who work with teachers to learn the processes and circumstances that impede or enhance the development of early career science teachers.
An analysis of the trajectory of early career science teachers who received induction support during the first two years in the classroom and professional development during the initial five years in the classroom can help design support systems for other early career science teachers as they develop the competencies required to become effective, successful science teachers of ELL students. The longitudinal examination of the participants’ pedagogical content knowledge (PCK) and inquiry practices situated in the context of the classroom, school, and district will enhance the present knowledge of the factors and circumstances that influence their professional development in urban settings. Moreover, administrators who hire early career science teachers will have new insights regarding the support and professional development required to improve the retention of quality content specialists in urban schools.

 Statement of the Problem

Current research efforts directed at improving the academic achievement of ELL students indicate that inquiry-based teaching helps promote both science literacy and language proficiency among students who are in the process of learning English (Lee, 2005; Stoddart, 2005). Unfortunately, many beginning science content specialists graduate from preservice programs that do not emphasize the implementation of inquiry practices. Even fewer programs provide their teacher candidates with field experiences in schools with high numbers of ELL students (Ladson-Billings, 2001). Among other factors, the lack of support of preservice teachers results in inadequate knowledge and skills to succeed in
their first years and leads to high rates of early career teacher turnover in urban schools (Ingersoll and Perda, 2009).

For early career teachers, induction programs offer potential professional development opportunities to succeed in the most challenging of conditions (Luft, 2007, 2009; Luft & Cox, 2001; Mamoud, 2000). School districts tend to offer induction programs, and these programs tend to address general issues (Luft, 2009; Van Velzen, Van der Klink, Swennen, & Yaffe, 2010), but do not necessarily focus on their immediate PCK needs related to the teaching of science (Luft, 2009; Luft, Roehrig, & Patterson, 2003). Efforts to document the learning trajectory of these teachers over the initial five years in the classroom are uncommon. There is a dearth of information on the research literature pertaining beginning teacher learning for this particular segment of the teaching profession. For instance, the literature search conducted for this study yielded only two articles that specifically examined secondary science teachers who had ELL students in their classrooms (Bianchini, Johnston, Oram, & Cavazos, 2003; McGinnis, Parker, & Graeber, 2004). Consequently, there is a great need for studies that analyze the trajectory of early career science teachers of ELL students. In particular, studies that focus on early career science teachers who participate in inquiry-based induction support and professional development for early career science teachers of ELL students can inform the field. Ultimately, the information gained from this research study has the potential to improve the design of programs that foster the development of reform-based practices known to support the academic and language achievement of ELL students (Bianchini, &
Solomon, 2003; Davis, Petish, & Smithey, 2006; Roehrig & Luft, 2004; Wood, 2009). This research study was designed to address the gap in the research literature pertaining to early career science teachers of ELL students. Teacher learning can be measured in two ways – through longitudinal changes in PCK and by analyzing teacher practices. The PCK and practices of early career science teachers who have ELL students are intrinsically embedded in the sociocultural context of the school and community (Luft, Bragg, & Peters, 1999). The immediate context surrounding beginning teachers is composed of colleagues, students, mentors, administrators, and all persons involved directly or indirectly with the school. At the district, state, and national levels, curriculum and assessment policies also exert a role on what teachers do in the classroom (Grossman & Thompson, 2004).

The longitudinal study of PCK and practices demands a careful analysis of contextual factors and the role these play in teacher learning. Circumstances related to testing and student performance are particularly predominant in urban schools, which operate under federal mandates such as No Child Left Behind (2001) and Race to the Top (2009). These are directly related to high stakes standardized testing scores and present challenges for administrators, teachers, staff members, and students. For example, in circumstances where a school is under probation based on overall reading and writing standardized scores, science teachers may have to dedicate instructional time preparing their students for the upcoming high stakes test to the detriment of student-centered science activities such as inquiry. For early career science teachers, these circumstances may have
an impact on their learning about teaching inquiry and their implementation of inquiry practices in the classrooms.

**Theoretical Framework and Related Literature**

This study examines the professional learning trajectory of early career science teachers of ELL students. During their initial years in the classroom, teachers learn how to interact with mentors, students, parents, colleagues, and administrators. Thus, teacher learning is a highly contextualized and nuanced social activity involving both cognitive and social aspects. Consequently, I draw from sociocultural theory, specifically from the perspective of Cultural Historical Activity Theory ([CHAT] Engeström, 1999) to contextualize the cognitive aspects of teacher learning explained through PCK (Lee, Brown, Luft, & Roehrig, 2007; Shulman, 1986). CHAT serves as the overarching framework for understanding social, developmental, and professional changes as teachers learn how to teach by becoming active participants of the teaching community (Engeström, 2001; Saka, Southerland, & Brooks, 1999). In this study, the PCK framework helps explain the cognitive aspects that shape the learning trajectory of early career science teachers, whereas CHAT situates teacher professional learning within the context of the classroom, school, district, and community (see Figure 1).

Teacher learning is viewed through the interactions among context, PCK and teaching practices. Because this inquiry focuses on early career science teachers of ELL students, I consider the PCK required for the integration of inquiry strategies with language domains and vocabulary practices as the teachers learn how to teach science to ELL students.
Rationale for the Study

This research study stems from three related areas: (a) the need to understand the role of science specific induction programs and districts on the preparation of reform minded early career science teachers, (b) the renewed interest in the learning trajectory of early career science teachers in urban schools, and (c) the dearth of studies addressing the role of science specific induction on the development of PCK and practices of these teachers. Knowledge generated from this line of inquiry may improve the design of induction and professional development programs and consequently the quality of early career science teachers of ELL students.

The goal of this study is to investigate the interaction between contextual factors and science specific induction support on the longitudinal development of PCK and practices of early career science teachers who have ELL students in their classrooms. By analyzing the trajectory of six early career science teachers, I attempt to illuminate how they learn to teach in ways that incorporate science inquiry and academic English. Current school demographic trends regarding ELL students and their teachers (National Center for Education Statistics [NCES], 2009) and my previous work with beginning high school science specialists (Ortega & Luft, 2010, under review; Ortega, Luft, Roehrig, & Stang, 2008; Ortega, Luft, Wong, & Firestone, 2009) helped formulate the rationale and purpose that guide this dissertation.
Limitations

The limitations of this study stem from issues of instrumentation and timing. Whenever the researcher is the main instrument of data collection and analysis, issues of bias and interpretation come into play. What researchers observe and notice in the field is influenced by their background and experiences. Consequently, interpretations are filtered by a personal understanding of the world (Erickson, 1985). To present a balanced account of the individual participants’ trajectory I conducted member checks by asking the individual teachers to evaluate the accuracy of their own case study (Silverman, 2006). In instances where information was not accurate or missing I amended my data records, which improved the veracity of the assertions, derived from the data analyzed for the study.

In this study, naturalistic observations were supported by employing classroom observation and interview protocols, which were previously validated and determined to be highly reliable (Creswell & Plano Clark, 2007). Multiple researchers participated in the process of data collection. In addition, researchers were randomly assigned to collect data from the participants. Researchers participated in training sessions each year to standardize observations and coding procedures. Data were coded by at least two researchers; any discrepancies in the coding were resolved by the intervention of a third researcher.

Limitations related to timing the use of instruments, particularly the use of the Language and Inquiry Science Tool (LIST) rubrics were unavoidable. I joined the research group in Year 3 of the study. The LIST was developed and used to
analyze the data during Year 4 of the study. The detailed nature of the field notes helped to minimize this limitation.

The five-year period of data collection resulted in a prolonged period of exposure to the participants and the context of the schools in which they learned how to teach. The multiple observations and interviews conducted throughout the duration of the study increased the trustworthiness of the assertions generated from the analysis of multiple forms of data. I am confident that data triangulation procedures allow me to present an accurate account of the participants’ learning trajectory.

Finally, in Years 3 and 5 of the study a state mandate that placed ELL students in an instructional block with a Language arts teacher cause a marked decreased in the number of beginning ELL students in the middle schools where two of the participants worked. This mandate created contextual pressured related to increases in class size Although no major changes in the PCK or practices were detected in the data collected from these teachers, the change merits mentioning as it may require a deeper analysis to uncover any ramifications related to teacher learning.

**Overview of the Following Chapters**

Chapter 2 includes a literature review that analyzes the empirical literature on teacher learning during the induction phase with a particular emphasis on science teachers of ELL students. In the review, I examined (a) teacher knowledge as PCK, (b) effective pedagogies for teaching science and language to ELL students, (c) the influence of preservice programs on teacher learning, and
(d) induction support strategies for beginning teachers of ELL students.

In Chapter 3, I discuss the research design and methodology employed in this study. First, I describe the background and preparation of the six participants selected for this multiple case study, and I present a rationale for selecting the participants. Next, I discuss each instrument used for data collection and analysis, as well as the type of data collected for the study. Chapter 3 concludes with a detailed description of the analysis procedures implemented in the study.

Chapter 4 includes a thorough discussion of each of the six case studies included in the study. The case studies were created by analyzing interview data regarding the interactions of the participants in the community of practice and the contextual factors surrounding each of the teachers, as well as the observed and reported practices from Years 1, 3, and 5. The analysis of the cases includes case comparisons within each case (i.e., longitudinal analysis), as well as cross-case comparisons within each group and among the three groups. Comparisons between the teachers with high and medium numbers of ELL students and the teachers with low numbers of ELL students serve to identify recurrent themes and categories, as well as instances of disconfirming evidence and contradiction.

Chapter 5 involves a discussion of research findings based on the theoretical frameworks, extant research, conclusions, and implications of the study. I conclude this chapter (and the dissertation) with questions generated from this research that will guide my next research project.
Definitions of Terms

The present study adopts an interdisciplinary approach by borrowing elements from CHAT, teacher learning, and science and language teaching to help explain the complexities of teacher learning. Adopting this approach creates issues pertaining to the registry of each discipline that must be addressed (A. Artiles & E. Koslosky, personal communication, September 1, 2010). One way of increasing the understanding among these fields is to provide a glossary of terms from relevant disciplines. Definitions of relevant terms follow to facilitate reading comprehension to all readers.

*Induction (n)* 1: The initial period of teacher development encompassing the initial three Years in the classroom. 2: A formalized support program offered to early career teachers to assist them in the transition from preservice teaching to classroom teaching.

*Science Inquiry (n)* 1: The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. 2: The activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (National Science Education Standards, 1996, p. 23).

*Language domains (n)*: The subjects of reading, writing, listening, and speaking that are required for students to master academic subjects; associated with the development of second language proficiency in the academic setting.

*Language tiers (n)*: A system of classification for vocabulary terms. Tier 1 vocabulary includes common, everyday words. Tier 2 words are the words that
indicate cognitive engagement students. Tier 3 words constitute the specialized terminology of a subject area.

*Scientific literacy* (*n*): That a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences; that a person is able to describe, explain, and predict natural phenomena; being able to read, with understanding, articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (National Science Education Standards, 1996, p. 22).
CHAPTER 2

Review of the Literature

Chapter Overview

Early career science teachers in urban schools encounter situations that influence the development of their PCK and practices. This review focuses on understanding how these teachers develop their knowledge of teaching science and academic English to their students, especially their ELL students. To understand the complexities surrounding this particular group of teachers during the initial five Years in the classroom, with this review I explore research studies from three areas: (a) teacher knowledge as PCK, (b) strategies for teaching science to ELL students, and (c) the role of affordances and constraints surrounding early career science teacher development during the first years in the classroom. The theoretical assumptions guiding the literature search and the resulting literature review are grounded on the sociocultural nature of teaching and learning represented by the CHAT framework (Engeström, 1999). Within CHAT, teacher learning is understood as social activity embedded in the context of the classroom and school. Though this lens, I can interpret the complexities ranging from state mandates to teacher perceptions

Early Career Science Teachers

The initial five Years of teaching have been recognized in the literature as a crucial time for early career teachers (Bianchini & Brenner, 2010; Grossman & Thompson, 2004; Feinman-Nemser, 2001; Huling-Austin, 1990; Luft, 2007; Saka, Southerland, & Brooks, 2009). According to Luft (2007),
The first years of teaching are periods of experimentation and modification, as teachers are constantly encountering new experiences, which impact the formation of philosophies, knowledge bases, dispositions, and abilities that will guide future growth. This initial phase of teacher development is also a time when teachers develop and solidify their repertoire of practices. (p. 534)

In their review of the literature Davis, Petish, and Smithey (2006) identified the following areas of concern for early career teachers: (a) the content and discipline of science, (b) learners, (c) instruction, (d) learning environments, and (e) professionalism. The authors also identified a need for longitudinal studies involving these teachers and their diverse learners. The context surrounding science teachers is an intrinsic component of teacher development; therefore, several of the research studies highlight the role of contextual factors in teacher learning.

One example of the role of context on early career teacher learning is the longitudinal study by Grossman and Thompson (2004) on how district policies regarding curriculum, professional development, and mentoring policies play a role on teacher learning. The authors followed three high school language arts teachers working in two districts with contrasting policies regarding teaching assignment, standards, curriculum, and mentoring. In this study, beginning teachers who had access to reform-based curriculum that matched their conceptual tools implemented more student-centered activities. The decisions
made at the district level regarding curriculum, mentoring, opportunities to cooperate with teachers who taught the same subject area, and the availability of professional development opportunities had a marked effect on the teachers’ concerns and in the affordances provided to advance their knowledge about subject matter and pedagogy. For instance, in schools were colleagues supported reform-based teaching, the beginning teachers were able to design and implement curriculum that was congruent with their preservice preparation.

The study by Bianchini and Brenner (2010) brings attentions to the importance of considering early career teachers’ needs and circumstances in the design and implementation of induction programs. The authors followed two early career secondary teachers (i.e., one in science and one in mathematics) who participated in a state-mandated induction program geared to support teachers of diverse students. Findings indicated that teachers perceived the program as constraining and not useful in helping them to teach in reformed ways. More studies that address the circumstances surrounding early career science specialists in urban schools can serve to provide greater insight regarding the role of constraints on teacher knowledge development. Similarly, Luft and Roehrig (2005) followed three early career science teachers during their initial year in the classroom. These teachers also worked with a highly diverse population in rural and urban schools. Unlike the teachers studied by Bianchini and Brenner (2010), these teachers did not receive induction support. Findings indicated that without adequate support early career teachers reverted to teacher-centered practices and
struggled throughout the year with issues related to understanding how to enact reform-based practices with their students.

In addition to developing skills related to classroom teaching and understanding the needs of students, teachers must negotiate becoming members of the community at the department, school, and district levels. This involves becoming familiar with the practices, norms, and habits of mind of these groups (Bianchini & Cavazos, 2007; Brickhouse & Potter, 2001; Wenger, 1998). The case study by Saka, Yavux, Southerland, and Brooks (2009) drew upon the CHAT activity system to document the initial year in the classroom of Nathan and Brad, two reform-minded early career science teachers. Whereas Nathan worked at a high school that was focused on increasing standardized test scores, Brad worked at a middle school where the collective goal was cooperation among teachers to maximize student learning. Nathan isolated himself and eventually adopted teacher-centered practices with limited opportunities for student learning. Contrastingly, Brad solicited the input of his colleagues and participated in frequent opportunities to discuss reform-based curricula and practices. Although the authors presented a detailed account of the teachers’ initial year of teaching, they could have explained in greater depth the details of the induction support program available to teachers in this study.

The paucity of research studies comprising the literature review confirm the need for increased investigations that explore how early career science teachers learn to teach ELL students in urban settings (Bianchini, Johnston, Oram, & Cavazos, 2003; Davis & Smithey, 1999; Fradd & Lee, 1999; Southerland &
Gess-Newsome, 1999). In the next section I review the definitions of PCK, present models of the construct and review the literature on the PCK of experienced, early career and preservice teachers; and examine the implications for understanding early career science teacher support and professional development.

**Teacher Knowledge Research**

PCK is defined as the skill a teacher has to represent content knowledge in a way that engages students in the interpretation of knowledge to understand academic content. Over the past 24 years, several authors and researchers have provided different interpretations for the notion of PCK (Gess-Newsome 1999; Grossman, 1990; Lee, Brown, Luft, & Roehrig, 2007; Shulman, 1986). Earlier on, Shulman (1986) titled his research on teacher learning *Knowledge growth in teaching*. Shulman’s inquiry reiterated the centrality of the support teachers are afforded during the induction period to teacher learning and development. Through his line of inquiry, Shulman pursued answers to the following questions:

1. How does the successful college student transform his or her expertise in the subject matter into a form that high school students can comprehend?

2. How does he or she employ content expertise to generate new explanations, representations or clarifications?

3. How does the teaching for learning occur? (p. 8)
Shulman (1986) defined PCK as

the particular form of content knowledge that embodies the aspects of content most germane to its teachability … an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them … to the learning. (p. 9)

Shulman’s definition of PCK helped other researchers explore teacher learning among teachers who specialize in multiple disciplines, including science. Subsequent research efforts have narrowed the understanding of PCK to specific content areas (e.g., Chemistry, Physics and Biology) and, specifically, to particular stages of teacher development (e.g., preservice, induction and beyond).

Grossman (1990) expanded Shulman’s definition of PCK to include knowledge of the community, school district, school, and specific students. By recognizing the importance of contextual factors on the development of PCK, Grossman’s model helped in understanding the PCK of teachers who work with diverse students in urban schools. According to Grossman, PCK develops from different sources. Whereas subject matter knowledge develops mainly during preservice teacher preparation, the areas of knowledge about curriculum strategies, student conceptions and difficulties develop through observations of classes – particularly observations of culturally diverse students. Classroom teaching experience involves topic-specific activities, and it develops during the inservice years (i.e., the initial year in the classroom and beyond). Knowledge of strategies and difficulties associated with teaching comes from professional
development opportunities. Grossman’s conceptualization of PCK is particularly useful in studying the development of teacher knowledge, as well as in designing professional development and support programs.

Gess-Newsome (1999) refined the developmental aspect of PCK by proposing two different models of the construct: the integrative model and the transformative model. The integrative model explains beginning-teacher PCK, and it is composed of three distinct elements: subject matter knowledge, knowledge of pedagogy, and context knowledge. Teacher knowledge in these three areas results in effective learning opportunities for students. The transformative model of PCK is an amalgamation of the same kinds of teacher knowledge, and it produces a new form of teacher knowledge. This model is more suitable for understanding the PCK of expert teachers. One criticism on the transformative model of PCK is that it tends to overlook decision-making, creativity, and personal growth.

Loughran, Milroy, Berry, Gunstone, and Mulhall (2000) presented PCK as composed of 12 different interconnected areas involving knowledge of content, students, and context. According to Loughran et al. (2000), PCK is a complex notion, only recognizable over long periods of time—perhaps the teaching of a unit of work. ... PCK develops through coming to understand concepts/content differently as a result of attempting to teach ... and recognizing the inherent incongruities in the knowledge and developing an understanding of it in practice. (p. 5)
More recently, Lee et al. (2007) focused on science teacher knowledge and defined PCK as “the knowledge that science teachers use to facilitate students’ understanding of scientific concepts and to encourage their scientific inquiry” (p. 52).

The use of PCK to explain teacher knowledge and teacher quality has become a part of the National Council for Accreditation of Teacher Education (NCATE, 2002), which defines PCK as

the interaction of the subject matter and effective teaching strategies to help students learn the subject matter. It requires a thorough understanding of the content to teach it in multiple ways, drawing on the cultural backgrounds and prior knowledge and experiences of students. (p. 55)

In an editorial, Abell (2008) examined the history and research of the construct and remarked that PCK continues to help educators and researchers gain a better understanding of teacher knowledge and development. In the next section, I review studies that explore the PCK of experienced and beginning teachers by using a variety of data collection strategies and instruments.

Studying the Pedagogical Content Knowledge of Experienced and Early Career Science Teachers

Besides understanding the development of PCK as a construct used to explain professional teacher learning, an equally important aspect of PCK research involves attempts to study and measure the PCK of experienced teachers (Henze, Van Driel, & Verloop, 2008; Lee & Luft, 2008; Loughran et al., 2000).
and the development of PCK in early career teachers (Lee et al., 2007; Luft, 2009; Nilssen, 2008; van Driel, de Jong, & Verloop, 2002). Knowledge gained from the study of experienced teachers’ PCK helps in expounding the complexities of teacher knowledge. Moreover, understanding the nuances of this construct is invaluable for the design of professional development, as well as for the development of instruments to measure different areas of PCK (e.g., content, context, and pedagogy). Concomitantly, studying how PCK develops among early career science teachers is important for science educators and others involved in designing and implementing preservice and induction programs.

Loughran et al. (2000) analyzed the PCK of nine experienced science teachers by using a combination of teacher interviews, artifacts, classroom observations, and the use of a tool to help teachers analyze their understanding of content s well as the examples that illustrate how they use PCK in science teaching. The tools used in this case were the content representation (CoRe) template and the teachers entries in the CoRe template designated as the pedagogical and professional experience repertoire (PaP-eRs). In this study, researchers emphasized the need for the use of multiple data sources and a prolonged period of data collection. The complexity of their approach yielded a nuanced understanding of subject-specific PCK. The usefulness of PaP-eRs to determine the PCK of novice science teachers is questionable, due to the extensive reliance on teachers’ complex reflections about their knowledge of students, curriculum, and pedagogy. Novice teachers may have difficulty translating emerging PCK into words. A less complex instrument in the form of
an interview to study the PCK of early career and experienced teachers was
developed by Lee and Luft (2008) to study the PCK of experienced teachers who
served as mentors to early career teachers. Lee and Luft (2008) found that
although experienced teachers shared similar views regarding the components of
PCK, they also had a personal interpretation of PCK that was unique for every
individual. These finding concur with Loughran et al. (2004), who determined
that PCK is a personal construct that requires teachers to self-reflect to gain a
deeper understanding.

Other researchers have studied the development of subject-specific PCK.
For instance, Dejong, Van Driel, and Verloop (2004) researched the development
of PCK for teaching particle chemistry in 12 preservice chemistry teachers. The
study found that after attending workshops and teaching chemistry content using
models, the preservice teachers developed a better understanding of how to teach
the subject and of difficulties related to subject matter faced by students. They
also found individual differences in PCK development among the preservice
teachers. These findings align with Grossman’s model and with Lederman and
Flick’s (2003) findings that PCK is germane to the subject and grade level and
highly contextualized. Findings from studying subject-specific PCK development
assist teacher educators in understanding the importance of ongoing professional
development for all teachers, and, in particular, for early career science teachers
who are learning how to enact new curricula, or teaching a subject outside their
area of expertise.
Nilsson (2008) highlighted the importance of subject matter knowledge when she investigated knowledge development in preservice teachers over the course of a year. In this study, the participants deepened their understanding of pedagogical content and context knowledge. Findings from this study indicate that subject matter knowledge played a central role on the development of other areas of PCK. Although the research helped in gaining an understanding of the role of field experiences and reflective practices on PCK development, more studies are needed that move beyond the preservice phase and into the inservice phase of teacher development. The field can benefit from research that focuses on broader aspects of PCK.

Thus, studying the PCK of early career teachers in different science disciplines has a wider applicability in terms of understanding the support teachers need during their initial years in the classroom. The research by Lee et al. (2007) represents an example of this line of inquiry. From the PCK interview by Loughran et al. (2000), Lee and colleagues devised and validated a semi-structured PCK interview. Their findings indicated that all 24 teachers who participated in an induction program during their first year of teaching experienced a significant change in PCK by the end of their first year of teaching. This research study brought clarity to PCK as a construct tied to science teacher learning during induction, but it did not extend beyond the initial year of teacher development. Research efforts that document and analyze PCK development beyond the initial three years of teaching, also known as the induction period, and into the fifth year of teacher development, will help provide a nuanced view of
how teacher knowledge develops in this crucial period of a teacher’s trajectory. Knowledge gained from longitudinal inquiries regarding PCK may inform induction and professional development efforts.

**Knowledge development in early career science teachers of English Language Learner students.** For urban science teachers of ELL students, an essential component of their learning involves melding the teaching of reform-based, inquiry pedagogy with academic English language skills (Buxton, Lee, & Santan, 2008; Lee, 2002; 2003; Lee & Fradd, 1998). Instructionally congruent pedagogies in the science classroom align with and value the ways of working and learning practiced in the students’ homes while promoting scientific reasoning and practices employed by scientists in the field and scientific community (Lee & Fradd, 1998). It is possible to ascertain changes in teacher knowledge by looking at the longitudinal changes of PCK and by examining teacher practices. One way to examine the quality and progression of teacher learning is by measuring teacher PCK and by analyzing teacher practices (Lee et al., 2007).

Early career science teachers of ELL students must learn how to deliberately integrate science activities and academic language skills into their classroom practices while simultaneously considering the diverse background of the students (Lee, 2007). The objective of melding science activities and academic language practices is to create an inclusive classroom that challenges the students and meets their language and academic needs, a difficult undertaking for any teacher (Martinez, Bailey, Kerr, Huang, & Beauregard, 2010). For
beginning teachers, this goal represents a formidable task (Luft & Roehrig, 2005). To become effective science teachers of ELL students, early career teachers must have a strong content background and a functional awareness of the structure of English and science vocabulary, as well as specific knowledge of their students’ proficiency (Bianchini & Cavazos, 2007). In addition, teachers must have the ability to design and deliver science instruction that integrates science inquiry with the use of vocabulary and the implementation of academic language skills (Beck & McKeown, 1985; Lee, 2004; Lee & Fradd, 1998; Snow, 2008). The literature search conducted for this review yielded three articles directly related to how early career science teachers learn to teach science to ELL students (Bianchini & Cavazos, 2007; Buck, Mast, Ehlers, & Franklin, 2005; McGuinnis, Parker, & Graeber, 2004).

Buck et al. (2005) used a case-study approach to analyze the experiences of an action research team as they documented the attempts of a reform-minded early career science teacher to create an inclusive classroom for her ELL students. The team of four included the science teacher herself, a science educator who taught at the university level, an English-as-a-second-language (ESL) teacher, and a graduate research assistant. Through an iterative process, the team supported the early career teacher by providing opportunities for self-reflection, by assisting her in enacting practices that were effective with her students, and by helping her create a classroom environment that supported the needs of her ELL students.

The findings indicated that artifacts, such as models and other manipulatives (as opposed to visual symbols), hands-on activities, and
cooperative learning helped increase the academic achievements of ELL students. Results illustrated the discrepancies between the theory and strategies learned in the preservice program and the complex realities of teaching science to students with different levels of academic language proficiency. Although the authors took great care in describing the planning required for structuring cooperative learning groups, they did not present enough detail on the science content strategies to help ELL students. The field stands to benefit from the similarities and contradictions that are bound to arise from multiple case studies with cross-case analysis of early career specialists who operate under circumstances similar to the ones encountered by the participant in this study. Buck et al. did not consider the participant's interaction with contextual factors outside the classroom. More studies that include the affordances and constraints surrounding early career specialists within and outside the classroom will offer a more complete understanding of the social context and its impact on early career content specialists who teach ELL students.

In contrast to the perspective adopted by Buck et al. (2005), McGinnis et al. (2004), and Bianchini and Cavazos (2007) conducted studies involving early career science and math teachers and included contextual affordances and constraints. McGinnis et al. (2004) followed five reform-minded math and science early career teachers during their first two years in the classroom and included affordances (e.g., technology, professional development) and constraints (e.g., colleagues, assessment pressure, and disruption of instructional time) beyond the classroom context. One of the participants, Ms. Lee, had high numbers of ELL
students in her classroom; therefore, her case study is of particular relevance to this review. For this teacher, issues of low literacy rates among the parents of her ELL students represented both a challenge and an opportunity to adjust her science instruction in a way that promoted academic learning and literacy skills in both languages. She implemented inquiry activities that allowed students to share science with their parents and relatives at home. In responding to the academic and language needs of all her students, she had difficulty with the wide range of English language proficiency among her students. Ms. Lee responded to this issue by carefully structuring small groups and by pacing the rate of instruction in a way that maximized student understanding.

She had the support of her principal; this, combined with her strong preservice preparation, provided her with the confidence to enact reform-based practices that met the academic and linguistic needs of her students. She experienced criticism from the other teachers who constantly reminded her of the need to cover more content and prepare students for standardized tests. This study helps increase the understanding of the role of school culture on the socialization of reform-minded early career science teachers of ELL students. Studies involving multiple case studies of early career science teachers who teach ELL students will help advance the understanding of the support systems, affordances and constraints that influence professional learning and retention for teachers in similar settings.

Similarly, Bianchini, and Cavazos (2007) followed Brian and Troy, two early career science teachers, from the final preservice year into the first year in
the classroom and during the fourth year in the classroom. Their qualitative case study focused on understanding how these teachers learned to teach from their students, from inquiry into practice, and from participating in professional communities. Through the analysis of the participants’ written work during the preservice year, and from observations and interviews, the researchers were able to analyze the longitudinal development of knowledge while considering the role of socially mediated interactions including both affordances and constraints. Both teachers were able to recognize the need to create opportunities for equitable participation for all students in science. Whereas Brian was able to scaffold his teaching to increase student learning, Troy concentrated on fostering a reform-minded teacher learning community at his school site. The findings indicated that even reform-minded, well-prepared early career teachers can experience difficulties mastering the different aspects involved in learning to teach science in equitable ways. The integration of site-specific induction, opportunities for professional development at the school site, and teacher reflection in the form of action research can positively impact early career science teachers’ progress toward teaching science in equitable ways.

The findings regarding preservice preparation were in line with prior findings by Buck et al. (2005), who indicated a mismatch between the content knowledge learned in courses about teaching diverse students and the realities experienced in the classroom. From the methodological standpoint, there is a marked disparity on the amount of data collected from the participants, with almost double the numbers of interviews conducted with one of the participants.
On Year 4, the researchers conducted only one classroom observation. Given the complexities involved in teaching, more observations were needed to buttress the trustworthiness of the assertions made about the participants’ practices.

**Learning to teach science inquiry to English Language Learner students.** For early career science teachers of ELL students, effective classroom practices include engaging their students in meaningful, sense-making inquiry science lessons that integrate the use of academic language skills, such as listening and discussing, reading, and writing (August, Branun-Martin, Cardenas-Hagan, & Francis, 2009; August & Shanahan, 2006). Efforts to help teachers implement science inquiry at the secondary level indicate that this is possible through carefully designed and sustained interventions (Bianchini & Cavazos, 2007; Buck et al., 2005).

To be effective science teachers of ELL students, early career science teachers must circumvent language barriers to communicate with their students and to assess their academic progress (Darling-Hammond, & Bransford, 2005). In addition, beginning teachers must create a classroom culture that builds trust and encourages students to take intellectual risks and develop a deep understanding of science content (Banks et al., 2005; Basu & Calabrese-Barton, 2007; Lee, Lewis, Adamson, Maerten-Rivera, & Secada, 2008; Lee & Luykx, 2007; Sconiers & Rosiek, 2000). Similarly, Fradd and Lee (1999) argued that science teachers play a critical role in creating a classroom responsive to the needs of ELL students. Teachers who take on a facilitator role promote students’ active engagement in science. In learning how to teach ELL students in effective ways, teachers must
move from theoretical to practical understanding of effective science teaching pedagogies. This transition occurs within the school context, and it is influenced directly by the students’ cognitive and language needs (Bianchini & Cavazos, 2007). Because of the central role a teacher plays on the academic and language proficiency of ELL students, it is important to examine forms of support that help teachers prepare to teach in ways that are responsive to the needs of their students.

**Language issues in the science classroom.** Learning the vocabulary of science presents challenges inherent to language learning for native English speakers and ELL students (Lee & Luykx, 2007; Lemke, 1990). Consequently, it is important for teachers to engage their students in science activities that promote inquiry and science literacy development among all students (Lemke, 1990; Roth & Duit, 2003). New teachers must understand second-language acquisition and development; without this knowledge, they may make decisions about the ELL students in their classrooms that can diminish the students’ opportunities to learn (Klingner, Artiles, & Mendez Barletta, 2006) For instance, teachers must allow their ELL students to access and use their native language in the classroom (Delpit, 1996). By embedding the language strand into their teaching, beginning teachers help their students develop their oral and written language proficiency (Valdez, Bunch, Snow, Lee, & Matos, 2005).

**Learning to Teach Science as Inquiry**

The *National Science Education Standards* (NSES, 2001) emphasize the importance of scientific literacy “in a world that is filled with the products of scientific inquiry” (NSES, 1996, p. 1). This form of literacy is achieved when
individuals “are able to learn, reason, think creatively, make decisions and solve problems” (NSES, 1996, p. 1). *Inquiry*, according to the standards is defined as “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” (NSES, 1996, p. 23). Equity and equal access are also a crucial component of the National Science Standards:

> Considerations of equity are critical in the science teaching standards. All students are capable of full participation and of making meaningful contributions in science classes. The diversity of students’ needs, experiences, and backgrounds requires that teachers and schools support varied, high-quality opportunities for all students to learn science. (NSES, 2001, p. 4)

According to Tippett (2009),

> The rhetorical goal of scientific discourse is consensus based on evidence rather than compromise or conciliation achieved through democratic processes. As scientists attempt to reach consensus, they engage in a process known as *argumentation* whereby they attempt to persuade others of the validity of their claims. (p. 17)

Argumentation is the central form of discourse for inquiry-based science. The qualitative research study by Rosebery, Warren, and Conant (1992) with Haitian students in elementary grades through the *Chêche Konnen* (Search for Knowledge) project, reported on the use of argumentation as a vehicle to promote
science learning and academic language skills among ELL students. Current science education reform proposes a shift to argumentation based on evidence and claims and away from the predominant rhetorical arguments used in teacher-centered classrooms (Driver et al., 2000). When students engage in arguments that link claims and evidence gathered through observation, data collection, and analysis, they implement academic language skills while increasing their understanding of natural phenomena (Tippett, 2010).

Science educators concerned with issues of equity and best practices for ELL students have recognized the impact of reformed-based inquiry science practices in helping students in the process of learning English. From a review of the empirical literature on this subject, two categories are apparent: case studies and large-scale professional development efforts. In this section, I discuss case studies first. The case studies focus on the role of prior knowledge and context on the teachers’ ability to implement inquiry. The second group of studies, although not specifically geared toward early career science teachers, illustrates successful professional development efforts focused in science inquiry strategies.

Although the role of professional development support on the academic and language achievement of ELL students is an area of paramount importance to teacher education, there is limited information on the role of professional development support for early career teacher. The literature search conducted in preparation for this review generated reports on large-scale professional development for elementary teachers (den Brok, Van Eerde, & Hajer, 2010; Lee, Deaktor, Enders, & Lambert, 2008). Contrastingly, the search yielded no research
Learning to teach inquiry: Case studies. Several case studies have identified the role of school and classroom cultures in the implementation of reform-based practices (Avramidou & Zembal-Saul, 2010; DeSouza & Czerniak, 2003; King, Shumow, & Lietz, 2001; Laius, Kask & Rannikmae, 2009; McGinnis et al., 2004). In a multiple case study of early career and math teachers, McGinnis et al. (2004) found that the beginning teachers’ perception of the culture of the school (i.e., the views of colleagues and administrators regarding science inquiry) was a major factor influencing the implementation of reform-based practices. The beginning teachers in the study displayed one of three responses: (a) resistance as they implemented reform-based practices is spite of their colleagues’ traditional practices, (b) avoidance by leaving their school after one or two years, or (c) compliance by adopting their colleagues’ traditional practices. Of particular interest from this study is the analysis of the individual attributes and circumstances of the participants and the role these played on their responses.

Another important implication is the need for professional development focused on reform-based practices to all teachers, regardless of their years of teaching experience. This may increase the likelihood of a school culture that embraces inquiry practices and supports early career science teachers as they solidify their practices during the induction phase of their development.

The qualitative, multiple case study by Lains et al. (2009) involved 16 chemistry and biology teachers from Stonia. Like their United States counterparts, these teachers identified culture – and specifically the difficulty involved in
changing the classroom culture to a more student-centered classroom – as a major impediment to the implementation of inquiry. A more recent research report by Avramidou and Zembal-Saul (2010) corroborates the influence of context on early career science teachers’ ability to enact reform-based practices.

**Learning to teach inquiry: Large-scale professional development.**

Large-scale professional development efforts involving both early career and experienced teachers have chiefly examined the role of professional development on the practices of elementary science teachers. Lee et al. (2008) reported on a large-scale professional development intervention in Florida. The three-year intervention involved an initial cohort of 56 teachers in six schools. In this quantitative study, approximately 25% of the students were classified as ELL. During the regular school year, the teachers in this study participated in a professional development intervention focused on science as inquiry, English language literacy, and students’ home language and culture. When compared to a control group, the students who received instruction by teachers who participated in the professional development had statistically significant mean differences in all measures comparable to test items from the National Assessment of Educational Progress (NAEP), the Third International Mathematics and Science Study (TIMMS), and the assessment items developed for the project. A factor analysis of intervening variables, such as ethnicity and socioeconomic status, indicated no significant differences in achievement among these groups. The researchers did not discuss issues such as alignment between classroom content and standardized test content or the time devoted to review test items.
Consequently, it is difficult to discern the effect of the curriculum from the role of test preparation on the correlation value. Finally, although the approach implemented by these researchers stands as a model for translating research to practice, this investigation did not specifically involve early career high school science teachers. The field could benefit from similar studies that include early career science teachers.

Stoddart (2005) reported on a smaller-scale professional development intervention involving 10 elementary teachers and their ELL students. Three of the participants were early career teachers. The peer coaches observed the teachers and met with them twice per week for five weeks to provide feedback regarding practices. In addition, teachers met with peers and researchers to analyze and reflect on their practices. The researchers documented the changes in teacher practices related to the implementation of inquiry and the increase in science vocabulary and language proficiency of the students. Results indicated a moderate-to-high correlation between the teachers’ use of inquiry and the students’ scores in science vocabulary and academic English measured by concept maps and the Woodcock-Munoz standardized assessment.

Although the results of the intervention correlated teacher change to student achievement, there were only moderate gains in science vocabulary proficiency for the students. The study did not report on the selection criteria for any of the participants. Furthermore, no explanation was provided for the exclusion of student achievement data from the larger group of 500 students who participated in the study. The sample size for the correlation analyses ranged from
20 to 46 students. Stoddart recognized the shortcomings of the relatively small sample size and indicated that further analyses of the results with a larger sample size were needed to provide stronger conclusions. The research studies conducted by Lee et al. (2008) and Stoddart (2005) serve as models of professional development implementation and its role on the academic achievement of ELL students in science and language. Further studies involving larger number of early career science teachers of ELL students are needed to illuminate the field. With this review I will now examine literature on effective pedagogies for teaching ELL students in the content areas.

**Strategies for Teaching Science to English Language Learner Students**

Studies documenting the implementation of strategies for teaching ELL students in the content areas (e.g., math, social studies, science) range from specific techniques to comprehensive pedagogical approaches. The explicit use of *cognates* (i.e., words that have similar spelling and meaning in the students’ first language and in English) was documented by Field, Wilhelm, Nickell, Culligan, and Sparks (2001), who researched the use of cognates to improve vocabulary learning and comprehension among middle school students in social studies. Cognates are also important to help ELL students gain access to the vocabulary used in the content area and to help them feel more at ease with the subject matter. One issue with the use of cognates is that teachers need to have command of one of the Romance languages (i.e., Spanish, Italian, French) to recognize these words in the content area. A second consideration regarding
cognates is the fact that students may not have knowledge of the word in their first language.

The use of techniques such as brainstorming and guiding questions (Seda, Liguori, & Seda, 1999) to help scaffold student academic language production is another example of a teaching strategy to increase student understanding in the content areas. Teachers can also provide cultural and language support by allowing student to use their first language as they negotiate meaning during group activities (Janzen, 2008). I will now review comprehensive instructional methods for teaching ELL student in the content areas.

Two different approaches for teaching ELL students in the content areas: the Sheltered Instruction Observation Protocol (SIOP) by Echevarria and Short (2000) and the Specially Design Academic English Instruction [SDAEI], by Sobul (1995) are evident in the literature. These approaches were selected for this review because of the emphasis on inquiry and problem solving opportunities for students and the melding of academic language skills in the content areas.

The SIOP instructional method was especially designed for implementation in linguistically diverse content classrooms. SIOP incorporates the scaffolding of content instruction by including ten different aspects related to the academic language and content needs of the students (e.g., language objectives, artifacts, comprehensible input and fair assessment tools.) By working in small groups, students engage in the implementation of language domains and vocabulary.
The SDAIE protocol is based on Vygotsky’s view of the social nature of learning in that it is based on the importance of social interaction as a means to achieve language development. It combines second language acquisition instruction with content instruction practices. The SDAIE facilitates language acquisition and academic success in content areas such as science (DeLuca, 2010; Hanes, 2004; Sobul, 1995). Inquiry, SIOP, and SDAIE include specific practices that foster student-centered classrooms. In these approaches, students learn in collaborative groups while they solve problems with the guidance of the teacher. The use of visuals, manipulatives, and semantic maps help increase understanding of science concepts. Finally, when these teaching approaches are implemented, students have opportunities to engage in academic content-related discussions and to practice academic language skills, such as reading and writing (Hanes, 2004). The elements of SDAEI, SIOP, and inquiry served as a framework to identify and analyze language and inquiry practices implemented by the participants whose teaching trajectory constitutes the focus of this research study and dissertation.

Throughout this section, I have discussed the literature pertaining to specific pedagogies for early career science teachers of ELL students. I will now focus on research literature regarding teacher preparation programs, induction support programs, and professional development opportunities offered by districts and universities, all through which teachers learn theoretical and practical aspects related to reform-based pedagogies.
The Impact of Preservice Preparation on Early Career Teachers’ Knowledge

In content areas such as science, teachers must encourage all students to participate in cognitively engaging science content. Although preparing teachers to work with diverse students has been widely recognized as crucial in promoting student achievement by teacher educators and researchers, teacher preparation programs offer limited-to-no field experiences in working with ELL students (Ladson-Billings, 2001). This is because many urban schools operate under restrictive policies that are driven by mandated, standardized tests and punitive accountability measures that limit available opportunities for preservice teachers’ in classrooms and schools serving predominantly diverse student populations (Anderson & Stillman, 2010; Gutiérrez, Asato, Zavala, Pacheco, & Olson, 2004). Subsequently, beginning teachers enter the field with varying degrees of competence in teaching science to ELL students.

Literature on the impact of teacher preservice preparation on early career teacher learning and practices is sparse; however, there are two studies that follow teachers from their teacher certification program through their first years in the classroom. Ensor (2001) described the transition of seven beginning high school math teachers in South Africa who did not receive induction support, whereas Roehrig and Luft (2006) drew on a larger sample size of 16 early career science teachers who participated in four different induction programs.

Ensor (2001) examined the experiences of seven beginning secondary mathematics preservice teachers as they transitioned from their last year of preservice into their initial year of practice. The participants taught in schools that
differed in degree of cooperation with colleagues in the department, in student population, and in class size. Ensor examined how the teachers adapted knowledge from their teacher preparation program to the contexts of their schools and classrooms, drawing upon classroom observations, reflective journals, and interviews as sources of data. The beginning teachers in the study transferred small tasks learned during preservice and gave new meanings to the terminology used to describe reform-based practices. For instance, the participants re-contextualized the term *visualization* to mean the use of drawings. Ensor concluded that the lack of field opportunities to practice what they learned in their mathematics methods classes limited the teachers’ ability to enact reform-based practices during their initial year in the classroom. The conclusions of this study reiterate previous findings by Biachini and Cavazos (2007) and Buck et al. (2005) on the disconnect between theory and practice in preservice education, as well the need for continued support and opportunities for professional development focused on reform-based teaching during the induction period.

Roehrig and Luft (2006) investigated the experiences of 16 early career secondary science teachers who participated in four different induction programs. Findings indicated that teachers who had an extended field experience and took two science methods courses implemented more reform-based practices than teachers who took fewer methods courses and had less field experience during their preservice programs. The authors used a cross-case analysis and multiple data sources, such as end-of-the-year interviews, interviews on reported practices, and classroom observations to generate robust assertions about the role of
preservice preparation and science specific induction on the beliefs and practices of the participants. These findings highlight the value of a strong preservice preparation combined with content-specific induction support. No data were presented on whether the courses or field experiences of the early career teachers prepared them for working in urban contexts with ELL students. Both of these studies concluded that affordances such as reform-based courses in science methods, and meaningful field experiences in their teacher preparation programs play a role in building the capacity of teachers to implement reform-based practices in their classrooms.

**Induction in Educational Research**

The term *induction* evolved from other professions, which used the word to designate the initial phase of socialization experienced by recently credentialed professionals. Teacher educators, policy makers, and school districts recognize *induction* as a teacher’s initial three years of classroom practice (Lawson, 1992). Two closely related connotations of this word are relevant to the content of this manuscript. The first connotation of induction was initially used in educational research literature in 1962 by Shaplin (as cited in Lawson, 1992) to designate the period of teacher development encompassing the initial years of practice. The second connotation refers to the support offered to teachers during this early phase of their careers (Feinman-Nemser, 2001; Veenman, 1984).

The definition of induction as an intervention gained popularity as a result of anticipated teacher shortages in the 1980s (Huling-Austin, 1990, p. 537). In recognizing the importance of teacher support during this crucial period, Huling-
Austin (1990) defined induction as a carefully designed program intended to provide systematic, carefully implemented, and sustained assistance that extends beyond a series of orientation meetings or evaluation used for teachers new to the profession. Cochran-Smith and Little (1999) offered a description of induction that incorporated the sociocultural nature of teacher learning by noting that during the induction period teachers learn in three dimensions: from their students, from their own practice, and from participation in professional communities.

More recently, Luft (2007), in an editorial, pointed to the importance of induction support in helping teachers transition seamlessly from preservice to the field by describing induction as

a period where practices and cognitive modes are conceptualized, constructed and crystallized …. Teachers are planning lessons, learning new curriculum, and dealing with management problems and developing knowledge bases needed for teaching…. Teachers are developing their views of equity in the classroom as they experience different populations of students…. The period of induction marks the formation of beliefs and practices in terms of teaching science … [It is] a period of experimentation and modification when teachers are constantly encountering new experiences which impact the formation of philosophies, knowledge bases, dispositions and attitudes. (p. 533)
The definition by Luft (2007) provides a greater insight into teacher development during the induction phase and helps illuminate areas of needed support for induction program design and implementation.

**The importance of early career science teacher induction.** Even when teachers enter the field lacking skills to teach in urban schools and implement reform-based practices, induction support programs can help teachers as they transition into their first years in the classroom. When early career teachers enter the profession they have the theoretical and practical knowledge of reform-based practices, but without the support provided by content-specific induction programs, most teachers adopt teacher-centered practices such as lecturing, verification activities such as cook-book labs and worksheet, and bookwork, which deny students the opportunity to become scientifically literate (Ensor, 2001; Luft, Roehrig, & Patterson, 2003). Learning how to teach inquiry requires participating in professional development specifically designed to promote inquiry practices, enacting inquiry-based activities with students in the classroom, and reflecting on the quality and effectiveness of the lessons (Avramidou & Zembal-Saul, 2010; Luft, 2009).

Luft (2009) reported the results of a longitudinal study involving 114 teachers who participated in four different induction modalities. The beginning teachers who participated in a science-specific induction program geared toward the development of inquiry practices implemented more laboratory activities (including directed inquiry), engaged in classroom discussions, and reviewed
The findings of this study demonstrate the importance of science-specific support in fostering the development of reform-based practices. Luft did not report specifically on the role of induction on the practices of teachers who had high numbers of ELL students. Although the study involved participants who worked with high numbers of ELL students, no distinctions or separate explanations were offered regarding these beginning teachers. Currently, little information can be found in the literature regarding the role of science-specific induction on the practices of teachers who have high numbers of ELL students in their classrooms.

The importance of induction support for early career science teachers of English Language Learner students. Early career science teachers of ELL students, like their colleagues who teach native English speakers, enter the classroom with idealized perceptions of what it means to teach science. According to Veenman (1984), the majority of these teachers experience a collapse of the ideals about teaching formed during teacher training. Without adequate support throughout the induction period, the demands of the classroom and the complexities involved in learning to teach, force beginning teachers to move away from reform practices, such as inquiry, and toward teacher-centered practices (Luft et al., 2003). This shift is particularly problematic for ELL students, as quiet and regimented classrooms deny students the opportunity to practice language skills while constructing their own understanding of science. Beginning teachers
who enact teacher-centered instruction practices give information, ask questions, give directions, make assignments, monitor seat-work, review assignments, and administer tests while excluding student-centered practices, such as small group discussion and inquiry activities. These practices constitute what Haberman (1991) called the “pedagogy of poverty” (p. 290).

An example of what happens to teachers when they do not receive support during the induction phase is illustrated in the literature by Simmons et al. (1999), who followed the trajectories of 69 beginning secondary and middle school math and science teachers over a period of three years. The participants were interviewed using the Teacher Pedagogical Philosophy Interview (TPPI), an instrument designed to elicit a teacher’s knowledge and beliefs about epistemology, the nature of science and mathematics, the nature of teaching and learning, the view of self as a teacher, and the educational environment (Richardson & Simmons, 1994). The researchers observed and videotaped the classroom practices of participants during three consecutive days and analyzed teacher journal entries. Findings indicated that throughout the initial three years of practice teachers reported student-centered beliefs but enacted teacher-centered practices. Without induction support, the beliefs and practices of the beginning math and science teachers who participated in this study converged toward teacher-centered practices.

One of the limitations of this study was the lack of qualitative data on student-teacher interactions, student achievement, or teacher practices. The authors reported that only 69 of the original 117 participants had complete sets of
data as teacher mobility, and attrition represented a major impediment to the continuity of data collection. Nonetheless, the findings make a compelling case for induction support as a way to promote and maintain reform-based practices on beginning math and science teachers. Moreover, the results indicate the need for studies that investigate the trajectory of early career teachers who are content specialist in urban schools.

Huling-Austin (1992) delineated the conditions that facilitate teacher learning during this crucial period of induction: teaching in a content area that matches the major field of expertise; teaching a single subject; having time to observe other teachers and the time to consult with other colleagues, including other early career teachers; receiving constructive criticism about their practices; and having a strong mentor in the same content area. In the case of early career science teachers of ELL students, the mentor should also be an expert in teaching diverse students who have language issues. The study by Achistein and Barrett (2004) illustrates the importance of mentors in helping early career teachers reconfigure their ideas about diverse learners. Through individual sessions, the mentors negotiated with varying degrees of success, a change in the frames the mentees used to judge student behavior and needs.

**Teacher learning through induction support.** It is during the induction phase that many beginning teachers have their first opportunity to work with ELL students. The affordances and constraints faced during this crucial period of teacher development have a marked effect on emergent practices. The goal of science-specific induction support is to provide professional development
focused on reform-based pedagogies while offering sustained support from mentors and content area experts (Luft, 2007). Addressing the needs of early career science teachers requires carefully designed and implemented induction programs.

Intervention programs and support offered during the induction phase are critical in helping beginning teachers transition into the profession and adopt practices responsive to the academic and language needs of their students. In addition, evidence indicates that induction programs impact teacher retention: Among teachers who participate in induction programs, the likelihood of leaving the profession within the first year decreases from 40% to 28% (Ingersoll & Smith, 2003). Besides decreasing teacher attrition, science-specific induction has an impact on teachers’ ability to enact inquiry practices (Luft et al., 2003; Rhoerig & Luft, 2006).

Teacher induction programs offered by districts and universities strive to ease the transition from the preservice program to the initial year of teaching and to help early career science teachers cultivate student-centered practices. These programs vary in their design and effectiveness. An evaluation study of induction programs in California indicated that teachers who participated in induction programs engaged their students in activities that were intellectually stimulating, aligned with curriculum frameworks, and held high expectations of their diverse students (Mamoud, 2000).

Beginning teachers’ experiences during this crucial phase of their professional development can set the course for the rest of their career. During
this time, teachers can benefit from participation in comprehensive, well-designed induction programs. Luft and colleagues (Luft, 2007; Luft & Cox, 2001) reported that 93% of the induction teachers surveyed attributed positive changes in their attitudes toward science classroom instruction and instructional ideology to their induction program.

**Induction support for teachers in urban schools.** Efforts to assist teachers during induction must be carefully designed and sustained for at least two years. Induction that involves a strong inquiry component has been identified as an effective approach to build the capacity of science teachers of ELL students (Bianchini et al., 2003). This manuscript now delves into the literature regarding induction programs with an emphasis on content specialists and urban school settings.

Induction support initiatives provide beginning teachers with quality mentoring and opportunities to interact closely with colleagues and science educators. Colbert and Wolff (1992) reported on this type of induction support in their findings from a large-scale induction program for urban elementary and secondary teachers. The goal of the three-year induction partnership between the Los Angeles District and California State University Dominguez Hill was to reduce the typical 50% beginning teacher attrition rate experienced by this highly diverse, urban school district. The program served 120 teachers most of who were in the process of obtaining their teaching credentials.

Principal nominated lead teachers to receive training in classroom observation and coaching. Each of the 24 lead teachers selected for this
intervention worked with a group of two to four beginning teachers. In most cases, the teachers in the group taught the same subject or grade level, and had classrooms near each other. The study participants (i.e., beginning teachers and lead teachers) met in their small groups for a total of 60 hours during the school year to discuss practical aspects of classroom management and reform practices. In addition, during the first year of the program the lead teachers and the early career science teachers enrolled together in university courses on effective instruction, management strategies, bilingual and ESL instruction, and cooperative learning. In subsequent years, beginning teachers enrolled in additional courses to complete their certification or Master’s degree programs.

The retention rate for beginning teachers who participated in the induction program was 8% higher than the retention rate of non-participants. The participants rated the collaborative group interactions and the university courses they attended with the lead teachers as being most useful in terms of effective classroom strategies. An analysis of the longitudinal data obtained from classroom observations indicated that beginning teachers improved their classroom management and instructional strategies. Moreover, these teachers provided more opportunities for student engagement and participation than teachers in the control group comprised of beginning teachers who did not participate in the induction support program.

The researchers did not discuss the reliability or validity of the instruments used to observe teachers and measure their practices, the teachers’ beliefs about their urban students, or details of the interactions between students and teachers.
Furthermore, the study did not provide information regarding the role of contextual factors inherent to urban school settings on the early career science teachers’ classroom practices. An area in need of exploration is the quality of the interactions between beginning teachers and their mentors and colleagues.

**Learning from Mentors**

Teacher learning occurs in the daily interactions of the classroom and school during the induction phase. Mentoring is an important component of induction support (Achistein & Barrett, 2004; Athanases & Achistein, 2003). Without the support of a knowledgeable mentor, teachers might resort to authoritarian measures that restrict or eliminate student cooperation and impede their progress toward reform-based teaching practices. Effective mentoring helps beginning teachers progress through the initial stage of shock, described by Veenman (1984), and move toward student-centered practices. For beginning teachers who teach ELL students, mentoring becomes an essential part of learning during the induction phase. These findings highlight mentoring from different perspectives: the general impact of mentoring on teacher retention, what mentors consider important aspects to help beginning teachers of linguistically diverse students, and how beginning teachers of linguistically diverse students learn in the company of qualified mentors (Achistein & Barrett, 2004; Athanases & Achistein, 2003).

Athanases and Achistein (2003) investigated the interactions between 20 pairs of beginning teachers and their mentors. The mentors participated in a university-sponsored Leadership Network for Teacher Induction (LNTI). The
researchers used a questionnaire to identify what aspects mentors considered necessary to help beginning teachers learn how to work with ELL students. The results indicated that mentors ranked helping the beginning teachers in three different dimensions: reflecting on students’ work, learning to modify practice by assessing students’ progress, and tailoring instruction to serve the needs of diverse students.

In addition to these categories, mentors identified the following mentor competencies for helping beginning teachers promote equity in the classroom: (a) an understanding the local and broader context related to teaching youth, (b) an understanding of what youth bring to class as individuals and social groups, (c) a broad repertoire of instructional strategies to guide beginning teachers, as well as knowledge of strategies and tools specific to learners from diverse cultural and linguistic groups, (d) the development of knowledge of self related to diversity and equity (personal beliefs about equity and diversity), and (e) the ability to focus new teachers on diversity and equity in the mentoring conversations.

Athanases and Achistein (2003) presented detailed conversations between mentors and their mentees over the course of the initial two years of teaching. The mentors were able to mediate the early career science teachers’ progression toward viewing individual students and their needs. Whereas ample information is available regarding the questionnaire administered to mentors, the researchers selected two representative case studies in lieu of quantitative data on the practices of the other 18 mentor-beginning teacher pairs. Research efforts that
include the fine detail of representative case studies will generate a more nuanced understanding on the role of mentors play on beginning teacher learning.

Achistein and Barrett (2004) reported on a two-year mentoring program to help beginning teachers reframe their practice dilemmas. Entman (1993) presents the notion of frames as organizing frameworks or patterns of interpretation and ways or organizing issues and seeing problems. Frames can help individuals as they conceptualize a problem. In that sense they are both enlightening and constraining. For instance, a frame for looking at student knowledge can help a teacher focus on student’s needs while obscuring key issues such as instruction and the social climate in the classroom. Reframing can help beginning teachers move toward student-centered practices. In the absence of mentors that help reframe deficit ideology (Valencia, 1997; 2010), i.e., the view rooted in oppression, pseudoscience (the false persuasion by scientific pretense, and educability) that culturally and linguistically diverse individuals are responsible for the gaps in academic achievement between them and their mainstreamed classmates, or for other difficulties these students may experience in the classroom and school setting. These views may persist and in some cases limit the practices early career teachers implement in their classroom.

The participants in this study were 15 beginning teachers of culturally and linguistically diverse students and their mentors. The purpose of the study was to document how beginning teachers learned to reframe how they view their students. Mentors helped the beginning teachers set goals for improvement of classroom issues, met with the beginning teachers every week, observed the
beginning teachers, and offered feedback. Beginning teachers observed the mentor’s practices and were able to ask questions afterwards. During regularly scheduled meetings mentors worked with their mentees in analyzing students’ work and classroom observations, and mentors experienced varying degrees of success in helping beginning teachers view perceived discipline and management as issues of relationship or social justice.

By looking at students’ work together with their mentees, the mentors were able to challenge the mentees’ assumptions about their ELL students. Through these interactions, beginning teachers learned to analyze student work and identify differences in language proficiency and how to support the academic needs of individual students. The varying degrees of success documented for the case studies indicate the importance of preparing and assigning mentors who are qualified and knowledgeable about ELL students and early career teacher learning.

The prevalence of managerial and political frames were significantly negatively related ($r = -.67$), as were managerial and relationship frames ($r = -.80$). Conversely, political (issues of equity) and relationship (pertaining to individual students and their needs) frames were significantly positively related ($r = .54$). This work presents some important implications for mentors of beginning teachers of ELL students. For instance, mentors need to engage beginning teachers in discussions that help them frame student issues beyond classroom management and control. As teachers modify their frames, they learn to focus on the needs of individual students and engage in issues of equity. In summary, when
teachers were concerned with issues of classroom managements, they tended to ignore political or relationship issues. Teachers who were concerned with political issues were also concerned with relationship issues. No data were provided regarding the mentees’ views of the mentor’s usefulness. This study presents an example of the dilemma concerning fidelity of implementation: Even if mentors received professional development to build their capacity to work with mentees in effective ways, not all mentors were able to shift their mentees’ frames. Although the mentors were described as caring and non-judgmental, the researchers did not provide data on the classroom practices of the mentors and the impact these had on the mentees. Similar studies that include the role of contextual factors on mentor effectiveness may inform the field of beginning teacher learning through mentoring as a component of induction support.

Learning from Reflection

Early career science teachers learn from reflecting on their practices. The NSES highlight the importance for teachers to become lifelong learners who engage in reflection about their experiences in the classroom as a means to track and analyze their own development over time (NRC, 1996). Reflection helps teachers bridge the disconnect between beliefs and practices and deepen their perception of diverse students (Bianchini & Cavazos, 2007; Danielowich, 2007). During reflection, teachers engage in a meta-cognitive exercise that allows them to think about what they have done in the classroom and about what they will do next. Through reflection, teachers understand that improvement in students’ performance begins with the teacher. The goal of fostering practitioner self-
reflection is to create a habit of mind that will allow teachers to continue to improve their competencies throughout their careers (Ladson-Billings, 2001).

Danielowich (2007) reported a multiple case study of four early career science teachers who worked at an urban school learned to negotiate conflicts between their goals and actual practices by reflecting in the presence of a university researcher, with other beginning teachers and individually through journal writing. Teachers in this study were invited to become aware of the conflicts between their goals and practices through critical self-reflection. In doing so, the participants learned to shape their practices instead of to evaluate their goals. According to Danielowich (2007), teachers recognized their own ethical and moral perspective and became empowered to change the conditions of schooling as a result of practicing critical self-reflection. This type of reflection allows teachers to honor their students’ needs and re-structure systems of oppression in science. When early career teachers engage in critical self-reflection they find ways to become empowered agents of change. Self-reflection is an intellectual pursuit. Critical self-reflection is pivotal in helping teachers tend to issues of equity. This observation coincides with the aforementioned work by Achistein and colleagues (Achistein & Barrett, 2004; Athanases & Achistein, 2003) on the role of reflection in helping beginning teachers reframe their views of diverse students.

In Danielowich’s (2007) study, teachers used journals to reflect on their practices and to answer to prompts formulated by the researcher. The conversations and meetings were transcribed and analyzed through open coding.
The beginning teachers engaged in cycles that involved planning, enacting, analyzing, and revising their science lessons while comparing their goals for practice to the actual practices they enacted in their classrooms. In addition, teachers engaged in analyzing and providing feedback for each other’s videotaped lessons. The conversations and meetings were transcribed and analyzed through open coding. This study illustrates the use of reflection as a tool to help beginning teachers move toward reform practices during the period of induction.

Whereas the assertions made by Danielowich regarding critical self-reflection are worth noting, only one of the four teachers in the study taught a large number of ELL students; this complicated the cross-case comparison presented in the research manuscript. Although the study revealed the potential benefits of engaging early career science teachers in critical self-reflection, the field can benefit from a similar study that involves a larger number of participants who have ELL students in their classes.

Induction programs can also facilitate self-reflection for early career science teachers. For instance, Luft and Patterson (2002) reported that during a science-specific induction program early career high school science teachers engaged with university researchers in self-reflection about their practice and about their development. Self-reflection in combination with other interventions geared to promote inquiry enabled the early career science teachers to implement reform-based practices in their classrooms. The authors did not disaggregate the data based on student characteristics, nor was there an emphasis on helping the teachers reflect on their ELL students. More research is needed on the role of
early career science teacher reflection focused on inquiry practices in classroom with high numbers of ELL students and its role on the implementation of student-centered practices.

**Contextual Factors and Early Career Science Teacher Learning**

Teaching and learning are sociocultural activities shaped and influenced by its participants and by the context of the classroom, school, and district. The sociocultural nature of teaching and the influence of contextual factors on teacher learning serve as a frame to understand the learning trajectory of the participants. In this study, the notion of teacher learning as a socially constructed activity that is part of an intertwined system of interacting components serves to frame the changes in PCK and practices of the participants (Engeström, 1999). Several studies have identified the role of school and classroom cultures in the implementation of reform-based practices (Avramidou & Zembal-Saul, 2010; DeSouza & Czerniak, 2003; King et al., 2001; McGuinnis et al., 2004; Lains et al., 2009).

In a multiple case study of beginning science and math teachers, McGinnis et al. (2004) found that the beginning teachers’ perception of the culture of the school – specifically the views of colleagues and administrators regarding science inquiry – was a major factor influencing the implementation of reform-based practices. The beginning teachers in the study displayed one of three responses: (a) resistance as they implemented reform-based practices is spite of their colleagues’ traditional practices, (b) avoidance by leaving their school after one or two Years, or (c) compliance by adopting their colleagues’ traditional practices.
Of particular interest from this study is the analysis of the individual attributes and circumstances of the participants and the role these played on their responses. Another important implication is the need for professional development focused on reform-based practices to all teachers, regardless of their years of teaching experience. This type of professional development may foster the development of a school culture that embraces inquiry practices and supports early career science teachers as they solidify their practices during the induction phase of their careers.

Finally, factors such as content knowledge and support also have been identified as constraints to the implementation of reform-based practices. King et al. (2001) found the lack of content background to hinder the implementation of student-centered practices, whereas DeSouza and Czerniak (2003) indicated that teachers perceived factors, such as availability of time, limited access to technology and other facilities, and the lack of support from school personnel, were impediments to providing effective science instruction to diverse students.

**Areas in Need of Research**

In this review, I discussed two major areas of research: beginning science teacher learning in urban schools during the preservice and induction phases (Bianchini & Cavazos, 2007; Buck et al., 2005; Ensor, 2001; Lee, 1999, 2002; Lee et al., 2007) and the role of contextual factors on teacher professional learning and implementation of reform-based practices (Avramidou & Zembal-Saul, 2010; DeSouza & Czerniak, 2003; Lains et al., 2009; King et al., 2001; McGinnis et al., 2004). Few preparation programs emphasize teaching practices to help ELL students succeed in the science classroom. Although the research
findings support the positive impact of induction intervention on teacher learning (Luft, 2007, 2009; Luft & Cox, 2001; Mamoud, 2000), few studies document the longitudinal changes on PCK and practices of beginning secondary science teachers who have high numbers of ELL students (Bianchini et al., 2003; Danielowich, 2007; Stoddart, 2005). More research studies that investigate the role of science specific induction programs on beginning secondary science teachers learning to teach ELL students will help in delineating critical areas of induction support. Ultimately, induction support programs will strive to meet the goal of scientific literacy for all students established by major reform documents AAAS (1993), NRC (1996), and NSES (2001).

The research questions posed by the studies reviewed in this manuscript probed teacher learning, attrition rates, and changes in the way teachers viewed their students as a result of induction support. Few studies were directly related to early career science teachers in secondary settings, and even fewer involved early career science teachers of ELL students in urban high schools. From the review, I conclude there is a need for longitudinal studies involving multiple case studies with the thick description of narrative to provide a detailed and comprehensive account of how early career science teachers in urban schools learn to teach science to ELL students.

**Implications**

The field of teacher learning and induction could greatly benefit from research studies related to how science specific induction programs support early career science teachers who have ELL students in their classrooms as they learn
and implement reformed-based practices. The information gathered from this line of inquiry will help in the design and implementation of programs geared to increase the numbers of effective science teachers in urban schools. Effective support for these teachers requires a prolonged, sustained collaborative effort between schools, districts, and universities. The assistance of government funding agencies is vital in supporting and retaining early career science teachers in hard to staff urban schools that serve the majority of ELL students in the United States.
CHAPTER 3

Methodology

Chapter Overview

Chapter 3 presents detailed information regarding the participants’ background, the methodological framework, instruments, and data collection methodology employed for this multiple case study. In particular, the design and validation of the LIST which served to analyze the practices of the participants. Details on the process of open and axial coding using the constant comparative method (Glaser, 1965) as described in Lincoln and Guba (1985) to generate codes and themes from different data sources will be provided. A discussion of disconfirming evidence will be included in the last section of this chapter.

The goal of this study was to analyze how six early career content specialists, who received science specific induction support, developed their PCK and practices during their initial five years in the classroom. A multiple case study with cross-case comparisons research approach with qualitative analysis was deemed necessary for this longitudinal study. Yin (2009) compares multiple case studies to conducting multiple experiments. In this study, each case serves as a replication of the instance of teacher learning (Campbell, 2009).

The issue of retention of reform-minded, qualified early career teachers has become more poignant with the marked increase in cultural and language diversity of the student population in the United States and abroad. All children, regardless of their cultural and language background must have access to quality education in order for nations to remain competitive in the global economy. This
research study focuses on the learning trajectory of early career science teachers who have ELL students in their classrooms. The goal of this dissertation research project is to present a nuanced account of the affordances and constraints surrounding the participants as they attempt to implement reform-based practices in their science classrooms. All six teachers initiated their careers and remained for five consecutive years in urban schools in the same metropolitan area in the southwestern United States.

The multiple sources of data, as well as the extended period of observation facilitate the detailed, rich account possible through a case study approach. Case study research is the in-depth study of one or more instances of a phenomenon in its real-life context that reflects the perspective of the participants involved in the phenomenon (Gall, Gall and Borg; 2007). By using multiple cases, I intend to look for disconfirming evidence, contrast, similarities and patterns across all six cases and among the three groups of teachers. According to Miles and Huberman (1994):

> Multiple cases offer a deeper understanding of processes and outcomes of cases ... and a picture of locally grounded causality.... Multiple case sampling adds confidence to findings. By looking at a range of similar and contrasting cases, we can understand a single-case finding … strengthen the precision, the validity and the stability of the findings. (p. 29)

A multiple case study is necessary when the unit of analysis consists of a phenomenon that is highly contextualized is being investigated (Stake, 1995). In
this research project the unit of analysis is the change in PCK and practices of six early career science teachers. In particular, this multiple case study with cross-case comparisons was conducted to understand the role of affordances and constraints on the PCK and practices of six the participants during their first, third, and fifth years in the classroom.

**Sampling**

The six teachers, whose trajectory constitutes the subject of this study, were a subset of 32 beginning secondary science teachers who participated in a two-year science-specific induction support program. Initially, all of the induction program participants were purposefully selected from teacher preparation programs local to the principal investigators of the study. Subsequently, to answer the questions formulated by this study, six beginning teachers (Martina, Kelly, Jim, Cindy, Enid, and Alana)\(^2\) were selected from the original group. Four of the participants (Martina, Kelly, Jim and Cindy) were selected because they taught ELL students. The students were classified as ELL according to the standardized state assessment test administered short after initial admission into the school, and every year at the end of the school year.

**Criteria for grouping and selecting participants.** The decision to select six teachers who taught high, moderate, and low percentages of ELL students was made earlier on in the design phase of the study. There were three related goals considered for this decision: a) to present a thorough analysis of the

\(^2\) Pseudonyms were used to protect the anonymity of the participants
circumstances surrounding the longitudinal trajectory of early career teachers who had ELL student in their classroom, b) to provide contrast, and c) to discard alternative explanations by looking at disconfirming evidence.

Martina and Kelly taught in schools with a student population comprised of 85% ELL students. For the purpose of the study, these two teachers were considered to have a high percentage of ELL students. Similarly, Jim and Cindy taught at schools where 40% of the students were classified as ELL. Cindy and Jim comprise the moderate percentage of ELL students group. Two additional participants (Enid and Alana) were selected as contrasting cases because they had few to no ELL students in their classrooms, and they comprise the low ELL group. Finally, the six participants were still teaching at the end of Year 5, all had complete data sets and could provide the necessary information to answer the research questions (Maxwell, 2007). The six participants had a bachelor’s degree and worked in urban middle schools and high schools located in the metropolitan area of a large city in the southwestern United States. Their average class size was 23 students and the average school size was 1,350 students. An overview of the participants can be found in Table 1.
## Table 1

### Characteristics of Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Degree/Certification</th>
<th>Length of Student Teaching Experience</th>
<th>Coursework related to science teaching</th>
<th>Prior Teaching / Research Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martina</td>
<td>Bachelor of Science/Geology</td>
<td>16 weeks</td>
<td>After school elementary science program / None</td>
<td>Informal teaching of homecare with hospital patients and their families / Medical research.</td>
</tr>
<tr>
<td>Kelly</td>
<td>Bachelor of Science in Nursing, Masters in Secondary Education/Science</td>
<td>16 Weeks</td>
<td>Science Teaching Methods I and II; Topics in Science Education; Secondary Curriculum</td>
<td>None/ Undergraduate fieldwork and research; Fish and Wildlife</td>
</tr>
<tr>
<td>Jim</td>
<td>Bachelor of Arts, Masters in Education</td>
<td>16 Weeks</td>
<td>Science teaching methods; Theory of Education; Special Education</td>
<td>None/ None</td>
</tr>
<tr>
<td>Cindy</td>
<td>Bachelor of Science in Information Systems, Masters in Educational Leadership</td>
<td>None</td>
<td>History and Philosophy of Science</td>
<td>None/ None</td>
</tr>
<tr>
<td>Alana</td>
<td>Bachelor of Science in Education/Biology</td>
<td>16 weeks</td>
<td>Science Teaching Methods; Topics in Science Education</td>
<td>None/ None</td>
</tr>
<tr>
<td>Enid</td>
<td>Bachelor of Science in Food and Nutrition with a Chemistry minor, Masters of Education/Secondary Science Certification</td>
<td>16 weeks</td>
<td>Science Teaching Methods; Science Laboratory</td>
<td>1 year teaching 4&lt;sup&gt;th&lt;/sup&gt;-8&lt;sup&gt;th&lt;/sup&gt; grade science in a parochial school</td>
</tr>
</tbody>
</table>
Teachers with high percentages of English Language Learner students. What follows is a basic description of each participant.

Martina. Martina's decision to study science resulted from the childhood outdoor experiences, from her father’s intense interest in science, and from her experience taking an introductory Geology course. In the initial interview, she shared the following:

My dad was constantly tinkering with things and doing experiments. I decided to become a teacher because I wanted to share my love of science with students. I enrolled in an introduction to geology course in college, and my professor was amazing! He discovered the first frozen woolly mammoth in Alaska. That’s when I knew that I wanted to teach earth science.

(Martina, Initial interview, August 15, 2005)

Martina's maternal grandmother was also an influential figure. According to Martina:

Growing up, I spent the summers with my grandmother who spoke to me in Spanish all the time. She worked for the court system as a bilingual interpreter. I admired her because she was educated and she helped people who otherwise would not have a voice. She was able to do her job well because she knew how to speak, read and write in Spanish and English. When I think about what's important for my ELL students, I think of her. I know that I have to make sure
my students learn how to read and write in English so they can be successful in college.

(Martina, member check interview, August 10, 2010)

Martina earned her bachelor’ degree in Geology with a minor in education and obtained her teaching credentials from a state university in the southwestern United States. Her coursework included general teaching methods and science teaching methods. While completing her degree Martina managed an after school science program while attending college. Martina taught 8th grade General Science for the initial two years of her career at an urban middle school with 85% ELL students. At the end of year two, she resigned her position and accepted a position as a Biology teacher at a high school nearby. The new school had a demographic composition similar to the middle school where she taught in Years 1 and 2.

**Kelly.** Prior to becoming a science teacher Kelly was a nurse for 25 Years. She decided to become a science teacher because she enjoyed the teaching aspects of nursing such as teaching patients and their families about post-operative care. She also knew that there was a shortage of good science teachers and she wanted to contribute to “the need for good science teachers”. Kelly attended a major university in the southwestern United States and graduated in a year from an accelerated science education masters program.

Her teaching preparation program included several foundational education courses as well as science methods (see Table 1). Her student teaching experience lasted for 16 weeks. She began her teaching career at an urban school where there
were 80% ELL students, and 94% of the students received free or reduced lunch. Kelly taught General Science at the same school for the entire time encompassed by this study.

**Teachers with moderate percentages of English Language Learner students.**

*Jim.* Jim graduated with a Bachelor of Arts from a university in the Midwestern United States. After graduation, he worked in a government agency but found the work unchallenging decided to go back to school to become a science teacher. When asked why he decided to become a teacher Jim replied:

My path to becoming a teacher was a long and winding road. I never thought I would become a teacher because I was an introvert. By the time I graduated from college, I saw an opportunity to become a Teach for America in Mississippi. At the end of the 2-year program there was no warranty I would be licensed. I ended up getting a 9 to 5 job in Florida with Fish and Wildlife Management. This job was boring, not very challenging. I wanted a more dynamic, challenging environment. I went back to school for my masters in education with a Biology certification. (Jim, Initial interview, July 12, 2005)

Jim began teaching in a suburban high school where there were 25% ELL students. The parents of these were migrant farm workers. The school demographics were rapidly changing as affluent families build new houses in what used to be farmland. At the end of year, one Jim left the high school and
moved to an urban school in the metropolitan area of a major city in the southwestern United States. In this new school, there were approximately 40% ELL students. He taught at that high school for the following four Years.

Cindy. Cindy worked in the healthcare system for 18 Years as a nurse and as a hospital administrator before deciding to become a teacher. She obtained a Masters degree in Educational Leadership and accepted a position as a science teacher with an emergency certification. Cindy did not participate in student teaching. Her coursework did not include courses in History and Philosophy of Science, Science Methods or the Nature of Science. When asked what motivated her to become a teacher, she had this to say:

I wanted do to something important that I could consider a career. I considered adult learning and development and decided to obtain a Masters in Educational Leadership. Then the opportunity to become a middle school science teacher came up and I decided to try it. It would mean having to take classes after teaching all day, but I decided to do it. (Cindy, Initial interview, September 11, 2005)

Cindy began teaching general science at a middle school where there were 30% ELL students, and 84% of all students received free or reduced lunch. By the end of the school year, she had not completed all certification requirements and her contract was not renewed. As a result, she left that school and after completing credentialing requirements during the summer, she became certified. From Years 2 through 5 Cindy taught 7th General Science at a middle school
where there were 20% ELL students, and 47% of all the students received free or reduced lunch.

**Teachers with low percentages of English Language Learner students.**

**Enid.** Enid had originally intended to obtain a bachelors' degree in Food and Nutrition with the intention of teaching high school Health and Nutrition. On the last year of college, she realized that these subjects were taught as part of the physical education curriculum. Two factors influenced her decision to become a high school chemistry teacher: she did not have enough credits to become certified in physical education, and she only needed a few classes to obtain her teaching credentials in Chemistry. In her own words:

> I always enjoyed science. When I realized that I did not have enough time to become P.E. certified, I figured that the shortest route into the classroom was to become a Chemistry teacher.

(Enid, Initial interview, August 21, 2005)

Enid taught at the same high school for her initial five years in the classroom. In this school students were from middle and high socioeconomic status and less than 1% of the students were ELL students and 4% of the total school population received free or reduced lunch.

**Alana.** Alana decided to become a teacher during her sophomore year in high school. Although she was always good in science, it was the
encouragement she received from a science teacher that made her decide to become a teacher:

    My teachers were role models for me. I saw how they lead happy, stable lives, and how they enjoyed teaching. When I thought about what I wanted in life, and how science is complex and explains the whys of the natural world: why there is life on earth, why there is gravity; I decided then to become a science teacher. (Alana, initial interview, August 25, 2005)

She began her teaching career teaching science at a middle school where the majority of the students were from affluent families. At this school, less than 1% of the student population was classified as ELL, and 5% of all students received free or reduced lunch. At the end of Year 3 she felt that other teachers in her department did not support inquiry teaching and were no longer helping her to grow as a teacher. She left the school and took a position as a Biology teacher at a high school that had 5% ELL students and 15% of all students received free or reduced lunch. She taught at the high school for the next two years.

**The induction support program.** All six teachers participated in the Alternative Support for Induction Science Teachers (ASIST) program, a science-specific induction program for secondary science teachers that emphasized the enactment of science inquiry and engaged teachers in reflective practice (see Luft, 2001). All ASIST participants attended monthly workshops taught by a university professor, consulted with induction program mentors about their practices, were observed monthly, and attended a state science-education conference. The first
year of the ASIST program focused on providing instructional support in the area of science as inquiry (NRC, 1996). During the second year, the ASIST participants engaged in a process of self-reflection by analyzing videotapes of their instruction with the assistance of induction program staff. Data in the form of monthly digitally recorded phone interviews, classroom observations, and end of the year interviews were collected on the participants during the two years they participated in the ASIST program and during Years 3, and 5 of their teaching career. For the purpose of this study, I am analyzing data from Years 1, 3, and 5.

**Data Collection**

Three forms of data were collected for this study: PCK interview, classroom practices, and general interviews. The semi-structured nature of the interviews allowed the participants ample time to share their views and opinion (Seidman, 1998). Triangulation was obtained by collecting multiple sources of data pertinent to the naturalistic character of the research, and to the questions guiding the study (Yin, 2009). Throughout the process of data analysis, a process of peer debriefing was followed to maintain objectivity. Equally important to the validity and credibility of this study was the inclusion of the participants' or emic perspective through the process of member check (Lincoln & Guba, 1985). This process was achieved by asking the participants to corroborate the interpretations that emerged from the data analysis.

**The pedagogical content knowledge interview**. The first form of data was the participants’ responses to the PCK interview developed by Lee, Brown, Puthoff, Fletcher and Luft (2005). The participants' answers to the interview
questions were coded with a scoring map developed by Lee, Brown, Luft and Roehrig (2007) (see Appendix E). According to Lee et al., the PCK interview coding map has an inter-rater reliability of 90%. The interview was digitally taped, and took between 15-20 minutes to complete. Briefly, the five questions that comprise this interview focus on knowledge of students’ needs (students difficulties, variations in learning approaches, alternate conceptions of natural phenomena), and knowledge of instructional strategies such as inquiry student learning. During the interview process, the participants were asked to respond to the questions and elaborate on the responses by providing examples. Ultimately, the interviewers sought responses that achieved theoretical saturation (Strauss & Corbin, 1990).

The validity of this interview was maintained by adhering to the coding protocols described by Lee et al. (2007). Briefly, two researchers coded each set of responses separately. Afterwards, the researchers discussed the values assigned to each interview item. In instances where discrepancies arose, a third researcher was called in to weigh in on the discussion and decide the final score. In addition, and for the purpose of this dissertation, the interview transcripts were read line by line with NVivo8 to identify codes. These codes were later compiled to generate a visual representation of the participants' PCK changes over the three years of data included in this study.

**Classroom practices.** The second form of data involved classroom practices. Teacher practices were captured by using two methods: observations of practice and interviews about practice. Classroom observations took place four
times throughout the school year for Years 1 and 3, and two times during Year 5 (see Table 2). The observations of teachers were conducted four times during each year. During an observation, observers wrote down the salient activities performed by both the students and the teacher in five-minute intervals.

Table 2

*Data Collection Schedule*

<table>
<thead>
<tr>
<th>Year</th>
<th>Data source</th>
<th>Phase</th>
<th>Collection schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Initial interview</td>
<td>1</td>
<td>Prior to teaching</td>
</tr>
<tr>
<td>1, 3, 5</td>
<td>Monthly interview</td>
<td>2</td>
<td>Eight times per year</td>
</tr>
<tr>
<td>1, 3, 5</td>
<td>Classroom observations</td>
<td>2</td>
<td>Four times per year</td>
</tr>
<tr>
<td>1, 3, 5</td>
<td>General interview</td>
<td>3</td>
<td>End of the school year</td>
</tr>
<tr>
<td>1, 3, 5</td>
<td>Pedagogical content knowledge interview</td>
<td>3</td>
<td>End of the school year</td>
</tr>
<tr>
<td>5</td>
<td>Member check interview</td>
<td>3</td>
<td>End of Year 5</td>
</tr>
</tbody>
</table>

Subsequently, the intervals were coded following the Collaboratives for Excellence in Teacher Preparation Core Evaluation Classroom Observation Protocol (CETP-COP) by Lawrenz, Huffman, Appeldoorn and Sun (2002). This instrument was piloted, field-tested, norm-referenced and refined to document the instruction of science and mathematics teachers. In order to ensure correct use of the instrument, researchers participated in initial training sessions. Every year thereafter, the research team held calibration meetings to ensure fidelity of implementation of the protocol. The observations were conducted during a period that had no interruptions caused by school breaks or standardized testing. The classroom observations followed a format of participant observation discussed in
Bogdan and Biklen (2006). This required observers to take on an unobtrusive role. Interruptions and other peripheral details were recorded to provide information about the immediate classroom context. The analysis of the observation notes was conducted with the LIST developed by Ortega, Wong, Firestone and Luft (2009). The previously coded intervals helped determine the amount of time devoted to the implementation of teach language domain during the observation. More details on the analysis will be discussed later in this chapter.

Interviews about practice were captured during eight monthly, semi-structured telephone interviews that were digitally taped. The interview sought to identify instructional practices described in Lawrenz, Hoffman and Gravely (2007) (see appendix C). These interviews occurred during a predetermined two-week window of data collection. During these interviews, the participants described one week of lessons. Details such as classroom organization, teacher and student actions, type of activity, curriculum sources, and use of technology were obtained for each day of reported practice.

All reported practices and details of classroom organization over the course of each year were subsequently recorded and tallied using an Excel spreadsheet. In order to capture rich detail regarding the circumstance surrounding the teachers during the school year, the participants were asked to reflect on their ability to motivate and assess students, about participation in professional development, added responsibilities and overall classroom climate, and any other details regarding their teaching that they deemed pertinent. For the present research study, 24 monthly interviews per participant were analyzed (for a
total of 144 interviews). In cases where unforeseen circumstances precluded the collection of a monthly interview, a makeup interview was conducted in the month of May. The interviews were conducted shortly after the lessons occurred to maximize the accuracy of the teacher's account and to minimize the loss of details.

As the study progressed, the research group employed an iterative approach that allowed for the modification of questions (see Appendix B). This decision was based on the evolving nature of teacher learning and on the complexities of authentic contexts such as classrooms. The longitudinal nature of the study and the extended period of data collection helped in building rapport with the participants. Additionally, during the initial two years of the study, the participants received instructional support and mentoring by members of the research team. Research bias was controlled by randomly assigning researchers to conduct and code the study interviews. This process increased the relative neutrality of the data collection and coding (Guba and Lincoln, 1985).

The third form of data came from semi-structured, digitally taped interviews conducted at the onset of the participants’ initial teaching year, and at the end of Years 1, 3, and 5 thereafter. The interviewer took extensive notes during these four interviews following the guidelines of Bogdan and Biklen (2006). Initially, the interview captured basic information about teaching that consisted of college major, length of student teaching experience, and basic school demographics such as socioeconomic status, class size and duration of class periods (see appendix I). In addition, information regarding the participants'
motivation for becoming a science teacher, as well as the nature and quality any prior teaching experience besides student teaching were ascertained during the initial interview. Other questions were aimed at determining the participant’s initial concerns and expectations of teaching. Over the years, the participants were asked to compare the support they received on instruction and curriculum that year from their mentor, colleagues, and administrators with the support received in previous Years (see Appendix J).

Data Analysis

In this study, data were analyzed by using three separate methods. The PCK interview was analyzed with the PCK coding map (see Appendix F) developed by Lee, Brown, Luft, and Roehrig (2007). Interview data were analyzed using elements from analytic induction (Bogdam, & Biklen, 2006) and the constant comparative method described by Lincoln and Guba (1985). The third method involved the analysis of teachers’ practices, and it was conducted by using the LIST rubrics and the coding interval chart included in the CEPT-OTC observation protocol by Lawrenz et al. (2002). The LIST was used to identify the level of inquiry implemented by the beginning teacher during the observation, as well as the use of vocabulary and the implementation of reading, writing, speaking and listening by the students and the teacher during the observed practices.

The pedagogical content knowledge interview analysis. Two researchers coded the participants’ answers independently and then collectively using a coding map; any discrepancies were solved by a third coder. The answers were quantified by assigning the following values to the responses: limited, basic,
or proficient. A response coded as limited if the teacher had limited or acknowledgement of students’ prior knowledge, variations in learning or difficulties with learning the content and if the teacher did not attempt to address these factors in the lesson. Likewise, an answer was coded as limited if the teacher used only one approach to instruction, and if the teacher had limited to no knowledge of how to implement inquiry. A basic score was given to a teacher if some attempt was made to incorporate prior knowledge; if the teacher implemented different approaches to address variations in learning style or difficulties without student input or if the teacher dealt with misconceptions in a limited way.

Regarding knowledge of inquiry practices, a basic score was assigned if the lesson described by the teacher had some, but not all of the features of inquiry. The designation of proficient was used if the teacher incorporated student’ prior knowledge, addressed misconceptions and students’ difficulties with learning in the lesson. Regarding knowledge of inquiry practices, a proficient code was assigned if the teacher provided an example of a lesson that had most of the features of inquiry or if when prompted, the teacher was able to describe modifications that incorporated the features of inquiry to a previously described lesson.

**Analytic induction and the constant comparative method.** A total of 24 monthly interviews, one initial interview, and 3 end of the year interviews from each participant were analyzed following thematic analysis methodology (Lapadat, 2009) and the constant comparative method as described by Lincoln
and Guba (1985). This involved reading the interview transcripts multiple times to identify the occurrence of pre-established codes and recurrent themes, topics or relationships, and marking similar passages with a code or label derived from CHAT. The following pre-established themes derived from the CHAT framework activity system analysis (Engeström, 1998) were: a) subject: the teacher, b) object: PCK and teaching practices, c) rules: state, district, school and department rules, mandates and regulations, d) community: the interactions between the teachers and students, colleagues, administrators and mentors, e) division of labor: functions performed by colleagues, mentors, university personnel and administrators to support the teacher, f) mediating artifacts: teacher artifacts including lesson plans, tests, worksheets and media, and g) outcomes: implementation of inquiry practices such as science inquiry and academic language practices.

A time ordered meta-matrix was used to help in identifying common concerns and affordances experienced by the participants over the Years documented in this project (Miles and Huberman, 2004). Finally, patterns, themes, and contradictions were identified both within each group and among the three groups of teachers (Miles and Huberman, 1994). The relationship among the different areas of PCK development and teacher practices for each participant and for each of the three groups of teachers was represented using a conceptual model graphic representation (see Figure 1) based on the CHAT activity system model (Engeström, 1998).
The Language and Inquiry Science Tool analysis. The second step of the analysis focused on understanding the nature and longitudinal development of the participants’ practices and included 10 classroom observations, 4 observations per year from Years 1, and 3, and 2 classroom observations from Year 5 from each participant. The notes were analyzed with the LIST developed by Ortega, Wong, Firestone, and Luft (2009). The LIST consists of three coding rubrics that help determine the level of inquiry, the language domains, and the type of vocabulary implemented by the students and the teacher during classroom observations (see Appendices A, B, C). The rationale and implementation of each rubric will be explained in the next sections.

**Level of inquiry rubric.** The level of inquiry implemented by the teacher and the students during the classroom observations was determined from the categories and descriptors based on The National Science Education Standards [NSES] (National Research Council [NRC], 1996). According to the NSES (1996), inquiry activities can be classified into four different levels or categories depending on the structure and cognitive demand of the task: a) open-ended inquiry laboratory/activity – students develop their own question to explore, along with determining the experiment and modes of data collection; b) guided inquiry/activity – the teacher provides the question, and the students are free to answer the question as they see fit; c) directed inquiry laboratory/activity – the teacher provides the question and the mechanism to answer the question. The rubric also included verification/ process activities to ascertain any changes in the frequency implementation of non-inquiry based practices over time.
**Language domains rubric.** The language domains rubric was designed to help determine the relative frequency of implementation of academic language domains: reading, writing, reading, and listening (Echevarria & Graves, 2007). The use of the domains pertains to the students interacting with one another and with the teacher as well as with printed material and electronic sources of information. In order to determine the implementation of language domains the observation notes were read and instances of language domain implementation were recorded. For instance, when the students participated in a small group discussion, the page and line number of actual text were indexed in a case dynamics matrix (Miles & Huberman, 1994) under the categories of listening and speaking (see appendix D).

The language domains rubric contains categories where one, two, three or all four language domains are implemented by the students and the teacher as they engage in science activities. Ideally, three or four language domains should be present in the lesson (Dejong-Filmore, & Snow, 2002; Ortega, et al., 2009). The time allotted to each activity was determined from examining the observation notes and the five-minute coded intervals from the CEPT-OTC observation protocol by Lawrenz et al. (2002). Depending on the implementation and length of time the students and the teacher engaged in different language domains (speaking, listening, reading and writing), the lessons observed were classified as **beginner, emergent, intermediate, or proficient. A beginner status was assigned** if only one language domain was salient (implemented during 50% or more of the total observation time. If a language domain was implemented for less than 50%
of the observed lesson, this was an indication that the students were engaged on more than one language domain during the lesson,

This decision was based on the analysis of data from a pilot case study (Ortega & Luft, 2010, in review). For instance, if the students were observed reading text for 25 minutes out of the total 50 minutes comprising an instructional period, a rating of emergent was assigned to observations of practices where two language domains were implemented with at least 40% of the instructional time devoted to each of the language domains. An intermediate rating was assigned to lessons where three language domains were each implemented for at least 30% of the instructional time. The category of balanced was used for observations of practice in which all 4 language domains occurred throughout the lesson with 20% of the instructional time allotted to each of the four domains. Time allotted to administrative or managerial tasks, or to non-science instruction was not included when calculating the percent time dedicated to each domain.

Vocabulary tiers rubric. The vocabulary tiers rubric helped analyze the observation notes and teacher artifacts. The vocabulary of science is complex and specific to the discipline (Snow, 2008). For ELL students in particular, learning content vocabulary is dependent upon contextual cues. Vocabulary can be classified in three levels or tiers. The non-academic vocabulary words fall into two different tiers. Tier one vocabulary includes the words that are used to name concrete objects and actions used in everyday experience. For instance, the words food, sky, and pencil belong to tier one. Words that are important in negotiating
cognitive and performance inquiry tasks (i.e., compare, contrast, measure, discuss, observe, graph, and analyze) belong two tier two. These are usually verbs and indicate student engagement within the context of the science lesson. Finally, vocabulary terms that are discipline-specific, also known as register, specific to science i.e. photosynthesis, inertia, and igneous (Beck, McKeown, & Kugan, 2002; Joos, 1961; Snow, 2008).

The analysis of vocabulary tiers was conducted by reading observation field notes and teacher artifacts (i.e., worksheets, tests, and other printed or electronic materials used by the students). Words were recorded under one of the three vocabulary tiers in the LIST coding matrix. The number of words in each tier was totaled. Using the vocabulary rubric, vocabulary practices were classified as beginning, intermediate or proficient. The rating of beginner was assigned to lessons that relied on the usage of tier one vocabulary terms. This category was assigned to content-poor lessons. The category of intermediate was used to denote lessons that contained a preponderance of two language tiers. There were three subsets of lessons included in this category: A lesson that included tiers one and three vocabulary in which students were exposed to de-contextualized vocabulary with an emphasis in understanding the registry of science by using less complex definitions. A lesson that consisted of tier one and two included students using simplified vocabulary while interacting within the context of science; this lesson lacked the usage of science registry. The last subset involved a lesson in which students engaged in the use tier two vocabulary and complex tier three vocabulary terms. Whereas this science type of vocabulary implementation may promote the
achievement of intermediate and advanced ELL students, it does not address the needs of beginners (Ortega et al., 2009). A proficient lesson involves the usage of vocabulary words from all three vocabulary tiers. During this type of lesson, students interact with science vocabulary in a contextualized manner; the vocabulary needs of beginning, and intermediate ELL students are addressed by careful scaffolding of tier three vocabulary terms.

**Validation of the Language and Inquiry Science Tool.** The LIST was validated over the course of two semesters during the 2008-2009 academic year. Preservice teachers enrolled in three different sections of a science methods course participated in the study. The main author of this manuscript taught the fall semester section to 23 preservice teachers. As part of the required coursework, preservice teachers were directed to write a science lesson in a descriptive narrative format that explained teacher and student interactions throughout the lesson. The information obtained from the first pilot run of the LIST was used to create a second iteration of the LIST. The spring semester involved preservice teachers from two sections of the same science methods course taught by one of the authors of this manuscript. Preservice teachers in the experimental groups were directed to use the LIST rubrics as a guide to generate their science lesson plan. The preservice teachers enrolled in the second section were introduced to the use the LIST after they submitted their lesson plans. This strategy allowed us to have a control group for comparison and statistical analysis. All three sections were involved in this study were similar in that instructors used the same syllabus and instructional materials. Preservice teachers in the experimental groups were
directed to use the LIST rubrics as a guide to generate their science lesson plan. Each lesson plan was scored separately by both the main author and the fall course instructor who then compared and discussed their scores. The inter-rater reliability value was 0.85. A t-test analysis indicated that the lesson scores of preservice teachers who used LIST ($M = 90, SD = 4.50$) were statistically significantly higher than the scores of the control group ($M = 78, SD = 4.00$), $t (39) = 2.07, p < .05$.

**Validity and Reliability**

The multiple approaches to collecting and analyzing the data followed guidelines for multiple case studies. This strategy integrates the case-oriented and variable-oriented approaches described by Miles and Huberman, (1994). This approach is characterized by "the cycling back and forth, or synthesizing of strategies aimed at understanding case dynamics and at seeing the effect of key variables" (Miles & Huberman, 2004, p. 208). For triangulation purposes, multiple pieces of data were collected throughout the duration of the study (Yin, 2009).

Additionally, reported practice interviews coincided with the classroom observations discussed previously. For analysis purposes, I compared the teachers' description of the lesson with the observer's account prepared during the observation. By analyzing each case separately, unique features of each case were preserved. Subsequently, longitudinal cross-case comparisons allowed the identification of recurrent patterns and discrepancies within groups, as well as among the three groups of teachers. The validity of this study was obtained by
implementing qualitative an interactive and cyclical process involving data collection, display and conclusion drawings/verification (Miles & Huberman, 1994)

In this chapter, I discussed the research design and methodology employed for this study. First, I described the background and preparation of the six participants selected for this multiple case study, and presented a rationale for selecting the participants. Next, I discussed each instrument used for data collection and analysis as well as the type of data collected for the study. Finally, I provided a detailed description of the analysis procedures implemented in the study. In the next chapter of this manuscript, I will share the results of the multiple case study. I will discuss the salient aspects of each case by answering each of the original research questions. I will compare the individual cases within each of the three groups of teachers. I will then discuss similarities and discrepancies regarding teacher knowledge and practices, contextual factors, as well as instances of disconfirming evidence among the three different groups of teachers.
CHAPTER 4

Findings

The first part of Chapter 4 includes a description of each case with comparisons within each of the three teacher groups. This section is divided into three sections, one section for each group. Within each section there is a description of the participants' classroom and school context with a detailed description of teacher practices focused on inquiry and language and on the changes in PCK experienced by the participants throughout Years 1, 3, and 5 of their teaching careers. The sub-sections for each participant begin with the interactions between the teacher and different contextual elements, such as students, mentor, colleagues, administrators, and policies at the school, district, and state levels. Collectively, these factors are presented through the theoretical lens of CHAT. Details of longitudinal changes in PCK, inquiry implementation, and language practices are presented in juxtaposition to the contextual affordances and constraints surrounding the participants.

The second part of the chapter consists of cross-case comparisons among the six teachers, based on salient themes directly related to the original research questions. This includes an analysis and discussion of the context, PCK, and practices across the three groups. I conclude with a discussion of the state mandate for self-contained English instruction for ELL students and the impact

2 Note: The three groups were initially determined by the overall percentages of ELL students in the teachers’ classrooms during their first year in the classroom.
this mandate had on the classroom culture and practices for some of the participants.

Section 1: Teachers with High Percentages of English Language Learner Students

I selected Martina and Kelly from the larger pool of ASIST participants because they were representative of the teachers who began their careers in school settings with high percentages of ELL students. Unique and complex individuals, they were both hired to teach middle school General Science during their initial year in the classroom. They differed in their perceptions of students' needs, on their views and approaches to dealing with contextual factors, and in how they each met the language and academic needs of their students. I discuss each of their cases separately. Subsequently, I compare salient aspects of their context, PCK, and practices.

The case of Martina. The analysis of data collected about Martina in Years 1, 3, and 5 of her teaching indicated changes in the contextual factors surrounding her, as well as in her PCK and classroom practices. In the following paragraphs, I address these changes and answer the research questions. The affordances surrounding Martina during Years 1, 3, and 5 were (a) the induction support available through ASIST and through the school district, (b) a school-based mentor, (c) a comprehensive science curriculum provided by the school district, and (d) professional development on strategies for teaching ELL students. The salient contextual constraints surrounding Martina during the same time
period were associated with pressure derived from district and state rules and mandates.

**Division of labor.** This category of the CHAT activity triangle (Engeström, 2009) is part of the social context surrounding the professional learning of teachers. For Martina, as well as for the other five teachers in this multiple case study, the division of labor includes any support they received from the ASIST program, induction support available from their district, and assistance received from mentors. Additionally, this category included any form of professional development available through the district, local universities, or conferences.

In Year 1, Martina was an active participant in the ASIST program. She consulted with the ASIST mentors and attended the monthly professional development workshop offered at the university by the principal investigator and the graduate assistants. She then went to her classroom and implemented the inquiry lessons she learned at the workshops. She shared the following about the value of the ASIST program:

Any time I had a question about a unit I would email the ASIST mentors and other teachers in ASIST and get answers right away. I started considering inquiry more because of the ASIST program. At first, I was just trying to get through. After I began the ASIST workshops, I started to think more about the 5E model of inquiry. I thought about my teaching and considered my students’
performance on the assessments. When I was going through the induction program, we would do an inquiry lesson each month. I would learn a lesson and then teach it to my students. (Martina, member check interview, August 10, 2010)

Science-specific induction made an impact on Martina’s implementation of inquiry. Through the program's professional development and support, she learned about inquiry and how to implement it in the classroom with her ELL students. When asked to describe an inquiry lesson she talked about a biomes activity she learned through the university-provided professional development workshops:

I taught a lesson on biomes; this was a lesson from an ASIST workshop. There were cards of different animals. On the back of each card, there was information about the animal. I asked the students to organize the cards into categories. At that point, I had not taught biomes. The students had to explain how they organized the cards. Kids discovered the concept of biomes on their own. (Martina, PCK interview, June 16, 2006)

During Year 1, Martina attended several professional development workshops in addition to the ASIST monthly professional development meetings and implemented what she learned in her classroom. Moreover, she actively
consulted with the science curriculum designer from the district. Here is how she described the professional development activities available to her:

We had tons of monthly professional development through the district, mostly on Structured English Instruction (SEI). We also had Essential Elements of Instruction, and the state science teacher conference. In the SEI class they have been teaching us about strategies: group works, visual instructions, kids writing and doing presentations. I have been using a lot those strategies in my own classroom. We also had science curriculum from the district with timelines and differentiating resources. Whenever I had questions, I called the curriculum map developer from the district. (Martina, end of the year interview, June 16, 2006)

In Years 1, 3, and 5, Martina had multiple sources of support and professional development. Although none of the professional development opportunities specifically targeted strategies for teaching ELL learners in the science classroom, the duration and quality of these opportunities coupled with Martina's strong science background had a synergistic effect on her practices. She was able to incorporate science and academic language strategies in her classroom with her EL students.

Another important aspect of the support system was the mentor available at her school. In her first year, her mentor was a math teacher. Martina met with her regularly to discuss management issues. In addition, her mentor observed
Martina's class once a month and then met with her to discuss the observation.

Here is what Martina shared about her experience at the end of Year 1:

My mentor helped me with organization and classroom management issues. She was mentoring 10 other new teachers at my school, so I think she was spread out too thin. I only went to her when I absolutely had to. When she came in to observe, she left me notes with one positive comment and one area for improvement. Afterwards, we meet and talk about my lesson.

(Martina, end of the year interview, June 16, 2006)

In addition, mentors from the ASIST program visited Martina every month and were available for consultation via email and over the phone whenever Martina had issues or questions pertaining to her students, her practices, or about management issues.

School community. The school community is also a very relevant part of the complex sociocultural milieu surrounding teacher professional development. All of the interactions involving students, colleagues, administrations, parents and staff are included in the school community category. For each participant, the most relevant aspects of the school community during the three Years encompassed by this study are presented. In order to provide a detailed description of the micro level, special attention was given to the interactions between the teachers and the students.

Martina interacted with students and colleagues. When Martina moved to the high school in Year 3, she planned lessons with other biology teachers. In
addition, the science department met once a month to plan and to talk about goals teaching and learning goals. Her department was focused on student performance measured by the end of the semester criterion-referenced test. Martina struggled with her colleagues' emphasis on "teaching to the test". She also recognized the difficulties associated with assessing her ELL students with multiple choice tests:

The one thing I can say bothers me about my colleagues is how focused they are on teaching to the district test. They have even suggested that I do not cover cell structure because there is only one question on the district exam. I do not teach to the test; I teach to the standards. (Martina, end of the year interview, July 1st, 2008)

Earlier in the year, she expressed her concerns about assessment during the monthly telephone interviews. This concern indicates that Martina recognized her students' need for differentiated assessment. This is what she said during a monthly interview:

I have a problem with giving my students multiple choice tests. I know better now; I tested my students on biomes with a multiple-choice test and they did horrible. I knew they knew the material because I heard them talk in their groups. I had them take the test on an essay format and it was like night and day! (Martina, monthly interview, May 13, 2007)

In Years 1, 3, and 5 the majority of her students were ELLs. The salient themes from the data analysis were a) Martina's emphasis on providing her
students with academic English skills to succeed in college and b) her high expectations about her students. Beginning in Year 1, Martina expresses the importance of academic literacy skills for the academic success of all students, especially for her ELL students. Instead of complaining about having to teach language domains to the students in her science classroom, she accepted the responsibility as a key component of her classroom practices. In several occasions I observed Martina helping her students with grammar and pronunciation as they prepared to present information to their classmates.

For Martina, the best part of her initial year in the classroom was watching her kids grow, improve, and understand what she was teaching them:

Two of my students were accepted to the International baccalaureate program at the high school. They had to have a high G.P.A. [grade point average] and write an essay to apply. Also, two other students were accepted into the biotechnology high school. I was so proud of them. (Martina, End of the year interview, June 16, 2006)

**Teacher artifacts.** The category of teacher artifacts includes curriculum maps, lesson plans, models and equipment. In Year 1 Martina received a curriculum map that helped her plan her instruction. Although the district had purchased science curriculum kits, Martina did not have access to professional development on how to implement the activities in the science kits:

I have all these FOSS kits in the science storage room, but I have no idea on how to use them. When we went over the science kits in
science methods class, we barely had time to work with the kits. I think we only spent about half a class period looking through them.

(Martina, end of the year interview, June 16, 2006)

Instead of following the teacher manual, she used the materials in the kits to implement the inquiry lessons from the monthly ASIST workshops. In Year 3, the science curriculum coordinator from the district met with all the science teachers. At that time Martina received a biology curriculum map with accommodation instructions for ELL and special education students, as well as inquiry lesson plans for her class. Martina used these lessons in her classroom. Here is what she shared regarding the curriculum resources available at her new school:

At the beginning of the year before school started we had an inservice with the district science coordinator. He gave us a curriculum map and inquiry lesson plans in ecology, cell biology. Instead of her having to go out and looking for everything, everything was ready. (Martina, monthly interview, January 19, 2007)

In her new placement, although she taught out of field, she was surrounded by colleagues who were more experienced and who were willing to share resources with her. Another important affordance present in Year 3 were the curriculum map and the support provided by the district science coordinator.

Rules and regulations. According to the CHAT framework, the validation system of the district in which the school is located, state credentialing
requirements, and the rules, regulations and incentives established by the school and district.

In contrast, assessment pressure was a salient theme for Year 3. The main focus of the school and department was to prepare the students for the district criterion assessment test and the mandated state assessment in science. This is what she shared:

I am worried about the CRT and AIMS assessment format. Multiple-choice tests are not the best way of figuring out what the students know. Last month, I gave my students a multiple-choice test on earth biomes and they did horrible. I knew better because during classroom activities and discussions, I heard them talk and I knew they had a handle on the content. I decided to give them an essay test over the same content and they did 100% better.
(Martina, monthly interview, December 13, 2007)

In regard to rules and regulations in Year 5, Martina felt overwhelmed with the paperwork requirements associated with the special education students in her class. In her own words:

This past year because of my special education students, I had tons and tons of IEPs [individualized educational plans] and progress reports to fill out. I felt so overwhelmed because I had so many inclusion students. I constantly had emails sent out to me about filling out this progress report on the students; and I just didn't feel
like I had the support from that department. (Martina, end of the year interview, June 24, 2010)

*Longitudinal changes in Martina's pedagogical content knowledge, inquiry, and language practices.* Martina experienced the greatest overall change in PCK at the end of Year 1 (see Table 3). At the beginning of her first year, she had a basic PCK orientation, but by the end of Year 1 her orientation changed to proficient. Martina's PCK orientations for understanding students' difficulties with science concepts fluctuated in a similar pattern: from limited to proficient between the onset of teaching to the end of Year 1. Martina's PCK orientations for understanding students' difficulties with science concepts fluctuated from limited to proficient between the onset of teaching to the end of Year 1, and then again from Year 3 to Year 5. In year 3, when she taught Biology for the first time to high school students, her overall PCK orientation although still considered proficient, experienced a noticeable shift. The changes in PCK were more marked in the categories of students' prior knowledge and students' difficulties with science concepts. In these categories, her orientation moved from proficient to limited. Over the three Years of data collection her total PCK orientations fluctuated between basic and proficient (see Table 4).
### Table 3

**Martina: Observed Practices**

<table>
<thead>
<tr>
<th>Year</th>
<th>Observation Number</th>
<th>Inquiry Level</th>
<th>Language Domains</th>
<th>Diagnosis</th>
<th>Vocabulary Tiers</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Verification/Process Skills Guided</td>
<td>Speaking/Listening</td>
<td>Emergent</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Guided</td>
<td>Reading/Writing</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Guided</td>
<td>Reading/Writing</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Guided</td>
<td>Reading/Writing</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Directed</td>
<td>Reading/Listening/Speaking</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Student Project</td>
<td>Reading/Writing</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
</tbody>
</table>
Table 4

*Martina: Longitudinal Changes in Pedagogical Content Knowledge*

<table>
<thead>
<tr>
<th>PCK Question</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>PCK 1 Students' prior knowledge</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 2 Variations in students' approaches to learning</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 3 Students' difficulties and misconceptions</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 4 Knowledge of inquiry instructional strategies</td>
<td>Intermediate</td>
</tr>
<tr>
<td>PCK 5 Representation of instructional strategies</td>
<td>Proficient</td>
</tr>
<tr>
<td>Overall Orientation</td>
<td>Basic</td>
</tr>
</tbody>
</table>

*Note.* PCK = Pedagogical content knowledge.

During Year 5, she taught Earth Science, a course in which she had a strong content knowledge base. The analysis of reported practices indicated that Martina implemented more inquiry lessons that supported her students’ learning of science during Year 5 (see Table 5). Overall, she reported implementing more directed inquiry than guided inquiry. Conversely, the examination of the observed practices indicated that Martina implemented more inquiry practices during year 1 than in any other year. This discrepancy between observed and reported practices for Year 5 can be explained by the fact that only two classroom observations were conducted that year. In retrospect, this decision reduced the chances to observe
practices by 50% and contributed to the discrepancies between reported and observed practices.

Table 5

*Martina: Reported Language Domain Implementation*

<table>
<thead>
<tr>
<th>Year</th>
<th>Listening</th>
<th>Speaking</th>
<th>Reading</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>7</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>22</td>
<td>21</td>
<td>33</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>16</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>Total</td>
<td>82</td>
<td>45</td>
<td>34</td>
<td>86</td>
</tr>
</tbody>
</table>

*Reported language and vocabulary practices.* An analysis of the reported practices implemented by Martina over the three years of the study indicated changes in the implementation of language domains. For instance, in Year 1 Martina implemented more classroom discussions. During the discussions, her students practiced academic listening and speaking skills. In Year 3, she doubled the frequency of reading and implemented writing in the form of bell work questions more often than any other language domain. By Year 5, student presentations were the most commonly implemented activities.

In regard to the implementation of science lessons that promote both scientific inquiry and language development of ELL students, the analysis of the classroom observations indicated that in Years 1, 3, and 5, her practices supported language skills development through the use of inquiry activities (see Table 3). The frequency of implementation of language domains during her lessons indicated that Martina’s practices fostered academic language proficiency, and that her students engaged with science context in meaningful ways. The analysis
of observed practices indicates that Martina implemented more proficient lessons in Year 3 than in Years 1 or 5.

Although the ASIST program was not specifically geared toward beginning science teachers of ELL students, the use of science inquiry in the classroom included the implementation of contextualized vocabulary and the practice of reading, writing, listening and speaking in English among her ELL students.

When I taught a lesson on Newton’s laws I gave the students pictures of athletes running, target shooting and throwing a ball. I asked the students to think about the movement and actions in the pictures.... It was really interesting to hear the students talking. They then had to use white boards and present to the class how they thought a particular law was applied in the picture. I formally introduced Newton’s laws afterwards. (Martina, PCK interview, June 16, 2006)

In Year 5, she reported implementing more inquiry activities in her classroom than in Years one or three. By the end of Year 5 her PCK orientation was classified as basic. Martina's understanding of inquiry increases from basic at the onset of teaching to a proficient orientation throughout Year 3; however, her representation of inquiry is higher at the onset of teaching than in any other year. This could be a result of the emphasis on inquiry pedagogy during he teacher preparation program. Observational data indicate that Martina integrated language domains and vocabulary in the context of inquiry. In Year 1, Martina
implemented a guided inquiry lesson in which her students worked in groups to learn about biomes. The following excerpts were taken from the field notes:

On each lab table Martina has placed sets of cards depicting animals and plants from different biomes. She circulates around the class and is keeping the kids on-track as they work on the lesson. For the second part of the activity, students continue to work in their groups to sort a set of organism cards into different biomes.

: 42 – M: There is a group of cards on each lab table. You will have to assign each animal and plant to a biome. Sometimes an animal will be assigned to two or more biomes. You will need a sheet of paper and on this sheet of paper you will write down the location of the organism in terms of its Biome.

Once the students have sorted the organism cards into different biomes, she asks the students from each lab table to explain how they decided to group animals and plants and how they determined if the organism was a producer, consumer or scavenger.

: 45- The kids are looking through the cards and they are organizing them.

: 50 – M: What does an earthworm eat?

S: Dirt with rotting matter in it.
M: Now, think about it. Based on this information; how would you classify and earthworm?

S: That's a scavenger!

The students go back to the task at hand and are sorting the cards. They are trying to give a label to each organism.

:55- Martina is circling through the room. She is talking to one group of kids and showing them how they can decide if it’s a producer or decomposer.

M: Look at the organisms that are in the biome. You are going to create a food web for one of the biomes of your choice.

She goes by a group and asks which biome the group has selected.

For homework Martina asked students to come up with a definition of biome based on their understanding from the card sort activity. The students also need to provide 5 examples of animals that can live in just one biome. (Martina, classroom observation, April 24, 2006)

During this classroom observation the students worked in groups and engaged in constructing their own understanding of biomes and food webs. Students were engaged in all four language domains and the use of contextualized science vocabulary. The ASIST program provided Martina with theoretical and practical understanding of inquiry and allowed her to recognize and select an inquiry activity. Another noteworthy finding is her PCK orientation toward
knowledge of inquiry compared to the PCK orientation for representation of inquiry. Whereas Martina's understanding of inquiry shifted from basic at the onset of teaching to a proficient orientation throughout Years 1 and 3, her representation of inquiry is higher at the onset of teaching than at the end of Years 1, 3, or 5. At the end of Year 3, when asked to share her understanding of inquiry in science she replied:

Scientific inquiry is a process to learn science through discovery. Students have an opportunity to test what they are interested in, such as the bacteria activity. I gave the students some ideas, but they chose other things. Some wanted to find out what kinds of bacteria lived in different places around the school. They shared their findings with other groups and came up with more questions; that is inquiry. (Martina, PCK interview, July 1, 2008)

In summary, the contextual circumstances surrounding Martina, a reform-minded early career science content specialist, included both affordances and constraints that played an important role in the longitudinal changes in PCK as well as in the implementation of academic language domains and vocabulary. The changes in PCK were a reflection of new challenges encountered in the context. For instance, changes in grade level, subject matter and age group represented a discrepancy that required internalization and new opportunities to learn. The gradual shifts in PCK capture by the PCK interviews were indicative of her learning.
Martina learned how to implement inquiry in her classroom with the help of ASIST. In addition, she learned about specific strategies to help her ELL students through professional development opportunities in her district. She had a curriculum map and resources to teach science. Although she experienced pressures from administration and colleagues regarding standardized testing, she was aware of the difficulties associated with multiple choice tests and devised valid assessments for her students.

**The case of Kelly.** Kelly was the second participant in the group of teachers with high percentages of ELL students. The analysis of data collected about Kelly in Years 1, 3, and 5 of her teaching indicated changes in the contextual factors surrounding her during Years 3 and 5. There were also variations in the degree to which she implemented practices regarding inquiry, language, and vocabulary. Overall, in Year 5 she experiences marked changes in her PCK. In the following paragraphs, I will provide examples to substantiate these changes, and answer the research questions that guide this dissertation.

Among the affordances available to Kelly during Years 1, 3, and 5 were:

a) the induction support available through ASIST and through the school district
b) availability of publisher inquiry science curriculum, c) her colleagues at the school, and d) opportunities for professional development. The salient constraints surrounding Kelly during the same time period were associated with: a) discipline issues, b) her perceptions about students c) excessive number of responsibilities outside the classroom, d) pressure derived from district and state mandated assessment.
Division of labor. In Year 1, Kelly felt overwhelmed with the new challenges related to classroom discipline, lack of equipment, textbooks and curriculum. She consulted with her ASIST mentor who provided ideas for general science laboratory activities. Although Kelly participated in the ASIST workshops and consulted with her mentors during the first semester of the academic year, by the second semester she was overwhelmed and missed sections or did not avail herself of the ASIST mentors. When asked about her involvement with the ASIST program, she replied:

I attended the first ASIST workshops and learned a lot, especially about activities I could use in my classroom. I used the ASIST listserv to communicate with other beginning teachers. Lately, I have not contacted my ASIST mentor because I haven't had time. At this point, I am just trying to get through the year. (Kelly, monthly interview, March 1st, 2006)

In Year 1, Kelly attended both mandatory and voluntary professional development sessions offered by her district. The focus of these sessions was discipline and classroom management. In addition, Kelly completed classes for her English as a Second Language (ESL) endorsement. When asked about the ESL endorsement courses she replied:

I am trying to get all of the endorsement credits to advance on the pay scale. I have been taking the classes through the local community college and on the weekends through the fast track
From her comments it is clear that she had multiple opportunities for professional development, and that her district offered incentives to teachers who completed classes and workshops.

In Year 3, she participated in professional development opportunities within and outside her school district. Over the summer, she completed the required workshop to become a teacher trainer for the commercially available inquiry-based curriculum kit adopted by her district. Professional development opportunities offered by local universities included summer sessions on space science, as well as two additional classes for her ESL endorsement offered during weekends through a local private university. In Year 5, she continued to participate in a Space Science summer institute for teachers at a state university. In Year 1, as part of the ASIST program, Kelly attended a yearly regional science teacher conference. Every year after that, she continued to request and obtain travel funds and release time from her district to attend national and local science teacher conferences. Kelly considered these conferences as an opportunity to learn about new activities for her classroom. For instance, in Year 3 Kelly attended a robotics session and as a result, she decided to become the robotics club sponsor at her school.

In Year 1, Kelly consulted with the ASIST mentors during the first semester of the academic year regarding ideas for laboratory activities. At the school site, her district assigned Cooperating Peer Teacher (CPT) was a 4th grade
math teacher. Kelly rarely consulted with her on matters pertaining to classroom discipline and management. When asked about her mentors, she shared:

I had a mentor through the ASIST program and she gave me ideas for how to do physical science activities with my students; She was very helpful. At the school I had a cooperating peer teacher, —a CPT, and I forget what the words stand for, she was supposed to help me; well, I really never saw her. (Kelly, end of the year interview, June 26, 2006)

The salient theme regarding administrators in Years 1 and 5 was the lack of discipline support for teachers. The school was placed in an improvement plan for discipline by a state task force. At the end of the second year, the principal left the school. In Year 1, Kelly had this to say about the discipline in her classroom:

Probably, the most frustrating aspect this past year was the discipline. I’ve had to deal with some very disrespectful kids. I was always having to stop to discipline, and so I tried to go through when I was talking about something and having a discussion, and then I always had to stop and discipline. These interruptions lost everybody’s train of thought. (Kelly, end of the year interview, June 26, 2006)

In Year 5, Kelly was observed dealing with students' off task behavior during a gas law demonstration. She slowed her speech and stopped midway through sentences in an attempt to quiet her students. This maneuver resulted in increased student side-talk and less content related interaction between Kelly and
her students. Frustrated, Kelly provided all the answers and explanations and moved on to the next activity.

The data from monthly and end of the year interviews indicate that Kelly had very limited interaction with other science teachers in her school. In her final interview, she explained her lack of interaction with other science teachers:

Well, for the past five years the other science teachers at my school have not been highly qualified. There's been a Social Studies teacher who had to fill in because there was no other position for him at all. When this happens, the teachers are not really into teaching. And the other science teacher was really a Math teacher. He just didn't do anything with the kids. (Kelly, end of the year interview, June 18, 2010)

In Years 1 and 3, approximately 85% of the students in Kelly's classroom were ELL. In Years 1 and 3, Kelly believed the students had no background or experience related to science. She also thought the students' lack of background made it impossible for them to understand topics such as acid rain. She shared what happened in Year 1 when she asked her 8th grade class to design science projects:

My students have had a hard time coming up with topics for the science fair project. I can tell that they have never wondered. It is hard to find something they can understand and do for their projects. I asked them to think about what they wanted to do, and they could think of something, but they did not understand it. One
group wanted to do acid rain, but I said no because they did not know about pH; they could not understand what they read. (Kelly, monthly interview, September 9, 2005)

Later, in Year 5 she described how she helped her students understand the concept of pH:

We did one day on pH by using the condensed version of a lab from UC Berkeley [University of California-Berkeley]. We used cabbage juice and observed the color changes when testing different common liquids like lemon juice, vinegar, water. The students grouped the liquids by color and then came up with a color line from bright pink to dark green. I showed them where the liquids fell in the pH scale, and the students measured the pH of the different liquids. We had a class discussion about acids and bases. Afterwards, we discussed neutralization and what they had to do to neutralize the pH of the liquids. The next day, I explained the relationship between pH and acid rain. (Kelly, monthly interview, April 8, 2010)

From these two examples of practice it is easy to discern that as Kelly progressed in her professional learning, she was able to scaffold her students' understanding of science concepts. Although initially she blamed her students lack of familiarity with activities to help students understand pH, in Year 5 she availed herself of inquiry activities from the Internet and successfully implemented a directed
inquiry activity to help her students understand the pH scale and to identify the 
PpH of household liquids.

In Year 1, the district did not provide Kelly with curriculum or a 
curriculum map. In Year 3, she received a curriculum map from the district 
science coordinator. That same year, the district purchased a publisher's inquiry-
based science kits curriculum. Kelly assisted in aligning the kits to the district 
curriculum and to the state standards. In Year 3 she became a trainer of trainers. 
In this capacity, she taught other teachers in her school and district how to 
implement the inquiry activities included in the science kits. This is what she 
shared regarding the kits in Year 5:

> I lose a lot of spontaneity using the curriculum kits. I am one of the 
people who trains the other teachers on how to use these kits, but I 
am thinking about deviating from the teacher manual; I really don't 
know how the district is going to react about this, but I am going to 
add my own questions to make it less rigid, more open for the kids 
to do their own thing, to discover. (Kelly, monthly interview, April 
8, 2010)

The analysis of Kelly's inquiry practices indicated that in Year 3 she 
reported implementing close to twice as many inquiry activities than in Years 1 or 
5 (see Table 6).
### Table 6

*Kelly: Reported Inquiry Practices from Monthly Interviews*

<table>
<thead>
<tr>
<th>Year</th>
<th>Inquiry Level</th>
<th>W.U.</th>
<th>Frequency (Total = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>4 4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>6, 8</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>1, 7</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 18)</td>
</tr>
<tr>
<td></td>
<td>Open</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>1, 7</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>2, 5</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 12)</td>
</tr>
<tr>
<td></td>
<td>Open</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>4, 5, 8 9</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Verification/ Process Skills</td>
<td>1, 2, 4, 6, 7</td>
<td>15</td>
</tr>
</tbody>
</table>

*Note. W.U. = Eight monthly phone interviews were conducted during the school year.*

The analysis of classroom observations corroborated the implementation of reported practices. In other words, Kelly implemented more inquiry during her third year, while during Year 5 she implemented less inquiry. In Year 3 we observed Kelly implementing a Periodic Table activity. She began the class by eliciting students' knowledge about chemical elements. After the students had a chance to answer the introductory question, Kelly reviewed the question by asking the students to share their answers:

9:35-9:40

*Warm-up*: Students are coming in and getting settled. They begin working on the warm-up question: What did you learn about the chemical elements? Kelly reminds the students that they can look at their work to help them.
9:40-9:45

K: What did you learn about the elements?

S1: We use them every day.

S2: They are organized.

S3: They have different names.

S4: There are a bunch of different ones.

S5: They are organized into some chart: the Periodic table.

K: You can add more information to your to your warm up questions.

Next, Kelly introduces the Periodic table activity to her students.

9:50

K: Open your science book to the periodic table. Today we are going to learn about the Periodic table of elements. I am going to give each group of three students a set of paint chips. Your job is to decide how you want to organize these paint chips. Each of you will have to write down how your group decided to organize the chips. Once you are done, we will go around have each group explain your system.

Students begin discussing how they will organize the chips. Some students arranged their chips by colors (blue chips, reddish chips). Some look like random colors put together. Most of the students have organized the chips are in long rows. Time is up. Students' hands are in the air. Kelly uses popsicle stick to call on student from each group.
9:55

S1: We decided to place the chips from darkest to lightest.

S2: We organized them by color.

S3: We placed them from lightest darkest.

S4: We organize ours from darkest to lightest and then by color family.

10:00

K: This is similar to how the periodic table was put together. Mendeleev had all these cards, with put all the information about the element on the cards. Eventually, Mendeleev figured out the periodic table. Items that have the same color have the same properties.

Kelly collects the paint chips and begins passing out element cards. The cards are made of construction paper. One side has the name, atomic number and element symbol; the backside has information about the element on it. The first 36 elements

10:00-10:10

K: All right kids, those of you with elements 1 through 16 line up against the wall. You are going to be an expert about an element. The rest of the class you line up across from one student. You are going to share the element name: description, abbreviation, uses in your card. Once you are done, move to your right to the next person.
The students take turns reading the information from the card to the classmate in front of them. This process takes about 10 minutes. All students are on task. Afterwards, Kelly calls the students by element state of matter back to their lab table (i.e., gases, solids, liquids). She then proceeds to use the textbook to show the students pictures of the original Periodic table and engages the students in a discussion about the history of the Periodic table. (Kelly, classroom observation, October 16, 2007)

In this activity, students engaged in directed inquiry with multiple opportunities to engage in small and large group discussion while constructing their understanding of the Periodic table.

With respect to the implementation of vocabulary tiers, the data indicated that Kelly progressed from beginning to proficient from Years 1-5. All the observed lessons beginning the second semester of Year 1 and throughout Years 3 and 5 indicated that Kelly implemented a balance of all three vocabulary tiers (see Table 7).
Table 7

*Kelly: Observed Practices*

<table>
<thead>
<tr>
<th>Year</th>
<th>Observation Number</th>
<th>Inquiry Level</th>
<th>Language Domains</th>
<th>Diagnosis</th>
<th>Vocabulary Tiers</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Verification</td>
<td>Writing/Reading</td>
<td>Emergent</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Verification</td>
<td>Listening/Writing</td>
<td>Emergent</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Process Skills</td>
<td>Listening/Speaking</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Guided</td>
<td>Listening/Speaking</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Directed</td>
<td>Listening/Speaking</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Guided</td>
<td>Listening/Speaking</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Verification</td>
<td>Reading/Writing</td>
<td>Proficient</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Directed</td>
<td>Writing/Listening</td>
<td>Intermediate</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Directed</td>
<td>Reading/Listening</td>
<td>Proficient</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Verification</td>
<td>Listening/Speaking</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
</tbody>
</table>

Data from the monthly interviews and end of the year interviews were the primary sources of information used to ascertain how district and school rules and regulations impacted Kelly and her students throughout the initial five Years of her career. The four salient themes were: a) reading assessment, b) extracurricular responsibilities, and c) student tracking by academic ability. In the next paragraphs, I will provide details for each of these themes.

The school where Kelly taught for all five years had a high percentage of ELL students and low reading and writing assessment scores were a major concern. Consequently, the school was placed under an intervention plan that included language instruction with a special emphasis on reading for all students.
The emphasis on testing disrupted the schedule and required that all teachers, including beginning teachers like Kelly, teach a reading class. Here is what Kelly shared regarding school issues in Year 1:

We do testing in reading and language to figure out where students are at in these subjects. Then students who are right on the line for meeting the standards in the state assessment test take enrichment classes for reading and language. All of us [teachers] have to teach one period of reading a day. This past week the students were gone because of the language testing, so the schedule was a mess.

(Kelly, monthly interview, March 20, 2006)

In Year 3 Kelly was asked to take on a number of responsibilities. She became a member of the science lesson planning committee, the student council sponsor, and a teacher-trainer for the science kits curriculum. Kelly was also asked to teach a science elective. Consequently, she taught 7th and 8th grade science and a 7th grade science elective. In her own words:

It was very difficult and stressful to have to teach three different preps. I taught eight-grade science, one science elective and the mandatory reading class. I was also helping two teachers who were new to the school. We were also required to attend monthly workshops on differentiated instruction. (Kelly, end of the year interview, June 12, 2008)

For Kelly, having the extra responsibilities did not deter her from teaching inquiry. She was able to apply knowledge about inquiry pedagogy and she used
her content knowledge to help in devising strategies to modify the curriculum
form the inquiry-based kits to make the activities less structured and more
inquiry-based.

Rules and regulations. In Year 5, the state mandated a four-hour block
of core classes for beginning and intermediate students. Principals at each school
site were given the responsibility to decide how to implement the unfunded
mandate. In Kelly's school, this resulted in a tracking system that placed honors
students, ELL students, and regular education students in separate classes.
Additionally, the tracking system resulted in the loss of one teacher from each
core area. This increased class sizes and impacted students and teachers. When
asked about this measure Kelly responded:

There was really nothing good this year, these were too many kids,
and it was a bad year.... I will continue teaching for five or six
more years, but I am looking to leave this school. It’s just too
much. I had 40, 39, and 38 [students] in my classroom last year;
and it’s going to be the same thing this year [Year 6] or actually
more. I am probably looking at 40 or 43 kids per class. (Kelly, end
of the year interview, June 18, 2010)

Longitudinal changes in Kelly's pedagogical content knowledge,
inquiry, and language practices. In Years 1 and 3 Kelly maintained an overall
basic orientation for PCK (see Table 8). This meant that she recognized students'
difficulties, variations in approaches to learning, and prior knowledge, but she
addressed these issues in a limited way. Likewise, her understanding and
implementation of inquiry included two or three elements of inquiry that were pedagogically limited of scientifically under-developed. In order to understand if Kelly's PCK orientation changes were due to a development in PCK or a consequence of the changes in student demographics in Year 5, it is necessary to examine her language and vocabulary practices in more detail.

In regard to the implementation of language practices, data from the monthly interviews indicate that Kelly reported implementing more writing activities in the form of introductory lesson questions (bell work) than any other language domain activity. Conversely, she reported implementing less reading activities than any other language domain (see Table 9). The LIST analysis of observational data indicated that in Year 1 Kelly implemented emergent lessons, a category that indicates the preponderance of two language domains during her lessons. Specifically, three out of the four lessons consisted of students listening and speaking. One example of this occurred in Year 1, during the fourth observation when she implemented the toothpick bridge building activity. Throughout the lesson the students listened to Kelly's directions, and then talked and listened to each other as they worked in small groups.
<table>
<thead>
<tr>
<th>PCK Question</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCK 1 Students' prior knowledge</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 2 Variations in students' approaches to learning</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 3 Students' difficulties and misconceptions</td>
<td>Limited</td>
<td>Basic</td>
<td>Limited</td>
<td>Proficient</td>
</tr>
<tr>
<td>PCK 4 Knowledge of inquiry instructional strategies</td>
<td>Limited</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 5 Representation of instructional strategies</td>
<td>Basic</td>
<td>Limited</td>
<td>Limited</td>
<td>Basic</td>
</tr>
<tr>
<td>Overall Orientation</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
</tbody>
</table>

*Note. PCK = Pedagogical content knowledge.*
Table 9

*Kelly: Reported Language Domain Implementation*

<table>
<thead>
<tr>
<th>Year</th>
<th>Language Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Listening</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
</tr>
</tbody>
</table>

By the second semester of Year 3, began implementing lessons that were classified as intermediate or proficient according to the LIST rubric. This means that during the lesson, the students engaged in three or four language domains. She continued implementing lessons that were classified as intermediate or proficient. The data also support a learning progression for Kelly’s language implementation and vocabulary tiers.

In summary, over the five-year period encompassed by this study Kelly experienced constraints and affordances related to curriculum availability, lack of support from colleagues in her department, excessive extra-curricular responsibilities, excessive number of students, and rules and regulations from her school and district. The data analysis indicated changes in her practices related to the implementation of inquiry, language domains, and vocabulary. She implemented more inquiry practices from Year 1 to Year 3, but in Year 5 she implemented less inquiry. A marked increase in class size was a major factor impinging upon Kelly’s implementation of inquiry in Year 5.

Overall, she implemented more short writing activities in the form of introductory questions than any other language domain. For Kelly, the support
from ASIST and the availability of inquiry based curriculum were instrumental in helping her develop her capacity to implement inquiry in her classroom and to think about how she could modify pre-existing curriculum to make it more student-centered. Although she held deficit views about her students, she learned how to teach inquiry and in doing so she also implemented academic language practices that helped her ELL students.

Section 2: Teachers with Moderate Percentages of English Language Learner Students

Cindy and Jim were selected from the pool of participants who had approximately 40% ELL students in their classrooms. Although the study included teachers in three other states, much like the participants who taught high percentages of ELL students, these two participants taught in the same state. Other similarities Cindy and Jim shared with Martina and Kelly were the grade level and the subject area they taught: whereas Jim and Martina taught high school Biology, Cindy and Kelly taught middle school general science. These similarities facilitated comparisons across cases.

The case of Cindy The affordances surrounding Cindy during Years 1, 3, and 5 involved the support from ASIST, district-sponsored professional development opportunities, and the help of the school curriculum and technology specialists. Among the salient contextual factors surrounding her during the same time period were: a) the lack of curriculum and materials, b) her colleagues c) school mandates related to testing, d) excessive extra-curricular responsibilities,
and e) the diverse needs of her students. In the following paragraphs, I will discuss these affordances and constraints.

**Division of labor.** Cindy received the assistance of the ASIST program during Years one and two. At the end of her first year in the classroom, she shared the following reflections about ASIST:

I communicated with ASIST people most often for things that I was looking for. I feel like if I had concerns, if I had problems, or I voiced my frustration with a lab I was able to get some feedback. A couple of times I sent information out, [through the ASIST listserv] about what I was thinking about doing and people would respond, especially when we got to the end of the school year and our final project was going to be building roller coasters. One of the ASIST mentor teachers in the group replied, and said she had done the rollercoaster project with her junior high students. (Cindy, end of the year interview. June 13, 2006)

In Year 3, Cindy attended classroom technology workshops to learn how to use the interactive computer board, microscope and document camera in her classroom. During the member check interview, Cindy shared with me how she was able to integrate the microscope with the document camera to show images on the interactive whiteboard. Her confidence and dexterity in handling and integrating the different technology components indicated that she was very comfortable with using technology in the classroom. In addition, in Years 1, 3, and 5, Cindy attended a national science teacher conference. In Years 3 and 5 she
participated in two different physical science programs held at the state universities.

At her school, Cindy was assigned a school mentor who was a math teacher. Her district also assigned a science mentor from another school to work with Cindy. This is what she shared about her mentors:

    My school-assigned mentor was a math teacher; we met regularly, but she only helped me with issues of discipline and classroom organization. The district assigned a science mentor, but I only saw this person once during the national science teacher conference. Other than that time, we really never met. (Cindy, end of the year interview, June 13, 2006)

_School community._ Cindy also received support from others in her school. For instance, she often relied on the school's technology specialist. Additionally, the curriculum director had a science background and Cindy consulted with her. Here is what Cindy shared regarding the assistance she received:

    Our technology director and I had a lot of interactions where I knew her and I could send a shout out: “Listen, I need this? Is it possible?” Those types of things, and the Director of Curriculum, she had a science background. That was real helpful in the fact that she knew the standards. She taught Science for a number of Years so she was familiar with it. (Cindy, end of the year interview, June 13, 2006)
According to Cindy, the school administrators did not support or emphasize science; instead, they supported instruction of other content areas and expected teachers to integrate these content areas into their teaching. She expressed concerns about her lack of preparation to fulfill their request:

I still feel like the administration really, really pushes math, reading and writing and doesn’t have the knowledge or understanding of other content areas like science. Those are the primary focus of concern and forget the other areas, but we’re expected to incorporate math, reading and writing into our content areas, which we do, but it’s like we are reading teachers; you are this; you are that. Well, that’s all good and fine, but we’re not especially trained in that area. (Cindy, end of the year interview, June 30th, 2010)

In Year 1 Cindy planned with another 8th grade science teacher who implemented inquiry in his lessons. Cindy was not quite comfortable with her colleague's approach to teaching:

The science teacher I worked with this past year and I butted heads a little bit. We just had different styles. I was willing to recognize his way of teaching, but I didn't feel that he was willing to recognize mine. There is more than one way to teach the material; and you just need to teach it the way you feel more comfortable teaching. (Cindy, end of the year interview, June 13, 2006)
In Year 3, Cindy was part of the 8th grade team. She also developed a working relationship with an 8th grade science teacher in her department. Here is what she shared about her interactions with her colleagues:

We had an awesome team this year. We all connected and supported each other very well. We had three new team members that came in. They just fit well within our team, which is unusual when you have that many new people that come in...My science buddy and I worked together more cooperatively. We tried to do the same things at the same time. We brought our classes together for instruction several times throughout the year, which was nice.

(Cindy, end of the year interview, June 2nd, 2008)

In Year 5, Cindy switched from teaching 8th grade Science to teaching 7th grade Science. Teachers in the 7th grade team emphasized the teaching of vocabulary. This is what Cindy shared during the final interview:

I was on a different grade team. I felt that our [7th grade] team was a little more unified and that what the other content area teachers, the way they taught was very similar to the way I taught and with respect, most of all, to teaching—focusing a lot on vocabulary and different aspect like that which I feel very strongly about. All the teachers on my team spent a lot of time teaching vocabulary.

(Cindy, end of the year interview, June 30th, 2010)

In Year 1, 45% of Cindy’s students were classified as ELL. In Year 3, due to a rezoning ordinance, the apartment complexes near the school were converted into
condominiums. As a result, many families had to relocate outside of the school attendance boundaries. Consequently, the school lost a considerable number of ELL students. Additionally, the state mandated that beginning ELL students had to receive four hours of language arts and math a day. Consequently, in Years 3 and 5 Cindy only taught 10 students who were classified as intermediate ELL according to the state's English proficiency test:

This year, we do not have as many ELLs because they all had to move out of the apartment complexes nearby. Also, because of the mandated ELL block I lost a lot of the beginning ELL students.

(Cindy, end of the year interview, June 2nd, 2008)

**Rules and regulations.** In Year 1 the salient regulation imposed on Cindy was the state mandated licensure requirement. In Year 1 Cindy focused on taking classes to fulfill the licensure requirements for the state high school Biology certificate. Consequently, Cindy was not able to participate in the school district beginning teacher induction support. By the end of Year 1, Cindy did not meet the certification deadline and could not be rehired. During the summer, she passed the state licensure test and subsequently found employment teaching 8th grade General Science at a different urban middle school. This new school housed grades 5th through 8th, and had similar student demographics.

In Year 3, the new school received a probation status for failing to make adequate yearly progress (AYP). That same year, the district hired a new superintendent. Concurrently, the state mandated a four-hour instruction block for ELL students. This label brought a series of new changes and responsibilities. In
order to create the instructional block for the ELL students, class sizes increased to 36 students. Cindy was asked to tutor ELL students two times per week after school. She decided to implement an improvement plan for her own classroom. Although the details of this plan were not clear, Cindy shared how she measured its effectiveness:

I wanted to document my improvement plan for vocabulary instruction, so I gave my students a pre- and a post-test, seeing your end-of-the year and to see the growth that was achieved by some of my students. All of them achieved growth, but I had some that had significant growth.... Including my ELL students which I saw a huge growth in, one of my ELL students went from 13 to 25. Another student went from 11 to 26. Another student went from nine to 21. The one who went from nine to 21 with an increase of 12, she was new out of our ELL program. (Cindy, end of the year interview, June 2, 2008)

In the following sections, I will discuss Cindy's practices and PCK.

_Longitudinal changes in Cindy's pedagogical content knowledge, inquiry, and language practices._ During her initial year in the classroom, Cindy's PCK orientation changed from limited to basic in the categories of understanding students variations in approaches to learning, students' difficulties with science concepts, and representation and inquiry instructional strategies. In Cindy's case, her lack of preservice preparation and content knowledge precluded her from implementing inquiry in her classroom. In Year 5, she was
asked to teach 7th grade Science. For Cindy, who had no formal preparation in Earth Science and no prior experience teaching 7th grade, this presented a challenge. This change coincided with a shift in her PCK related to knowledge of inquiry strategies (see Table 10).

Table 10

*Cindy: Longitudinal Changes in Pedagogical Content Knowledge*

<table>
<thead>
<tr>
<th>PCK Question</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 3</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCK 1 Students' prior knowledge</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 2 Variations in students' approaches to learning</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 3 Students' difficulties and misconceptions</td>
<td>Limited</td>
<td>Basic</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 4 Knowledge of inquiry instructional strategies</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 5 Representation of instructional strategies</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>Overall Orientation</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
</tbody>
</table>

*Note. PCK = Pedagogical content knowledge.*

Cindy equated students' Internet research with inquiry. Here is how she described an inquiry lesson at the end of Year 5:

One of the lessons from last year had to do with part of our investigation of volcanoes and earthquakes. I had the kids do a
Webquest [university-developed Internet resource] and answer questions for me regarding the volcanoes and earthquakes. Regardless of the level the student; intellectually, they were able to recall the information and use it to be able to identify and answer questions. It was a series of lessons that led to the Webquest lesson. It was an accumulation of several lessons combined over several days. I started out with general info and vocabulary, lead to info and facts. The kids did lots of exploring on what they already knew. Afterwards, I showed brain pop video and Inside Planet Earth. This provided background knowledge before going in the lab to investigate a volcano or an earthquake they chose. Students worked individually, except for some of the resource students who worked in pairs. Students had to do the research and answer questions. They had to select final projects; word searches, Power points, crossword puzzles or they were able to do posters. (Cindy, end of the year interview, June 30, 2010)

When we asked Cindy if this lesson was a good representation of inquiry she replied: "Actually it was an example of inquiry in science. Even though they were not doing anything hands on they were using the science skills they had to increase their information on earthquakes and volcanoes."

Cindy's PCK orientation for students' prior knowledge was classified as basic throughout the three Years of data analyzed for this study. In the category of
variations in students' approaches to learning Cindy changed from limited at the onset of her teaching career to basic at the end of Year 5.

The analysis of Cindy's reported and observed practices, indicates that with regards to inquiry practices, Cindy implemented guided inquiry in Year 1 (see Table 11). Contrastingly, she implemented directed inquiry activities during all three Years; particularly during Year 3, when the district adopted the inquiry-based science kits curriculum from a publisher. Cindy expressed hesitation about using inquiry. In Year 3, she co-taught with a colleague who regularly implemented science inquiry in his classroom. During the initial observation of Year 3 Cindy and her colleague took their classes to a nearby city park to launch bottle rockets. This was the culminating activity of a unit on Newton's Laws.

Table 11

*Cindy: Reported Inquiry Practices from Monthly Interviews*

<table>
<thead>
<tr>
<th>Year</th>
<th>Inquiry Level</th>
<th>W.U.¹</th>
<th>Frequency (Total = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guided</td>
<td>5, 7</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>2, 5, 6</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 14)</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>2, 3, 4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Process Skills</td>
<td>1, 5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Student Research</td>
<td>2, 3, 6</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 2)</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>2, 5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Process Skills</td>
<td>2, 6</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note.* W.U.¹ = Eight monthly phone interviews were conducted during the school year.
When class begins Kathy and her co-teacher distribute the bottle rockets the students built earlier in the week. The Students weight the rockets and record the information in their science journals. Kathy tells the students that today they will be going to the park to launch their rockets. The students are very excited.

10:16-10:21

K:

You need 500ml of water in your rocket. Once we are at the park each group member has a function. The launcher will place the rocket on the launcher and push on the bicycle pump 10 times to 70 psi. The timer will use the stopwatch to determine flight time. The altitude tracker will record the maximum height of the rocket. The recorder will write down the time and altitude data.

While Cindy describes the duties for each group member, her co-teacher demonstrates each procedure. The students fill up their rockets with water up to the 500 ml mark. Students line up and head out to the park accompanied by a chaperone, Cindy and her co-teacher.

10:31-10:41

Once at the park, the students take turns launching their rockets. They are all engaged in the activity. Each member of the group is performing the assigned duties. Unfortunately, only 5 out of the 10 groups launch their rockets before it is time to head back to the classroom.
Note: On the way back to school Cindy shares with me that she did not think this activity was successful because it took too much time. She did not feel that students were ready for the launch. "That's the thing with inquiry, I do not feel comfortable with it. I think everyone has a different style, and I am more comfortable with Power Points and helping kids out with vocabulary building." (Cindy, classroom observation, October 9, 2007)

We did not observe Cindy implementing inquiry lessons after the rocket activity. In Year 5 Cindy implemented more verification and process skills activities than in Years one or three. Overall, Cindy implemented less inquiry in Year 5. The implementation of guided inquiry coincided with a shift from emergent to intermediate with respect to language domains. Similarly, by the end of Year 1 her vocabulary practices were diagnosed as proficient (see Table 12). This meant that she implemented vocabulary from all three tiers in her lesson. This trend continued in Years 3 and 5.
<table>
<thead>
<tr>
<th>Year</th>
<th>Observation Number</th>
<th>Inquiry Level</th>
<th>Language Domains</th>
<th>Diagnosis</th>
<th>Vocabulary Tiers</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Verification</td>
<td>Reading/ Writing/ Listening</td>
<td>Intermediate</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td>2</td>
<td>Book work</td>
<td>Reading/ Writing</td>
<td>Emergent</td>
<td>3</td>
<td>Beginner</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Worksheet</td>
<td>Reading/ Writing</td>
<td>Emergent</td>
<td>3</td>
<td>Beginner</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Guided</td>
<td>Reading/ Listening/ Speaking</td>
<td>Intermediate</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Directed</td>
<td>Writing/ Listening/ Speaking</td>
<td>Intermediate</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td>2</td>
<td>Missing Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Process Skills</td>
<td>Reading</td>
<td>Beginning</td>
<td>1</td>
<td>Beginner</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Student Project</td>
<td>Reading/ Writing/ Listening/ Speaking</td>
<td>Proficient</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Lecture with Discussion</td>
<td>Reading/ Writing</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
</tr>
<tr>
<td>2</td>
<td>Lecture with Discussion</td>
<td>Listening/Reading</td>
<td>Emergent</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
</tbody>
</table>
The LIST analysis of Cindy's observations indicates that she implemented at least three language domains during inquiry lessons. This is an important finding that lends support to the importance of implementing inquiry in classrooms where students are learning academic English skills. An analysis of the reported language practices indicated that in Years 1, 3, and 5, Cindy implemented more writing than any other domain (see Table 13). Contrastingly, she implemented less reading than any other language domain during the 3 years included in this study. Nonetheless, in Year 3 she implemented more reading than in any other year. In Year 5, she reported implementing practices that involved more listening and less reading on the part of her students. For instance, she lectured using a Power Point presentation while her students took notes. This coincides with the observation data from Year 5. Both observations conducted in Year 5 Cindy implemented Power Point lectures with class discussions.

Table 13

*Cindy: Reported Language Domain Implementation*

<table>
<thead>
<tr>
<th>Year</th>
<th>Language Domain</th>
<th>Listening</th>
<th>Speaking</th>
<th>Reading</th>
<th>Writing</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td></td>
<td>23</td>
<td>15</td>
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<td>3</td>
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<td>5</td>
<td></td>
<td>32</td>
<td>16</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>83</td>
<td>43</td>
<td>22</td>
<td>106</td>
</tr>
</tbody>
</table>

In summary, Cindy reported implementing more inquiry and a more balanced implementation of language domains in Year 3. This was the year her district purchased commercially available science kits. Toward the end of Year 1 she implemented all three vocabulary tiers. In terms of language domains she
consistently implemented a combination of 2 or 3 language domains with an overall lower implementation of reading practices and a preponderance of implementation of writing and listening. For Cindy, the lack of preservice preparation and content knowledge played a role on her implementation of inquiry. When she began teaching, she had no prior teaching experience and not content knowledge. She did not feel comfortable implementing inquiry in her classroom. Although she was proficient with the use of technology in the classroom, she relied heavily on the use of Power Point lectures. Cindy's uneven progress exemplifies the struggles in professional growth experienced by alternatively certified early career teachers. Although she had the help of ASIST and other forms of professional development, the deadlines and requirements of emergency certification overwhelmed he and played a negative role on her implementation of inquiry. Contrastingly, her grade team valued the emphasis on vocabulary. Cindy embraced the goals adopted by her grade team and dedicated a considerable part of instructional time (every Wednesday) to teaching vocabulary.

**The case of Jim.** For Jim, the marked differences in socioeconomic status, language proficiency and academic goals between the students from the suburban schools he taught during his student-teaching experience and the students he taught in Years 1-5, became the central theme of his discussions about practices. Jim expressed his overall lack of satisfaction with his students, colleagues, rules and regulations during the interviews. He was consistently brief, often ending his answers with "that's it; that's all I have to say." As the individual researchers tried to probe deeper, Jim refused to elaborate, unless the details
pertained to the low expectations and dissatisfaction he held for students' performance, colleagues and administrator at his school. Consequently, I drew upon observational data to bring out the salient aspects of his practices.

**Division of labor.** In Year 1 Jim was a regular participant of the ASIST program; however, he taught physical sciences and this placed him outside his content area. He experienced issues related to lesson design, classroom and discipline management. In his own words:

ASIST provides me with concrete examples of inquiry and I also like to meet with other teachers during the Saturday workshops. Right now, I am just trying to keep my head above water. I am trying to work up to implement some inquiry for next semester. Right now I am just trying to teach. I do not think I am doing as well as I should be doing. There were a lot of lessons where I did too much lecturing; these lessons were not engaging. (Jim, monthly interview, December 13, 2005)

In Year 1, Jim attended monthly professional development workshops available through his district. He attempted to implement the strategies with his ELL students, but he was not successful at implementing the strategies in his classroom. This is how Jim described his attempts:

I started a professional development on differentiated instruction offered by my district. I thought it would be beneficial, but when I tried to use the vocabulary-building concept map strategies with my ESL students, they did not know what the words meant, so how
were they supposed to make concept maps of those words? (Jim, monthly interview, February 28, 2006)

In Year 3 he volunteered to participate in a reading integration professional development offered through WEST ED. When asked about this experience he shared:

This past year I integrated more reading in the curriculum. All of the strategies I learned through the reading workshops work when students are reading at grade level. For my kids who are reading at second or third grade, this stuff is useless. (Jim, end of the year interview, June 21, 2010)

With regards to mentoring, Jim consulted with the mentors from the ASIST program. Although he was assigned a school-based mentor, in Years 1, 3, and 5, his interactions with these mentors was minimal. For instance, in Year 1 his mentor was a biology teacher from his school; however, Jim shared that only met with his mentor occasionally and that she did not contact Jim or visited his classroom. Instead of relying on his mentor, Jim received help in the form of lesson plans from other science teachers at his school. In Year 1, his district offered mandated monthly meetings for early career teachers. The meetings addressed general concerns not related to teaching science or EL students.

In Year 3 Jim had two mentors: a district assigned mentor and a school-based mentor who was a general science teacher. He reported meeting with the mentors sporadically and talking about general topics that were not directly related to science. During Year 3 Jim took on added responsibilities such as
teaching and extra period, sponsoring the chess club, and representing biology
teachers from his school at the district level. Consequently, he had little time
available to meet with his mentors.

**School community.** With regards to his students, in Year 1, Jim shared
that science inquiry only worked with "upper level kids". This is a view he
maintained throughout the five years of the study. For instance, in Year 1 he
shared the following during a monthly interview: "I am trying different things to
make the kids work more. Inquiry may help with the upper-level kids" (Jim,
monthly interview, December 13, 2005.) Besides the fact that during Year 1 Jim
was teaching outside his content area, he also had to contend with moving to
different classrooms throughout the day. He made the time to help his ELL
students, but shared how difficult it was to find the time to help all of them:

Some of my students are ESL, but there are no interpreters or
aides. The students seem to understand me only when I speak [to
them] slowly, and one on one. More often than not, my ESL
students don't get it. Take for instance my student from Russia; his
English is spotty and I don't know any Russian. I have to prod him
to take notes, and he only comes for tutoring every once in a while.
I also have a couple of Mexican students that are really struggling.
One of them works really hard, whereas the other girl, once I sat
down and explained chemical equations and ionic compounds and
she picked it up. I was trying to hold her hand through it. The
problem is that I have ten other students like her and I would have
to do the same thing for them. I know that the kids are frustrated. These are the kids I could help, but when I do, it slows the rest of the class too much, and I lose the other students. Besides, a lot of these kids have had minimum science, or never had science before.

(Jim, monthly interview, February 28, 2006)

In Year 3 when asked what he would do to modify a lesson to include more inquiry, he responded:

It would actually be nice to make the lesson more inquiry by asking the students to provide explanations as to why they did what they did. Maybe the other teacher can do it that way, but with the kids I have this is not possible. (Jim, PCK interview, June 6, 2008)

At the end of Year 5, we asked Jim to reflect on his teaching and how he learned how to teach:

My classroom management is better than it has been in the past. My students' scores on the district test have improved. I narrowed the curriculum down and concentrated on what was on the test. I went about teaching to the lowest kids because the administration was concerned about test scores. I have to teach a mile wide and millimeter deep. I have to teach to the lowest common denominator. I have so few kids that read and write at grade level that if I taught at grade level I would have to fail half of my kids. It has been like this for the past five years.... I've learned the most
about teaching from talking to other teachers. Meeting and observing people and seeing what they were doing. (Jim, end of the year interview, June 21, 2010)

During the final PCK interview, Jim described how he would teach a lesson on atomic structure. Afterwards, he was asked to comment on whether the lesson was a good example of inquiry. This is what he shared:

This lesson was not a good example of inquiry because it was all direct instruction, and there was no open-endedness to it at all. An inquiry lesson would take a lot more time. I don't think my students would get a lot out of it given the topic. Inquiry is suited for more high level thinking. For more knowledge-level stuff it's just a waste of time. (Jim, PCK interview, June 21, 2010)

By the end of Year 1, Jim decided to leave his school. He accepted a position at an urban high school where approximately 45% of the students were ELL. In Year 3, the school was under a mandated improvement plan for failing to achieve AYP. It was clear from Jim's descriptions, that the improvement of standardized test orientations was a school-wide goal:

Last year's scores in the district test were abysmal. My kids scored six points higher than the kids in the other science classes. Now I feel that I have to simplify everything and teach to the test. I am going to teach only the basics. (Jim, monthly interview, September 18, 2007)
This answer indicates that Jim was willing to modify the curriculum as a result of assessment pressures from the administration. This may help explain the decrease in the implementation of inquiry in Years 3 and 5. In his school, neither colleagues nor administrators fostered the implementation of inquiry practices. This attitude reinforced Jim's views of the usefulness of inquiry for high-achieving students similar to the students he encountered during his student teaching experience.

In Year 3 Jim taught Biology; this was his second year teaching in his content area of expertise. At the high school he did not have to travel, and he had access to technology in his classroom in the form of interactive computer boards and a mobile computer lab. As a result of continued professional development, particularly the Integrative Reading professional development, he learned to implement strategies for reading in science. By Year 3, Jim had access to biology curriculum he developed during the previous year. Here is what he shared about the strategies he was implementing in his classroom: "This year, I do not have to worry about curriculum anymore because it is all planned out. I have geared the curriculum for the students' level. For my ESL students I use white boards, total physical response, and reading articles" (Jim Monthly interview, December 7th, 2008). From this comment, it is obvious that Jim responded to the language proficiency needs of his students by incorporating teaching strategies for the ELL students in curriculum and classroom practices.

In Year 3, Jim shared that some of his students did not like science and were not motivated:
Some of my kids do not like science; they do not have a strong drive to excel; most of them are happy if they get a C or a D. They know they will get in the community college. Others are not even concerned with going to college. (Jim, monthly interview, December 7, 2008)

The school where Jim taught during his first year was in transition with regards to student demographics and teacher turnover. Consequently, most of the teachers were new to the profession. Jim decided to partner up with another early career science teacher to plan curriculum. He also received help from two other science teachers. They shared lessons and materials with Jim. In Year 3, Jim taught an extra period. Consequently, he had little time to interact with other teachers in his department. In Year 5, the administration asked teachers to meet regularly to teach to the district objectives, and to synchronize their curriculum and assessments. Here is what Jim shared regarding his interactions with other science teachers:

Our administrators wanted us to form professional learning communities (PLCs) so we could meet regularly to get into the same sequence with the rest of the Biology team at the school. Together, we came up with a common sequence. I created common tests and Power Point presentations. I did that because the other teachers were not contributing. This past year, we worked together a lot better because the administration required us to do it. (Jim, end of the year interview, June 21, 2010)
Jim's comment indicates that the main objective of the mandated PLC was to promote uniformity and synchronicity among teachers of the same discipline. He also shared that the PLC improved communication and collaboration among teachers. Jim's response was to contribute to the PLC with Power Point presentations and assessments. This is a second example of Jim's compliant attitude toward administrative requests and mandates.

*Longitudinal changes in Jim's pedagogical content knowledge, inquiry, and language practices.* Based on the PCK rubric by Lee and Luft (2007), before Jim started teaching, he had an overall basic PCK rating regarding student learning and science inquiry. This means that he had an understanding of PCK in these areas, and that he addressed them in his practices without student input. He maintained this basic orientation during Year 1. During Year 1, he taught physics, a subject outside his content area. The observation notes indicate that Jim had difficulties implementing activities. In two of the four observations we conducted in Year 1 Jim repeated the activities from the previous day. Here is an example from the fourth observation in Year 1:
T: O. K., yesterday the lab on wavelength, frequency and speed was a little confusing, so we are going to repeat the lab; this should take about 15 minutes. You need to designate someone to copy the information your group collects on the board. [During the lab, the students use stopwatches and rope to calculate the average speed of waves. Afterwards, Jim asked the students to share their data with the class.]

T: What happens when the speed of the wavelength decreases? This is an example of what I told you yesterday; wavelength and frequency are inversely proportional. [He then asked students to put their lab sheets away and to get ready to take notes on electricity and circuits.] (Observation 4, Jim's class, April 19, 2006)

In Year 3, when his school did not make AYP, Jim focused on teaching the objectives in the district criterion referenced test. This focus coincided with a change to limited on his PCK orientations in all the areas (variations of students' approaches to learning, students' difficulties with science concepts and instructional strategies and representation of inquiry). During the fourth observation in Year 3, Jim implemented a lesson where students worked individually on a reading strategy called Talk to the Book. Here are the field notes from the observation:
[Note: Today the class is starting the study of the nervous system. Jim begins class by providing instructions and discussing the agenda for the next two days.]

*T:* Tomorrow you will conduct an experiment to test for factors that affect reaction time. Before we get to that point, you need to read the nervous system chapter from the textbook. Today you will be doing a talk to the book assignment [The students take out their textbook and begin outlining the chapter. They are working individually]. (Observation 4, Jim's class, April 13, 2008)

Throughout the period, Jim walked around monitoring student progress without interacting with them. Midway through the class period he assigned a second reading, much to the dismay of the students who are not done with the first assignment.

*T:* Within your small groups you will have 10 seconds to answer the questions.

*T:* [Reads the question] What is the largest portion of the human brain?

*T:* [assigns another reading on the peripheral nervous system. Students protest.]

*S:* We are not even done with the first part.

*T:* Okay I will give you a little bit of a break. I will show you a video on the peripheral nervous system. [The clip lasts for about a minute, teacher goes over the content of the video and he
then re-introduces the reading. The students ask questions on the nervous system.]

S: Are there nerves in our ears? Are there nerves on our eyes?

T: Yes, there are nerves in our ears. [Students go back to work on their textbook. Jim asks his students to put their books away; soon after the bell indicating the end of the period rings.]

(Observation 4, Jim's class, April 13, 2008)

In Year 5, Jim incorporated inquiry and ELL strategies in his teaching. During the last observation he implemented a directed inquiry lesson that incorporated all language domains and a balance of all three vocabulary tiers. On that day, Jim began his class with a review of energy that incorporated visuals, white boards, and the use of Latin root words as a way to help students connect Spanish terms to Tier 3 vocabulary. The class engaged in two separate activities. The first part of the class included an interactive review of trophic levels. During the second half of the class, Jim introduced a directed inquiry activity. During this activity, the students identified the independent and dependent variables. These are the notes from the five-minute coding interval notes taken during the observation. I this first segment Jim used an interactive computer board to show Power Point slides he prepared for the teacher-led review:

[Herbivores (a single term appears on the screen)]

T: Herbivores obtain energy by eating only plants.
T: Second one, carnivores. What are they going to be eating?

S: Carne [About 12 students call out in unison].

T: That is right!

Jim shows a picture of a comedian eating a tire. The students joke about the picture with him.

S: That's how I feel when I eat a burger from the school cafeteria!

In the second part of the lesson, Jim introduces directed inquiry lab on abiotic factors:

T: Today we are going to set up an experiment. Put your pencils down. [He explains what the purpose of the lab is, and he shows the materials to the students.]

T: What are the two variables we are looking at in this experiment?

S: Growth and type of soil.

T: Write on your white boards, at least one per table. What is the independent variable going to be? [The students consult with each other and agree on the answer before writing it on the whiteboard.] Put them up. [Jim surveys students' answers by reading the whiteboards.]

T: I’ll give you another hint. The independent variable will cause the other one to change.
T: All right, let’s see them [answers on the whiteboards] again.

T: Okay, it looks like you are in the right page.

T: Now write it down on your paper.

T: What are the abiotic factors in this experiment? [Jim mentions some of the factors: sunlight: water, soil. (Jim, classroom observation, November 15, 2009)]

In the first part of this lesson Jim used the Spanish word carne (meat) to help his students remember the meaning of the Tier 3 term carnivore. This shows that Jim was helping his ELL students make a connection between a Tier 1 Spanish term and a Tier 3 science term in English. The image of the man eating a tire elicited a few laughs among the students and provided a brief moment of levity in the classroom. In the second part of the lesson, Jim introduced a directed inquiry lab. He asked the students to consult in their small groups to identify the independent and dependent variables for the upcoming experiment. Student engaged in small group discussion and used whiteboards to write down their answers. Jim provided immediate feedback to the students and gave them a second opportunity to modify their answers.

In summary, during this lesson he used students’ prior knowledge of vocabulary and fostered student interactions that involve listening, speaking and writing. The practices observed in Year 5 coincide with a basic PCK orientation in the category of students’ prior knowledge. In contrast with his earlier attempts in Year 1 to implement differentiated instruction strategies, in Year 5 Jim
implemented student-centered strategies while fostering the use of academic language domains among his students. Thus, Jim experienced longitudinal changes that indicate professional learning in the area of student knowledge.

In terms of reported and observed inquiry practices, Jim reported implementing guided and directed inquiry in Years 1, 3, and 5 (see Table 14). Overall, he reported implementing more inquiry in Year 1 than in any other year included in this study. His implementation of inquiry decreased progressively from Years 1 through 5 (see Table 15). In terms of language domains, Jim reported implementing almost twice as much listening and writing than reading or speaking over the three Years of practices included in this study.

Table 14

Jim: Reported Inquiry Practices from Monthly Interviews

<table>
<thead>
<tr>
<th>Year</th>
<th>Inquiry Level</th>
<th>W.U. (^a)</th>
<th>Frequency (Total = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guided</td>
<td>2,5,6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>2,4,8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>1,3,4,6,7,8</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 4)</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 3)</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>7,5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Student Research Project</td>
<td>1,7</td>
<td>4</td>
</tr>
</tbody>
</table>

Note. W.U.\(^a\) = Eight monthly phone interviews were conducted during the school year.
Table 15

Jim: Reported Language Domain Implementation

<table>
<thead>
<tr>
<th>Year</th>
<th>Listening</th>
<th>Speaking</th>
<th>Reading</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48</td>
<td>26</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>24</td>
<td>19</td>
<td>84</td>
</tr>
<tr>
<td>5</td>
<td>28</td>
<td>3</td>
<td>10</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>56</td>
<td>41</td>
<td>180</td>
</tr>
</tbody>
</table>

This trend holds for Years 1 and 5, but in Year 3 Jim reported implementing more writing than any other language domain. In Year 3, when he participated in the integrated reading professional development, he implemented twice as many reading activities than in Years 1 or 5.

The LIST analysis of observed language domain practices indicates that overall, Jim implemented equal amounts of beginning, emergent and intermediate lessons in Years 1 and 3 (see Table 16). In Year 5, students we observed students engaged in all four language domains. With respect to the implementation of vocabulary, Jim implemented more lessons that included vocabulary from Tier 3 than from any other tier. He also implemented a combination of Tier 1 and Tier 3 vocabulary.
Table 16

*Jim: Observed Practices*

<table>
<thead>
<tr>
<th>Year</th>
<th>Observation Number</th>
<th>Inquiry</th>
<th>Language Domains</th>
<th>Diagnosis</th>
<th>Vocabulary Tiers</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Verification Lab</td>
<td>Listening Writing</td>
<td>Emergent</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Video</td>
<td>Writing/Listening</td>
<td>Emergent</td>
<td>1, 3</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Lecture with Discussion</td>
<td>Listening Reading Writing</td>
<td>Intermediate</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Verification Lab</td>
<td>Listening Reading Writing Speaking Listening</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Verification Lab</td>
<td>Beginner Listening Speaking Writing</td>
<td>Beginner</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Verification Lab</td>
<td>Listening</td>
<td>Beginner</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Verification</td>
<td>Writing Speaking Listening</td>
<td>Intermediate</td>
<td>1, 3</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Verification</td>
<td>Reading Writing</td>
<td>Emergent</td>
<td>3</td>
<td>Beginner</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Student Project</td>
<td>Reading Writing Listening Speaking</td>
<td>Proficient</td>
<td>1, 3</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Guided Inquiry</td>
<td>Reading Writing Listening Speaking</td>
<td>Proficient</td>
<td>1, 2, 3</td>
<td>Proficient</td>
</tr>
</tbody>
</table>
In summary, Jim's professional learning trajectory was as winding and complex as his path to become a science teacher. He struggled with content, context and pedagogy throughout all three Years, but more especially during Year 1. He also struggled to accept the differences between the students he encountered during student teaching and the students he taught in Years 1, 3, and 5. Jim resorted to rationalizing his students' lack of academic success and motivation to their parents' lack of interest in education, and to the students' home environment. In spite of his deficit views, Jim tried to make his teaching more engaging and meaningful to his students.

It is plausible that through professional development and daily interaction with his students Jim learned to incorporate strategies to scaffold academic English language skills. Moreover, assessment pressure and the failure of his school to meet AYP in Years 3 and 5 played a major role on Jim's practices. Other than the inquiry focused professional development provided by the ASIST program, Jim taught all five Years in school contexts where there was no support for inquiry. Moreover, he did not have a strong mentor to help him reframe his deficit thinking. Although ASIST provided him with clear examples of inquiry, we only observed him implementing inquiry in a single instance, during the last classroom visit. In spite of his struggles and views, to this date, Jim continues to teach science at the same school. He exemplifies what happens when someone who does not initially set out to become a teacher ends up in a high needs school. Jim could have benefitted from an early intervention to help him reframe his thinking, or perhaps reconsider his decision to become a science teacher.
Section 3: Teachers with Low Percentages of English Language Learner Students

This third group of teachers includes Enid and Alana. I decided to include them for multiple case study because they allowed an increased understanding of the contextual factors and the role these pay on teacher practices. Both of these teachers began their careers in suburban schools. Although Alana moved from a middle school to a high school between her third and fifth year of teaching, Enid remained at the same high school throughout all five years. Unlike Kelly, Cindy, and Jim, their schools did not receive a failure to make AYP label. I will now examine their professional earning trajectory.

The Case of Alana

Alana taught 8th grade General Science at a suburban middle school for the initial three years in the classroom. Among the affordances available to Alana were: a) ASIST, b) district and school administrators, c) colleagues, and d) curriculum resources. The constraints experienced by Alana were related to: a) the lack of professional development on strategies for teaching ELL students, and b) an increased number of ELL students.

Division of labor. In Year 1 Alana participated in the ASIST program and in a district-sponsored induction program. She attended ASIST on a regular basis and found the examples of inquiry from the monthly workshops to be useful. She also participated in monthly, mandatory beginning teacher meetings and technology workshops available through her district. She had a mentor who was a 7th grade science teacher. They meet every day at lunchtime; however, Alana felt
that her mentor was not very helpful because she taught a different grade level. As Alana reflected on her professional learning at the end of Year 1, she shared the following:

This past year I feel that I have grown exponentially. I am more knowledgeable about the content and how to teach it. I know more about my students and how they learn. I had the help from the ASIST program. I attended the workshops and got ideas for inquiry lessons. Through my district I participated in the BEST [Beginning Educator Support Team] program for new teachers. I had meetings once a month. (Alana, end of the year interview, August 26, 2006)

Although Alana received support from two different induction programs, the BEST induction program covered general issues such as classroom management and discipline.

Contrastingly, in Year 3 due to budget cuts, her district offered limited opportunities for professional development. At her school she participated on monthly functional reading and differentiate instruction workshops. In her continued pursuit of opportunities to grow as a teacher, she networked with other teachers and created a professional development summer institute for other teachers. In Alana’s own words:

This year, I have not participated in any professional development outside the school. The district will not pay for substitutes to cover my classes during the day. I am a good teacher, but in order to
become great I need more opportunities. When the district adopted the FOSS kits I began looking for opportunities to collaborate with other teachers across the valley who were trying to learn how to go beyond what was in the kits. We ended up creating a summer institute for other teachers. We now meet once a month to plan the institute. The people from the science curriculum kits are going to send two experts to help us with the institute. It will be available to any teacher. Because of this lack of opportunities to grow I decided back in February I want to leave this school. (Alana, Monthly interview, May 8, 2008)

In Year 5, Alana taught at an urban high school. Unlike her experience with lack of professional development at her previous high school, at her new school she found support and opportunities for professional development. She attended a national science teacher conference as well as a one-week technology camp during the summer. Throughout the year, she participated on two separate workshop series; the first one was designed to develop a professional learning community and the second one was aimed to implement a school-wide online grading system. In the final interview she shared:

I finished up my ESL certification. I also participated in a several technology workshops because we have a lot of equipment at our school: interactive computer screens, document cameras, computers. These workshops were very useful. Although I question if some of this stuff [technology] is going to be beneficial;
in the end, being able to hook up my microscope to the document camera and being able to show clips and to grab pictures from different sources to add to Power Point presentations is great. As long I learn something that I can use, it is worthwhile the time and effort. (Alana, end of the year interview, June 2, 2010)

Other than being able to have access to the technology in her classroom Alana did not receive salary incentives for attending these workshops. She appreciated the opportunity to incorporate new resources in the science classroom.

**School community.** The longitudinal analysis of the school community in the middle school where Alana taught for the initial three years in the classroom indicate that in Year 1 Alana received the support of individuals from the district and school. During the end of the year interview she shared the following about her interactions with colleagues, administrators and district support personnel at her school:

I always could go for help to my assistant principal or colleagues for help. I went to the math teacher across the hall. He was not my official mentor, but he adopted me. If it wasn't for him, I do not know how I would have survived my first year. The science coordinator at the district was always willing to help. She visited my classroom and gave me materials and lessons. Also, the assistant principal was a former science teacher and he stopped by my class every couple of weeks to see how I was doing; he even
gave me a CD full of lessons. (Alana, end of the year interview, June 9, 2006)

Most of the support was provided by individuals from the district and from her school on an individual bases. It is also evident that the individuals providing support to Alana were proactive in their efforts by taking the initiative to visit Alana's classroom. Overall, the help she received from different members of her teaching community consisted of activities and lesson plans. She viewed the support as instrumental and effective in helping her navigate through her first year in the classroom.

In Year 3, although Alana was still teaching at the same school, there were marked changes in the school community. This is what she shared at the end of Year 3:

At our school there is no collaborative teaching at all. I consider collaboration essential to develop an inquiry curriculum and to grow as a teacher. I feel that I am the one offering the other teachers advice and curriculum; I get nothing in return. The teachers are restricting themselves to teach the inquiry from the curriculum kits. They do not feel the need to cooperate with each other. If is not in the [science curriculum] kits, they do not want to go beyond and teach more inquiry-based lessons. This is why I am leaving the school. (Alana, end of the year interview, June 9, 2008)

By Year 5, Alana was in her second year of teaching Biology, her content area of expertise, at the high school where she moved at the end of Year 3. At this
school, she participated in a professional learning community. During the PLC meetings teachers worked on a common curriculum and assessment. One of the PLC members was a reform-oriented science teacher who implemented inquiry in her classroom. This is what Alana shared about her colleagues and administrators in Year 5:

People at my high school were willing to work together and share their ideas. In going from the middle school to the high school the school size doubled. I did not see the administration at my school because I was one of many and they did not have enough time. I definitely felt less individual attention, but administrators did their job and were available to answer questions. (Alana, end of the year interview, June 2, 2010)

In Year 5, her colleagues fulfilled the need she expressed earlier regarding the collaborative interactions that she considered important for her professional growth. Although the PLC was mandatory, most teachers collaborated and had common goals. In the next paragraphs, I will discuss details of Alana's students, and the role they played on her learning trajectory.

The student demographics and characteristics fluctuated throughout the Years encompassed by the study. Alana was aware of these changes and tried with different degrees of success to adjust her practices to meet the needs of her students. In Year 1, there were no major issues with her students. In Year 1, she taught at a school were students were from affluent families. Although she had 12 students with individualized education plans in a class of 25, we did not observed
discipline or behavior problems. When asked to provide details about her students in Year 1, Alana had this to say:

My students are great for the most part; of course, in every period there are two or three students who did nothing all year. This was frustrating because I worked on lessons after school hours and on the weekends, only to have the kids not care. (Alana, End of the year interview, June 9, 2006)

Although the lack of interest displayed by a few or her students was a source of frustration for Alana, she did not share how she tried to modify their behavior, nor did she share about accommodations for her students who had IEPs.

In Year 3 Alana had an increased number of special education, minority, and ELL students in her classroom. She was not prepared to differentiate the instruction. She resorted to slowing down the pace of instruction. Although the number of students with IEPs was about the same as in Year 1, the school demographics were in flux. This strategy frustrated her. Here is what Alana shared regarding her students in Year 3:

This year I had way too many special education kids and ESL kids. This was really hard because there were kids with a behavioral plan sitting next to a higher level kid who is ready to rock and roll. Their own peers were holding these kids back. I had kids who did nothing all year, nothing! (Alana, end of the year interview, June 9, 2008)
Alana expressed a great degree of frustration regarding the academic differences among her students. She did not mention specific attempts to differentiate instruction for her students. At the end of Year 3, she decided to leave her school. Although she did not directly mention her frustration about her students as the reason for her departure, she did share that she was not growing as a teacher, and that she needed a different environment.

In Year 5, she also shared her inability to motivate and connect with her high school students:

The composition of my students, like I said, we have a lot of lack of motivation, it's very diverse. A lot of the kids come from the inner city, not much support at home, not much motivation, and it's hard to connect it. I understand what it's like to have a bad background but I have a hard time connecting with students who just don't want to learn. My expectations are that you don't have to get an A, it's how are you going to make where you are now better.

(Alana, end of the year interview, June 2, 2010)

Alana's comment indicates that she expressed deficit views about her students' academic ability. Without the help of a mentor or colleague, Alana was not able to reframe her views about her students' academic potential, and about how she could engage her students by making connections between the science content in her classroom and the students’ lives.

Teacher artifacts. In Years 1 and 3 Alana had a curriculum map and a commercial set of inquiry-based curriculum kits. Although the kits provided some
structure and activities that could help in the flow of curriculum, Alana found them restrictive and believed they contributed to the lack of cooperation among teachers. She found the kits provided a starter for inquiry science, but did not include enough inquiry. This is what she shared:

> There is no collaborative teaching among science teachers in my department, which I feel is necessary to continue to build inquiry-based instruction in all areas, all the time. Even though we have a lot of curriculum kits, if something is not in the kit, my colleagues do not want to go beyond. When you have all those curriculum kits the need to sit down and collaborate becomes less of a priority.

(Alana, end of the year interview, June 9, 2008)

Whereas at the middle school she had the curriculum kits, in Year 5 she participated with other Biology teachers a PLC to redesign the curriculum. Teachers added inquiry while maintaining the sequence and flow of instruction. In addition, they created common assessments and agreed on a common sequence of instruction. This is what she shared about her experience with colleagues in Year 5:

> Through the PLC, I worked with other Biology teachers. Although we did not all agree on everything, there was an amazing teacher who incorporated lots of inquiry in her teaching. We worked on the Biology curriculum by incorporating inquiry. In Year 5, I included topics that were in the news, issues that students could connect to
because they were part of the national news: stem cell research, global warming. (Alana, end of the year interview, June 2, 2010)

Thus in Year 5, Alana was able to collaborate with other teachers, in particular with a more experienced reform-minded colleague who was willing to infuse inquiry through the Biology curriculum. She also incorporated technology to help her students who were absent from school. In spite of her deficit thinking, she tried to incorporate practices to foster student involvement in science. It was not clear how students gained access to the podcasts she created. In the next paragraphs I will discuss the role of rules and regulations imposed by the districts and schools.

**Rules and regulations.** For Alana, there were very few constraints imposed by her administration or district. In Year 1 her participation in the BEST district induction program was a requirement for employment. In Year 3 all state certified teachers had to complete 90 contact hours to obtain their ESL endorsement. In Year 5, all teachers in the school were required to participate in a professional learning community. The goals of the PLC were to infuse inquiry in the curriculum and to align the curriculum and assessments to the state science test the school. The relatively few demands from the administrations could be explained by the fact that none of the schools where Alana taught failed to make AYP. In what follows, I will discuss Alana's inquiry and language practices and the development of her PCK.
Longitudinal changes in Alana's pedagogical content knowledge, inquiry, and language practices. In terms of PCK, Alana maintained an overall basic orientation in approaches to student learning and inquiry (see Table 17).

Table 17

Alana: Longitudinal Changes in Pedagogical Content Knowledge

<table>
<thead>
<tr>
<th>PCK Question</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCK 1 Students' prior knowledge</td>
<td>Limited</td>
<td>Limited</td>
<td>Basic</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 2 Variations in students' approaches to learning</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 3 Students' difficulties and misconceptions</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 4 Knowledge of inquiry instructional strategies</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Proficient</td>
</tr>
<tr>
<td>PCK 5 Representation of instructional strategies</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>Overall Orientation</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
</tbody>
</table>

Note. PCK = Pedagogical content knowledge.

A closer examination of her PCK orientations uncovers two trends: a) Alana's PCK orientation toward student learning shifts from basic to limited when she moves to the high school to teach Biology, and b) she maintained a basic orientation regarding inquiry instruction throughout the five Years encompassed by the study. In Year 5, she taught at an urban school with a more diverse student
population. In this school, approximately 20% of her students were ELL and came from middle and low income families. Throughout the monthly interviews we conducted in Year 5, Alana referred to her students' lack of motivation and interest in science. She struggled to make the content of her class relevant to the students. During the PCK interview conducted at the end of Year 5, she discussed an activity involving cell stem research. As an introduction to the activity, she provided her students with an article presenting both sides of the argument on the topic. Next, the students used the Internet to find information about the topic. Afterwards, students had to write an essay presenting the facts that helped them formulate an opinion about stem cell research. For this lesson, Alana assumed that her students had little to no prior knowledge. Moreover, she did not consider variations in students’ approaches to learning or difficulties or misconceptions.

The following is an excerpt from the PCK interview:

*Interviewer:* Did you consider prior knowledge?

*Alana:* No, because they did not know what a stem cell was in the first place. Some kids kind of did, but for the most part, nothing to this level.

*Interviewer:* Did you consider variations in students’ approaches to learning?

*Alana:* I did not differentiate the multiple ways to do the particular assignment, no.

*Interviewer:* Did you consider students’ difficulty with specific science concepts, such as misconceptions?
Alana: For this assignment?

Interviewer: Yes, just this assignment.

Alana: I think that they could have gotten a little fuzzy when we were talking about the stages of what a fertilized egg going to a zygote, going to an embryo and the amount of cells were in each stage. I do not think it was really important to get the overall concept. Could they have had misconceptions on different parts? Yes, but to understand the overall concept, I doubt it.

According to the PCK coding rubric, Alana had a limited PCK orientation of students' cognitive background, variations to learning approaches, difficulties and misconceptions about the topic of stem cell research; however, when we asked her to determine if this lesson was inquiry-based she was able to reflect on it:

Interviewer: Is this a good example of inquiry in science

Alana: No.

Interviewer: Why not?

Alana: Because there was no self-discovering. There was not any thinking involved that had to do with observations and gathering information and coming up with an idea using the information they collected. (Alana, PCK interview, June 2, 2010)

Although she elected to share a non-inquiry lesson as an example of a lesson that was successful; she also recognized the lack of inquiry in the lesson. This reflection coincides with the basic representation and interpretation of inquiry.
For Alana, the availability of inquiry-based curriculum in Years 1 and 3, and the presence of a reform-minded biology colleague at the high school, played a positive role in her inquiry practices. The inquiry-based professional development she received through ASIST helped her understand inquiry instruction and allowed her to modify the 8th grade inquiry-based curriculum kits at her to include more inquiry. The analysis of Alana's reported inquiry practices indicates that in Years 1, 3, and 5, she reported implementing more directed inquiry than guided inquiry (see Table 18). This coincides with the observed practices (see Table 19). Her reported implementation of language domains indicates that during all three Years included in this study, her students predominantly engaged in writing activities. In fact, students engaged in writing twice as many times as they engaged in listening (the second most frequently implemented language domain.) Contrastingly, she reported implementing less reading than any other language domain.
Table 18

Alana: Reported Inquiry Practices from Monthly Interviews

<table>
<thead>
<tr>
<th>Year</th>
<th>Inquiry Level</th>
<th>W.U.</th>
<th>Frequency (Total = 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guided</td>
<td>4, 7, 8</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>3, 4, 6, 7, 8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 18)</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td>7, 8</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>3, 7</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Inquiry Level</td>
<td></td>
<td>Frequency (Total = 11)</td>
</tr>
<tr>
<td></td>
<td>Guided</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>2, 3, 7, 8</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>2, 5, 7</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Process Skills</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. W.U.\(^a\) = Eight monthly phone interviews were conducted during the school year.
### Alana: Observed Practices

<table>
<thead>
<tr>
<th>Year</th>
<th>Observation Number</th>
<th>Inquiry Level</th>
<th>Language Domains</th>
<th>Diagnosis</th>
<th>Vocabulary Tiers</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Process Skills</td>
<td>Speaking, Listening</td>
<td>Emergent</td>
<td>1</td>
<td>Beginner</td>
</tr>
<tr>
<td>2</td>
<td>Directed Inquiry</td>
<td>Writing, Speaking, Listening</td>
<td>Intermediate</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Directed Inquiry</td>
<td>Writing, Speaking, Listening</td>
<td>Intermediate</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Directed Inquiry</td>
<td>Reading, Writing, Speaking, Listening</td>
<td>Proficient</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Process Skills</td>
<td>Listening, Reading</td>
<td>Emergent</td>
<td>Tier 3</td>
<td>Beginner</td>
</tr>
<tr>
<td>2</td>
<td>Directed Inquiry</td>
<td>Reading, Writing, Speaking, Listening</td>
<td>Proficient</td>
<td>1,2,3</td>
<td>Proficient</td>
<td></td>
</tr>
</tbody>
</table>
The analysis of observed practices showed that we observed Alana implementing directed inquiry in all three years, and that she implemented more inquiry in Year 1. This is an excerpt from an observation conducted in Year 1:

10:03

A: Today you will be observing different substances at your lab stations. I will call one person from each group to get the substance and place it on the table. You will rotate clockwise to the next station when you hear the music.

Once the students have placed the substances on the lab tables, Alana gives the students 2 minutes to record their observations. While the students are working, she tells me that she doesn't have any specific curriculum she has decided to use the 5E Model she learned in the ASIST workshops. She adds that because the FOSS Kits, which she uses quite a bit are based on the 5E, this was not a hard decision.

10:20

Students are writing their observations while talking quietly in their groups. They hold up the glass jars and turn them around.

As I walk around, I notice that the students are writing down the physical properties of each substance.

10:30

After the students have made all the observations, Alana points to the board and initiates a discussion about pure substances.
and mixtures. She asks students to discuss in their groups whether each of the samples they observed were pure substances (made of one type of matter) or mixtures (made of more than one substance).

A: Is a fruit a pure substance?

S1: No, because it is made of pulp, seeds and juice.

S2: also, because fruits have pesticides.

A: What about milk and eggs?

S3: Milk is a pure substance, but an egg is not.

A: Milk has all sorts of substances in it: water, sugar, fat, Calcium.

She ends the lesson by asking student to add the words substance and physical property to their vocabulary list. (Alana, classroom observation, February 2, 2006)

In this lesson, her students engage in directed inquiry by constructing their own understanding of the term substance. During this activity, her students were also engaged in at least three out of four language domains (see Table 19). Moreover, during the implementation of inquiry, she included terms from all vocabulary tiers. Thus in Alana's case, inquiry implementation coincided with the implementation of academic language domains and vocabulary that helped her ELL students navigate through the content of science and academic English while being introduced to science specific vocabulary in the context of inquiry.

In summary, during her initial year in the classroom Alana received induction support from her district and from ASIST. She had a curriculum map
and inquiry-based curriculum. In Year 3, she decided to leave the suburban middle school where she taught and moved to an urban high school to teach Biology. At her new school she engaged in the design and implementation of inquiry-based curriculum in the company of a reform-minded, more experienced colleague. Because of the support she received regarding the implementation of inquiry, she was able to maintain a basic PCK orientation of inquiry strategies. Contrastingly, her PCK orientation about student learning fluctuated from limited to basic between the onset of teaching and Year 3.

Whereas this change occurred while she was teaching at the middle school, when she switched to an urban high school, her PCK orientation declined from basic to limited. In Year 5, she implemented less inquiry because the Biology PLC goal of implementing inquiry in the curriculum was a work in progress. Alana could have benefitted from interacting with a mentor or colleague to help her reframe her deficit view of diverse students. In Alana's case the only regulation imposed throughout the five Years we observed her classroom was the mandatory participation in the goal oriented Biology PLC at the high school where she taught in Year 5.

The case of Enid. Enid is the second participant who taught at a suburban school where there were no ELL students. Unlike Alana, Enid remained at the same high school during Years 1 through 5 of her teaching career. Whereas Alana set out to become a Biology teacher at the undergraduate level, Enid's original plan was to teach Health and Nutrition; however, during the last year of her undergraduate studies she realized that this content area was taught through
the physical education curriculum. She then determined that she needed fewer credits to earn her credentials in Chemistry than in any other science content area. Much like Jim, Enid could be considered a fortuitous science teacher. In the next paragraphs, I will examine the affordances and constraints surrounding Enid as she developed professionally.

Among the affordances surrounding Enid were a) the ASIST program, b) professional development opportunities available through the school district, c) the support of mentors and colleagues, d) participation in a PLC, and e) curriculum and resources. The salient constraints present during this time period were associated with the areas of teacher cognition and social interactions. Specifically, Enid experienced issues related to a) the academic subjects she taught, b) students, c) parents, d) lack of support for inquiry practices by most of her colleagues.

**Division of labor.** In Year 1, Enid received induction support and mentoring from two different programs. In Year 1, Enid participated in the ASIST program. She attended all the monthly workshops and consulted with the program mentors during monthly classroom observations and over the phone whenever she had questions about management or inquiry instruction. She also participated in a beginning teacher induction program through her district in Years 1 through 3. Whereas in Year 1 she attended mandatory meetings, in Year 3 the district mentors were available for consultation. During Year 1, she met once a month with an assigned mentor who was a math teacher. Her mentor observed Enid twice a month and provided feedback. Informally, she received mentoring support
from teachers in her department. This is what Enid shared about the mentoring support she received during her first year in the classroom:

I had the support of the science department chair and the other science teachers, definitely the core team. Our department is so incredibly supportive. I had the ASU mentor teachers, and the district mentor program. I didn’t have an official mentor in the department, but there were teachers that I knew who were definitely in the mentor role. (Enid, end of the year interview, June 27, 2006)

In Year 1 Enid participated in several professional development workshops on differentiated instruction, ESL strategies, and cooperative learning. She also attended two science teacher conferences. In Year 3, Enid participated in a PLC to discuss articles related to educational issues and best practices. In Year 3, she attended concept map professional development sessions and conferences. As a result, Enid became a concept map trainer for her school and district. In Year 5, she participated in the physics PLC and assisted in developing the conceptual physics curriculum at her school.

Besides the teachers in her department, Enid also received support from the administrators at her school. This is what she shared about them at the end of Year 1:

The principal did all my formal observations, and then we had the follow-up meetings and he was incredibly supportive. When I had a formal observation—he came in and he was very positive. And
the assistant principals, all the administrators were very supportive.

(Enid, end of the year interview, June 27, 2006)

In Year 3, the new administrator visited Enid’s class regularly. He instituted and directed PLCs for each department. In Year 5, the objective of the PLCs changed and teachers met to discuss and plan curriculum in their respective content areas.

**School community.** In Years 1 and 3, the Chemistry teachers in her department shared resources and materials with Enid. Enid also met regularly with the Earth Science teacher in the department to review instruction and discuss lesson plans. In Year 5, Enid was asked to teach Conceptual Physics. Because Enid was out of her content area of expertise, she received the support of an experienced, reform-minded physics teacher who encouraged Enid to implement inquiry activities. This teacher taught in the classroom next door. Consequently, Enid relied on her colleague's support on a daily bases. This is what she shared about the value of the support she received from her colleague:

> I worked with a different teacher that I hadn’t worked with before, who was phenomenal. I learned a lot of things from her. She’s been teaching Chemistry and Physics for 20 Years at all levels. It was amazing what she could come up with. That’s why she was phenomenal. Plus, she was just a really good teacher. She would explain things to me, and made it very easy to understand. (Enid, end of the year interview, June 12, 2010)

In the next paragraphs I will discuss the salient constraints Enid experienced in the initial five Years of her career.
Most of Enid's constraints arose from her understanding of content pedagogy, and from decisions she made during her preservice preparation. Throughout her initial year in the classroom she experienced issues of pacing, classroom management and student learning. This is what Enid shared about content and pacing during the end of the year interview:

Not knowing the pacing was difficult, because, you know, they give you a curriculum, and they say, —This is what you have to get through—, especially in chemistry. I just was racing. I was trying to keep up with the other teachers and I let them dictate my speed. This was very frustrating for me because the topics that I should have spent more time on I sort of rushed through. (Enid, end of the year interview, June 27, 2006)

From this comment, it is obvious that Enid was trying to maintain the instructional pace set by her colleagues instead of considering her students' cognitive needs. This decision contributed to decreased student understanding of key science principles. Enid was aware of this situation and reflected on it:

Come the end of the year when the students were supposed to have a solid foundation of something that I should have spent more time on the beginning, and they were struggling. I had to repeat some things because they didn’t get it. So I think pacing and then knowing which topics need more attention than others, which ones I can kind of pick up the pace, and which others I really need to slow down! (Enid, end of the year interview, June 27, 2006)
During several monthly interviews Enid shared her difficulties with classroom management, organization and related issues with students and parents. Here is a composite of her comments made throughout Year 1:

I am having huge problems with the organizational part of teaching. I find the textbook confusing, and I do not know what to emphasize.... I am struggling to keep up with the paperwork aspect of teaching. I've decided not to accept late work.... The warm-up questions are not working because students realized I wasn't grading them.... The parents and students are demanding that I do re-takes on the quizzes; this is a big problem. (Enid, monthly interviews, September 23, 2005 through February 21, 2006)

Although Enid was aware of the recurring content and pacing issues related to student learning, she did not explain if she addressed them, or if she received specific advice from colleagues or mentors.

By Year 3, Enid had improved her pacing. This is what she shared about her teaching at the beginning of the school year:

Teaching is much easier now that I only have one prep [a single subject]. Things are going smoothly and I am more comfortable with the materials and with pacing. This year my students are having more Ah, ha! moments; this may be because I taught quantum numbers before electron configuration.... The flow and organization of things are going well. (Enid, monthly interview, September 21, 2007)
In Year 3 Enid was familiar with the curriculum. Although her school adopted a new Chemistry book and purchased computers and instrument probes, she was able to adjust her pacing and use the new curriculum resources available. Consequently, the issues pertaining to student learning and parental complaints did not surface in Year 3. She shared that she was a bit behind in the curriculum in comparison to her colleagues; however, she did not try to rush through instruction. This is what she shared about considering students to determine the pace of instruction: "When a concept was harder we spent more time on it. I looked at student behavior. If they are not getting it, they begin to sleep and not pay attention" (Enid, end of the year interview, June 4, 2008). Although she was more aware of the connection between student understanding and behavior, she relied on clues from her students' body language to determine when they understood the concepts. Moreover, she did not consider the possibility of her students’ lack of engagement as a signal that they already understood the concepts covered in the lesson.

In Year 5 Enid taught honors and regular Conceptual Physics, a subject outside of her content area. She experienced issues with students and parents that were very similar to the issues from Year 1. This is a composite of her comments from the monthly interviews:

Freshmen students are challenging; they do not want to put forth the effort. I had a an irate parent call me last week to blame me for his son's lack of progress ... I am having a hard time determining student learning and readiness.... Freshmen students want to be
spoon-fed; it is a challenge to get them to think on their own. Their parents question my ability to teach. I've had more parent conferences this year than in the past four years put together. I question if it is the students, or if it is the class itself. (Enid, monthly interviews, November 4, 2009 through March 10, 2010)

Enid struggled with parent and student issues throughout the year. As I observed her teach optics during a scheduled classroom visit, she corrected herself twice and had to ask the students to erase and rewrite the notes she was giving them.

This is an excerpt from the field notes:

*T*: We are going to draw the optics of a flat mirror. And is the image right side up or upside down?

*S*: Right side up. [A single student answers; Teacher draws the mirror diagram.]

*T*: [Continues to draw the diagram and says quietly, as if talking to herself] I already messed this up. It is a ray and I, so I am actually going to draw this here. [She then directs her attention to her students and speaks in a louder voice.] So, what this is, and I did not draw it exactly right…. [She uses the tip of the pen to show the trajectory of the ray, then tells the students that the angle, according to the law of reflection, should be the same.] That was the law of reflection.

She checked the physics textbook and then proceeded to lecture. From her demeanor it was clear that Enid's understanding
of optics was questionable at best. Her students complained about having to erase the notes and asked questions to try to clarify their understanding. (Enid, classroom observation, March 9, 2010)

**Rules and regulations.** For Enid, the rules and regulations imposed by her school and district varied from year to year and had an impact on her practices. For instance, in Year 1 she traveled to different classrooms throughout the day. For an early career teaching Earth Science and Chemistry, this was a difficult situation that impinged upon her ability to organize and manage practical aspects of instruction. Additionally, in Year 1 she taught Earth science, a subject outside her area of expertise. In Year 3, there was a marked increase in class size due to state-mandated budgetary cuts. In Year 5, due to district restructuring, the high school added 9th grade and consequently, Enid was asked to teach 9th grade Conceptual Physics. Once again, she taught a subject outside of her content area. In Year 5, Enid tried unsuccessfully to pass the content knowledge test for physics. As a result, she was not able to fill the physics position available at her school. Her other option was to go back to teaching chemistry in two different high schools. At the end of Year 5 she resigned and accepted a job as a math and science curriculum writer with a publishing company.

Even with the support offered by the induction programs, her mentors and her colleagues, the demands imposed by administrative decisions at the school and district level overwhelmed this early career teacher and caused her to leave teaching.
Teacher artifacts. In Years 1, 3, and 5, Enid received curriculum maps and resources for each class she taught. Whereas in Year 1 her colleagues provided her with lesson plans and resources, in Years 3 and 5 the district adopted new textbooks for Chemistry and Physics. Enid worked with other teachers to determine the alignment and sequence between the curriculum resources and the curriculum maps.

Another salient aspect of Enid's approach to teaching was her reluctance to do laboratory activities. Although Enid taught Chemistry, she did not feel comfortable with implementing laboratory activities with her students. She did not see the connection between doing labs and student learning. In her own words:

Doing labs is much harder for classroom management. I have to be so on top of things. Even on the days when everything goes exactly as it should, I ask the students, “What did you do? How did this relate to you or how can you connect this to what we learned in class?” They have no idea. I ask myself: “Why did I waste all that time and energy setting up that lab?” (Enid, end of the year interview, June 4, 2008)

In Year 3 she had access to new technology. Enid had this to say about the resources available to her:

This past year we had computer carts and the probes to go with them. The best part was that it was available. We received little training and this made it frustrating. The probe labs are very step
by step and don’t work all the time. The students and I didn’t understand how to use the technology, so we missed the boat on what the lesson was about. (Enid, end of the year interview, June 4, 2008)

Unfortunately, her limited content area knowledge and her limited expertise with technology interfered with student learning. Instead, she felt more comfortable using other classroom practices: "I used different techniques in the classroom more often. I am moving away from lecture and going to white board, inquiry labs, thinking maps, jigsaw, and other activities that I did not used before" (Enid, end of the year interview, June 4, 2008).

The lack of sustained, quality professional development that provided teachers like Enid the opportunity to practice using instrument probes resulted in confusion and missed learning opportunities for her students. In the next paragraphs I will examine the longitudinal changes she experienced in PCK and practices.

Longitudinal changes in Enid's pedagogical content knowledge, inquiry, and language practices. Overall, in terms of PCK Enid maintained a basic orientation throughout Years 1, 3, and 5 (see Table 20).
Table 20

Enid: Longitudinal Changes in Pedagogical Content Knowledge

<table>
<thead>
<tr>
<th>PCK Question</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 3</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCK 1 Students' prior knowledge</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
</tr>
<tr>
<td>PCK 2 Variations in students' approaches to learning</td>
<td>Limited</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 3 Students' difficulties and misconceptions</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
</tr>
<tr>
<td>PCK 4 Knowledge of inquiry instructional strategies</td>
<td>Basic</td>
<td>Basic</td>
<td>Limited</td>
<td>Proficient</td>
</tr>
<tr>
<td>PCK 5 Representation of instructional strategies</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Proficient</td>
</tr>
<tr>
<td>Overall Orientation</td>
<td>Basic</td>
<td>Basic</td>
<td>Basic</td>
<td>Proficient</td>
</tr>
</tbody>
</table>

Note. PCK = Pedagogical content knowledge.

Nonetheless, she experienced longitudinal changes in areas of PCK related to student learning and inquiry. For instance, the area of student prior knowledge she maintained a limited orientation from the onset of her teaching career to the end of her fifth year in the classroom. This means that Enid did not consider student knowledge, nor did she incorporate ways of determining her students' knowledge as part of the lessons. In the area of variations to students' approaches to learning, Enid's orientation changed from limited to basic by the end of Year 1. Subsequently, she maintained this orientation up to and including her 3rd year in...
the classroom. This is what she shared about students' variations in approaches to learning during the PCK interviews before she began teaching and in Years 1, 3, and 5:

There are days and times when there is no other way, other than boring lectures to get the information across. I try to incorporate a little bit of everything. Not every lesson has everything, but I do try.

(Enid, PCK interview, August 21, 2005)

In this answer, Enid did not offer any concrete examples of how she considered this issue when she planned or implemented her science lessons.

By the end of her first year in the classroom, this is how she answered the same question regarding students' variations in approaches to learning:

I do consider it somewhat, because I did try to teach the topic in various ways, explaining it in different ways, but they were all chemistry related. So if you don’t understand it to begin with, it’s like you speak English and I’m trying to teach you in Korean, German, and Science. It’s not going to make any sense until I bring it down to what you can relate to. So, yeah, I tried to do things, but I don’t think it helped. I had a student from Korea and he spoke perfect English, but he was having a hard time understanding the concepts. I photocopied my Power Point slides; that way he would not have to worry about having to copy everything down. I don't know if that helped him. (Enid, PCK interview, June 27, 2006)
In this answer, although Enid explained how she tried to consider students’ variations by teaching in a way that was relevant to the students, she was unsure if incorporating variations or providing one ELL student with paper copies of her Power Point slides made a difference. It is clear from her comment that she was not adept at using strategies to help ELL students. In Year 3, Enid provided similar answers that indicated a basic orientation regarding this aspect of PCK related to student learning.

In the area of PCK related to inquiry, Enid's orientation remained basic up to the end of Year 3. Subsequently, in Year 5, it progressed to proficient. This is how she described an example of inquiry before she began teaching:

In inquiry we talk about certain concept; I tell the students: here is the materials, here is the concept, now figure out a lab; or I would tell them the basics about a concept and they have to research it on their own. For example: We did a lesson when we were talking about adaptations. I introduced it, gave them the notes, and they had to put the concept in a way that others could understand it. Kids had to pick what they wanted to check for. I gave them M&Ms and they had to pick whatever they wanted to do. They checked different external factors on the M&Ms. They had to figure out what they could test and how to put the concept to explain it related to the concept. (Enid, initial PCK interview, August 21, 2005)
In this lesson, she is describing a guided inquiry lesson where students practiced manipulating variables through experimentation. Some of the elements of inquiry such as limited engagement a chance for students to explore and explain their findings based on evidence were included in the lesson. Although elements of inquiry are present, it is not clear how exposing candy pieces to heat and chemicals related to adaptations.

In Year 5, she provided an example of a physics inquiry lesson she obtained from the reform-oriented physics teacher in her PCL:

This past year I did an inquiry lesson in introducing pendulums and harmonic motion. The only thing that I told them before we started is what a pendulum was, what a period meant, and just basically how to set it up. I gave them the materials, but I didn’t give them anything other than that. It was really interesting because it was a good learning experience for all of us. Afterwards, we went over it together as a class. We looked at the results that everybody collected from their trials. There were notes; but I was writing the information that they were giving me based on observations and data. (Enid, PCK interview, June 12, 2010)

Through this detailed description, Enid shared a lesson that included all the key elements of inquiry. Although she was not observed implementing inquiry lesson during the three years of data collection, it is clear that she understood inquiry. The self reported data indicates that she was successful at implementing inquiry in her teaching. From ASIST, she learned about principles and
applications of inquiry. Unfortunately, in Years 1 and 3, she did not find the support she needed to incorporate inquiry in her classroom. Instead, Enid used the Power Point lectures and worksheets she received from colleagues. In Year 5, Enid received the guidance and encouragement of a reform-minded, more experienced colleague who understood the value of inquiry and who was willing to help Enid. Thus the combination of inquiry focused professional development and the encouragement of a colleague at her school made helped Enid understand and implement inquiry in her classroom.

During the monthly interviews indicated that she implemented mostly guided inquiry, and that she did not implement open inquiry. Overall she reported implementing inquiry a total of seven times during years 1, 3, and 5. In general, Enid reported implementing more inquiry in Year 3 (see Table 21).

Table 21

*Enid: Reported Inquiry Practices from Monthly Interviews*

<table>
<thead>
<tr>
<th>Year</th>
<th>Inquiry Level</th>
<th>W.U.</th>
<th>Frequency (Total = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Guided</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>1, 5, 8</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Guided</td>
<td>3, 9</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Guided</td>
<td>5, 6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Directed</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

*Note.* W.U.\(^a\) = Eight monthly phone interviews were conducted during the school year.
Coincidentally, that same year Enid was only teaching chemistry and was familiar with teaching the content. Moreover, instead of using the curriculum materials provided by the other chemistry teachers, in Year 3 she implemented activities from the new textbook and resources that included inquiry.

Finally, the analysis of reported language domains indicates that overall, her students engaged more in listening and writing than in any other language domain. This agrees with the data on observed practices, in that Enid used PowerPoint lectures that required students to take notes. Enid reported implementing less reading than any other language domain. In Year 5, Enid reported implementing the same number of activities that involved reading, listening, and speaking (see Table 22). In Year 5 students engaged in less writing, and for the first time, she implemented more reading than in Years one or three. This change in reported language domain implementation could be partly attributed to the influence of the reform-minded physics teacher who helped by sharing student-centered activities with Enid.

Table 22

*Enid: Reported Language Domain Implementation*

<table>
<thead>
<tr>
<th>Year</th>
<th>Listening</th>
<th>Speaking</th>
<th>Reading</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>19</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>8</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>40</td>
<td>23</td>
<td>48</td>
</tr>
</tbody>
</table>
In summary, although Enid's original intent was not to become a science teacher, she chose to participate in the ASIST program as well as in other professional development opportunities. At her high school, well-intentioned colleagues shared materials and activities with Enid and provided her with informal mentoring. Unfortunately, with the exception of one-reform-minded physics teacher who encouraged Enid to implement inquiry in her classroom, most colleagues did not implement inquiry. The changes in teaching assignment interfered with Enid's PCK development, particularly in the area of student learning. Enid's case illustrates the importance of combining induction efforts with support at the school site by assigning early career teachers to teach in their content area of expertise, providing them with a stable environment, and carefully matching them to work with a reform-minded mentor.

**Salient Trends across Cases**

Here, the salient trends among the participants are presented and discussed based on the original research questions. In this multiple case study cognitive and sociocultural aspects the participants' professional learning were uncovered and analyzed through the CHAT framework. Although the implications of this research project are transferable only to a similar set of circumstances, the degree of variability among the six teachers in this study helped buttress the trends identified in the cross-case analysis. The identification of these trends helps bring clarity to the role of ASIST and contextual factors on teacher learning. Four of the teachers worked in schools that served students of culturally and linguistically diverse backgrounds; therefore, the findings of this study have direct implications
for all involved in preparing, hiring and supporting early career science teachers who want to work in diverse settings. In what follows, the study implications will be discussed in light of extant research studies.

1. Question 1: How did the PCK and practices of six early career science teachers change over a five-year period?

Based on the PCK interview by Lee and Luft (2007) the trends in longitudinal changes in two areas of PCK will be discussed. The first area pertains to student learning (i.e., prior knowledge, variations in approaches to learning, misconceptions and difficulties with science concepts). The second area of PCK pertains to the understanding and representation of inquiry strategies. I will present the salient trends within these areas with specific examples to illustrate both the participants' and researcher's perspective.

Theme 1: Participants experienced changes in pedagogical content knowledge related to student learning. Two salient factors influenced this area of PCK: the presence of ELL students and changes in grade level, subject and school. Specifically, teachers who had high percentages of ELL students in their classes, or who experienced changes in the numbers of ELL students from one year to the next, also experienced changes in PCK related to student learning. Teachers who moved to a different school, and therefore experienced changes related to the sociocultural context (i.e., school community, division of labor, rules and regulations, subject and grade level) also experienced changes in this area of PCK. In the following paragraphs, the role of ELL students will be
addressed first, followed by the impact of changes brought about by overall changes in the school context.

Martina and Kelly had a limited PCK orientation regarding students' difficulties and misconceptions before they began working with ELL students. This means that they did not consider these aspects of student learning when planning or implementing their lessons. Subsequently, their PCK orientation fluctuated (see Tables 6 and 7). In Martina's case, the changes in school, subject area and grade level could have contributed to her increased fluctuation in this area of PCK. For Kelly, fluctuations in the number of ELL students in Year 3 could have contributed to the changes she experienced. For both teachers, the fluctuations may be symptomatic of the tentative character of their PCK.

Although PCK is cumulative, new circumstances and challenges require cognitive adjustments as teachers internalize the new circumstances and continue to learn about their students and about other contextual factors.

Contrastingly, Jim, Cindy, Alana and Enid experienced less changes in this area of PCK. Specifically, Cindy and Jim maintained a limited orientation for Years 3 and 5; whereas Alana and Enid for the most part, maintained a basic orientation except for the shift toward a limited orientation experienced by Alana in Year 5 when she moved to a new school with a moderate percentage of ELL students (see Table 17).

All four teachers who changed schools during the five-year period (Martina, Cindy, Jim, and Alana) experienced fluctuations toward a more teacher-centered PCK after they moved schools. A closer analysis of the placement
circumstances at their new schools indicated that all four teachers experienced changes in content area or grade level. Additionally, in Year 5 the percentage of ELL students in Alana's class increased from less that 10% to approximately 35%. Contrastingly, Kelly and Enid who remained at the same school did not experience changes in their PCK related to students' variations to approaches to learning. Here are some excerpts from the PCK interviews that illustrate the differences in this area of PCK for Martina, Jim and Alana before and after they changed schools, grade level and content area. This is what Martina answered at the end of Year 1:

I had a lot of ELL and some special needs student. I made modifications. I paired them up with a partner, and I also made variations during assessment. All students learn different and have different abilities. I offered extra credit within a test; an for doing above and beyond on a project. In projects my ELL students did really well and excelled. But in other tasks I just had to guide them because they did not understand what the question asked. (Martina, PCK interview, June 16, 2006)

In this answer, Martina illustrated a proficient orientation toward students' variations to learning. She provided information of how she modified her instruction with respect to student grouping and how she assessed students depending on how they could express what they had learned. She incorporated students' variations in approaches to learning in her instruction and assessment. At the end of her first year as a Biology teacher at the new high school, her PCK
orientation shifted toward a basic approach. Here is what she answered when asked about variations in students' approaches to learning:

Yes [I considered variations] – especially because of high ELL population. It is important for them to read and speak and listen and write. I did incorporate these. I incorporated research, reading, and oral answers to teacher questions. (Martina, PCK interview, July 1, 2008)

Although she incorporated different approaches, she did not involve the students, or provided specific examples of students' variations in learning science concepts. In this answer Martina focused on fostering academic language proficiency among her students. Likewise, Jim experienced a shift on PCK toward student learning when he moved to the new school. Here is what he answered at the end of Year 1:

Well, I considered variations about how students learn in that I had an activity where there was discussion, and there was some writing. There was more lecture, and also a hands on [activity] and visuals. I also had students who were ELL and a couple of students with IEPs; I considered how I would group these students so I could help them, and how students could help the ELL students.

(Jim, PCK interview, June 3, 2006)

In this answer, Jim illustrated a basic orientation of PCK toward students' variations in approaches to learning. He considers different ways to present concepts and how to group ELL and special education students. In Year 3, Jim
was at a new school where he taught Earth and Space Science. Here is how he responded to the same question regarding students' variations in approaches to learning about relative position and motion:

With the curriculum there’s not much room for variation so just covering the material is basically all I can do, and some of our kids have trouble with that. We do some things, like we did vocabulary that will hopefully help with the test scores. A lot of times, I rather teach the basics and have just two students who do not understand than try to teach more advanced stuff and have most of the kids get lost. (Jim, PCK interview, June 6, 2008)

In this answer, Jim's orientation to PCK was classified as limited because he does not consider any variations to students' approaches to learning; instead, he teaches basic concepts to make sure everyone understands.

Finally, Alana maintained a basic orientation while she taught at the same middle school in Years 1 through 3. This is how she answered at the end of Year 3:

In the genetics lesson, we did an inquiry activity. I used pictures and had them discover heredity by looking at their families. (Alana PCK interview, June 9, 2006)

Here Alana illustrated a basic PCK approach because she provided examples of different activities, but she did not incorporate student input. In Year 5, Alana taught at a high school with moderated percentages of ELL learners. Here is what she shared regarding students' variations to approaches to learning:
I did not give multiple ways for them to do this assignment. I think this lesson was good for students who were good at reading and writing, and not at interpersonal [communication], and those that do not necessarily want to work with others. I did not differentiate the multiple ways to do the particular assignment, no. (Alana, PCK interview, June 2, 2010)

This answer exemplifies a limited orientation in that Alana did not consider variations in students’ approaches to learning. Although she had ELL students in her classroom, she did not make any modifications to the activity, the assignments or the assessments.

In general, teachers who worked at schools where colleagues and administrators focused on standardized test scores fluctuated between a limited and a basic PCK orientation toward considering students' difficulties with specific science concepts. For example, Cindy and Jim experienced a decline toward a limited orientation in Years 3 and 5. When Martina moved to a high school where teachers emphasized the district exam results, she experienced a similar shift on her PCK from Year 3 to Year 5.

For Cindy and Jim, the shift on PCK orientation coincided with increased pressure brought upon by their respective districts and principals as a result of federally mandated school improvement plans. In Years 3 and 5, both Jim and Cindy mentioned how they focused their instruction on improving student scores on the science district assessment. Here are their answers to the PCK question about students' difficulties:
To tell you the truth, no, I did not think about their difficulties with this lesson. I just thought about what I could and couldn't talk about. It was low-level direct instruction of basic concepts. (Jim, PCK interview, June 21, 2010)

Similarly, Cindy was not able to recall how she dealt with students' difficulties in Year 5:

I did, I looked at the difficulty of the concepts and I tried to predict where the students are going to have trouble with understanding. I do not remember specifically if they had any misconceptions on volcanoes and earthquakes. (Cindy, end of the year interview, June 30, 2010)

Neither Jim nor Cindy focused on students' difficulties when planning their lessons. In Year 3 when Martina moved to a high school where teachers emphasized the district exam results, her PCK orientation in this area shifted from proficient to limited. In contrast, during Year 1, Martina worked with a mentor allowed her to understand her students' difficulties, and to teach in ways that would help them overcome the difficulties. Here is how Martina described her approach to helping students:

When the students were really having a hard time grasping concepts, I used examples they could relate to in helping them understand and make connections. I was confused and trying to figure out what to do, but my mentor teacher told me not to lower the expectations. In physics, when we were studying Newton's
laws, I had the students work in pairs to determine what law of motion they saw expressed in a set of pictures to help them make connections. (Martina, PCK interview, June 16, 2006)

In Year 3, she shared the following regarding students' difficulties with genetics:

Not really, I didn’t think there would be any [misconception or difficulties] that would come up. When there were, I would catch them. As the students did research, they learned.

(Martina, PCK interview, June 24, 2010)

These two answers illustrate a marked change in her attention toward students' difficulties and misconception. Whereas it is true that she was teaching entirely out of her content area of expertise, she was also more focused on assessment issues. Moreover, in Year 3 she was observed reviewing for the district test during two out of four observations.

**Theme 2: Pedagogical content knowledge related to knowledge and representation of inquiry strategies was influenced by contextual factors.**

The last two questions of the PCK interview explore teachers' understanding and representation of inquiry. The teachers are asked to describe a successful lesson they taught during the year. If they select a lesson that does not involve inquiry, the interviewer asks the participant how the lesson could be modified to reflect more inquiry. At that point, the teacher either shares how the lesson could be modified to include inquiry, or offers a description of a different inquiry lesson. Obviously, the structure of this question ties the teachers' opportunity to implement inquiry to their representation of inquiry.
Thus factors related to school culture such as the support for inquiry practices by other colleagues in the department and assessment pressures from the district, administrators and colleagues impacted the teachers’ knowledge, representation, and implementation of inquiry. In this study, only two teachers: Alana and Enid, were proficient in their PCK for knowledge of inquiry instructional strategies by the end of Year 5. Overall, their orientation was basic from the onset of teaching to Years 1 and 3, with the exception of Enid's limited orientation in Year 3. According to the PCK scoring map by Lee and Luft (2007) teachers who are proficient in this category of PCK describe using scientific inquiry for teaching lessons and incorporate most (4-5) of the 5 essential features of classroom inquiry into their lesson. Additionally, the teachers provide examples of representations that are pedagogically effective, scientifically accurate and well-linked to students’ prior knowledge and experience.

Alana provided an example of a guided inquiry activity on cell structure she modified from a procedural lab implemented at the beginning of the year:

At the beginning of the year I designed a cell membrane lab from a standard cookbook lab where students are given the facts and they look for specific things – versus these are your options you get to choose, you’re gathering info. Self-discover – choose what your testing, analyzing your own results and your own conclusion – I turned it [the activity] around to have kids more involved in guided inquiry. (Alana, PCK interview, June 2, 2010)
In Year 5, Alana participated in a PLC where she worked with an experienced colleague who valued science inquiry and encourages Alana to implement inquiry activities in her classroom.

Likewise, during the PCK interview at the end of year 5, Enid described a guided inquiry pendulum lesson she received from an experienced, inquiry-minded physics teacher at her school. During the activity, students worked in small groups to explore the properties of a pendulum. She summarized inquiry as "student-driven exploration of science.

Contrastingly, Cindy and Jim who taught in schools where the principals implemented a mandatory school improvement plan focused on improving assessment scores, experienced a shift toward a limited understanding and representation of inquiry in Years 3 and 5. They taught at school were their colleagues and administrators did not support inquiry. Cindy was teaching 7th grade General Science, a subject that included mostly Earth and Space Science concepts for the first time. She provided an example of an Internet-based student project, which required the students to answer factual question and considered it a good example of inquiry. Jim on the other hand, shared an example of a direct instruction lesson, correctly defined inquiry, but considered inquiry better suited for students who were at a higher level than his own students. Jim's adherence to the school plan of what he perceived was teaching only the basics, prevented him from implementing inquiry in his classroom.

According to the PCK rubric, a limited orientation is indicative of teachers who describe implementing a lesson that verifies a previously covered concept or
directs the students in how to proceed through the lesson. None of the essential features of classroom inquiry are present (NRC, 2000). In addition, these teachers described implementing representations (e.g., illustrations, examples, models, analogies, and demonstration) and materials that are ineffective, scientifically inaccurate, or are not linked to students’ knowledge or experience.

Likewise, Martina and Kelly, who both had a basic orientation regarding their knowledge and representation of inquiry, did not have the benefit of working with a colleague who supported the implementation of inquiry at their school site. One common affordance for Martina and Kelly was the availability of curriculum maps and inquiry-based curriculum. In Year 5, Martina described a bacteria lab in which the students investigated the presence of bacteria in differences locations around the school. Kelly described a balloon car race.

**Theme 3: When teachers implemented inquiry strategies, their students engaged in more language domains and in the implementation of contextualized vocabulary.** The analysis of the observed practices indicates that for all six teachers this is a trend for all three years of data collected. Martina, Alana and Jim implemented inquiry lessons in which students were engaged in all four language domains and in the contextualized use of science vocabulary. In the case of Kelly, when she implemented inquiry, her students engaged in at least three academic language domains while using contextualized vocabulary. Cindy's students engaged in tree out of the four language domains and in the contextualized use of vocabulary. In summary, more often than not, when these six early career teachers implemented inquiry in their classrooms, their students
engaged in academic language domains and used science vocabulary within the context of inquiry.

**Affordances and Constraints Surrounding the Teachers**

In order to answer question two, I examined the contextual affordances and constraints across all cases and found commonalities that will be explained in the following paragraphs. I first present the questions and then I proceed to explain each trend.

2. Question 2: What were the affordances and constraints surrounding six early career science teachers who taught varying percentages of ELL students?

The emerging themes associated with affordances and constraints surrounding the participants are related to the support from ASIST, mentors, the availability of curriculum maps and curriculum, the opportunities for professional development, interactions with colleagues; and rules and regulations related to assessment, teaching loads and responsibilities. The next paragraphs will expand on the details of these contextual factors and their impact on the professional development of the six teachers.

**Theme 4: Teachers who participated in Alternative Support for Induction Science Teachers and had access to inquiry curriculum implemented more inquiry in their classrooms.** For instance, Martina and Kelly were active in the ASIST program and consulted with program mentors regarding science inquiry activities. They implemented the inquiry lessons from the ASIST workshop and even modified lessons to meet their curriculum. In fact,
we observed Martina and Kelly implementing more inquiry than the other four participants. One way of explaining this trend is that by taking full advantage of the help provided by ASIST, they were more effective in implementing inquiry. Success in turn, fostered more implementation of inquiry practices (see Table 23).

Table 23

*Number of Observed Inquiry Lessons per Participant*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Number of Inquiry Activities</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 1</td>
<td>Year 3</td>
</tr>
<tr>
<td>Martina</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Kelly</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Cindy</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Jim</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Alana</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Enid</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

For instance, an analysis of the reported and observed practices indicates that Cindy, Alana, and Kelly implemented more inquiry than Jim or Enid. Kelly and Alana took on an active role in the implementation of the kits beyond their classroom. Kelly worked with other teachers in her district to align the curriculum kits with the district science content standards and became a professional developer for other teachers in her school. Alana became part of a district-wide group of teachers who were interested in developing their expertise in the use of the inquiry kits. Finally, Cindy added Power Point presentations to each unit and helped align the 7th grade curriculum with the science kit curriculum.

Both Kelly and Alana shared their how they wanted to modify the kits: Whereas Kelly wanted to make the kits less structured and more student-centered;
Alana wanted to cooperate with teachers who were using the kits and "go beyond the kits to create more inquiry activities". Her efforts culminated in a summer institute that included teachers who were implementing the kits in their classroom. Martina, in spite of having access to the same inquiry-based curriculum kits at the school where she taught for the first two years, did not have access to professional development on implementing the curriculum kits. Instead of using the curriculum, she used materials from the kits to create lessons based on the inquiry workshops from ASIST.

Theme 5: Reform-minded mentors and colleagues played an important role in supporting professional teacher learning. The mentors and colleagues available from ASIST and at the school sites played a significant role in helping the participants as they experienced different aspects of teaching. Mentors observed the teachers and provided feedback. Through the ASIST mentors the participants reflected about their students and about teaching. At the school site, some of the mentors also provided feedback on observations and reminded the early career teachers to maintain high expectations for all their students. One of the most crucial aspects of the mentoring was the emphasis they placed on the importance of science inquiry as an effective practice to help all students. This was particularly important for Kelly, who in Year 1 blamed her students' background for the difficulties she had implementing a unit on science fair projects and shared that "the students never wondered before, and did not have any prior knowledge about science." Although she persisted on her deficit views about the students' lack of motivation and about the low priority they
placed on academics, she learned to implement inquiry with her students. The end result was that Kelly learned to teach in reformed ways that benefitted her ELL students.

Alana also expressed deficit views about her students in the urban high school where she taught in Year 5. For this teacher, a reform-minded teacher who valued inquiry and implemented activities in her classroom served as a role model and encouraged Alana to implement inquiry. Contrastingly, Jim shared a very strong deficit ideology throughout the interviews we conducted in Years 1, 3, and 5. He was observed implementing inquiry once, during the last observation. He considered inquiry to be an inadequate practice for the students he taught. Jim could have benefitted from working with a mentor who confronted his deficit ideology and helped him reframe his thinking about diverse students and about the benefit of inquiry for all students.

Theme 6: Teachers who taught a single subject in middle school settings in Year 1 implemented more inquiry than their high school counterparts. Martina, Kelly, Cindy, and Alana who all taught a General Science in middle school settings during their first year in the classroom, were observed implementing more inquiry in the first or third year in the classroom than either Jim or Enid who taught more than one subject in high school settings. In his first year, Jim taught Physical Science and Biology, whereas Enid taught Earth Science and Chemistry. Throughout years 1,3, and 5 of classroom observations, they implemented less inquiry than the other four participants. Jim and Enid struggled with issues of content and pedagogy. In Year 1 they were not sure about
how to sequence instruction. Jim was observed repeating experiments; whereas Enid did not know which concepts she should concentrate on, or which concepts were peripheral or inconsequential to her students' understanding of chemistry. Also, both Jim and Enid struggled with classroom management issues.

**Theme 7: District and school assessment impacted the implementation of inquiry.** All four teachers working in urban schools with high and moderate percentages of ELL had to contend with administrative measures related to standardized testing and school improvement plans. Teachers responded in different ways to these regulations. For instance, Martina and Cindy were asked to hold after-school tutoring sessions to prepare ELL students in math, reading and writing. Martina was asked to take over the functions of the language arts teachers and prepare her students for the state assessment during science class. She opted for leaving the school at the end of her second year. At the high school where she taught in Years 3 and 5, her colleagues emphasized the importance of teaching only the content that was part of the district criterion reference test.

The middle school where Kelly taught for all five years was placed on probationary status for failing to make AYP. As a result, students received reading instruction once a day. Kelly was asked to teach a reading class in Years 3 and 5. This extra class diverted Kelly's attention and energy from preparing for her science class. In addition, the school implemented mandatory reading assessment five times during the academic year. During testing days, the schedule was disrupted leaving little time for science instruction.
In the case of Jim, the administrations measures to the schools’ probationary status for failing to achieve AYP was to mandate teacher participation in subject PLCs. Teachers were instructed to work on aligning the science curriculum and assessments to the district science test. Jim's reaction to this requirement was to teach only the basics and to almost eliminate inquiry from his classroom practices.

The regulations may have served to reinforce Jim's pre-existing deficit ideology as he equated the alignment to simplifying the curriculum to make sure the students passed the district and state science exam. His perception of the requirements resulted in a teacher-centered classroom where students for the most part, were passive recipients of information. For Jim, these requirements solidified practices that run contrary to the use of inquiry and to creating a science classroom that is conducive to the science achievement and academic language proficiency of ELL students. In the end, the sincerity of Jim's implementation of inquiry during the last observation was questionable. Although the activity involved inquiry and incorporated the use of all language domains and contextualized vocabulary, it was not a representation of his teaching. The presence of an observer could have influenced his decision to implement a student-centered lesson.

For the teachers in this study, inquiry was at least initially, an important strategy for allowing students to construct their own knowledge about science. They elected to be a part of the ASIST group. At the cognitive level they understood the value of inquiry. For Martina, Kelly, Cindy and Alana, the
availability of inquiry curriculum and the support administrators fostered the implementation of inquiry. For others like Jim and Enid, the culture of the school precluded the implementation of inquiry. For Jim the perceived obstacles became insurmountable. He internalized the needs of students as deficiencies that made impossible the implementation of inquiry. His professional development unfolded within schools that were under scrutiny and assessment pressures. Jim learned to teach only the basics to improve students' scores in the district exam. Enid also understood the importance of inquiry, and she consistently demonstrated a cognitive understanding of inquiry. She implemented inquiry only when a more experienced colleague modeled the use of inquiry. Even for Martina, to a certain extent, emphasis placed on preparing for the district test by her colleagues at the high school played a role on her implementation of inquiry.
CHAPTER 5

Discussion, Implications, and Future Research

Chapter 5 involves a concluding discussion of research findings based on the overarching theoretical frameworks, questions, extant research, and implications of this study. The first section involves a discussion of the findings in relation to CHAT and to the literature review conducted for this study. Next, the chapter delves into the research and practice implications generated by the findings. This chapter and the dissertation conclude with guiding questions for future research projects.

Discussion

I will now discuss the findings and trends in terms of the extant literature. These findings are related to the trends discussed earlier in Chapter 4 and pertain to teacher professional learning embedded in the larger context of the classroom, school and district.

The CHAT framework that guided this study was helpful in exploring the complexity of cognitive and sociocultural factors surrounding the participants during the initial years in the classroom. In turn, this research reinforces the usefulness of this CHAT for understanding the complexities of teacher learning. The findings related to cognitive aspects will be presented first, followed by the details pertaining to contextual factors. Due to the high degree of interconnectedness between these two areas, at times the discussion will simultaneously draw upon cognitive and sociocultural aspects of teacher professional learning to explain the major findings uncovered by the study.
Discussions of teachers' longitudinal changes in pedagogical content knowledge and practices. The cognitive aspect of teacher professional learning was explored through changes in PCK related to student learning, inquiry practices and the implementation of language domains and vocabulary. The first major trend in the findings pertained to the PCK related to student learning. The analysis of the PCK of the six participants’ two distinct patterns: teachers who taught high percentages of ELL students experienced fluctuations in this area of PCK. Conversely, teachers who taught moderate and low numbers of ELL students experienced little to no change in their PCK.

Two possible factors were identified as plausible explanations for this difference. The first factor pertains to the circumstances encountered by the teachers during their initial year in the classroom. The second factor pertains to additional professional development opportunities available through the school and district that helped the teachers address the specific needs of their ELL students.

Teachers with high numbers of ELL students interacted predominantly with students who were simultaneously learning science and academic English skills. Through this interaction, they were confronted with students' difficulties to a higher degree than teachers who had moderate or low percentages of ELL students. As a result of this experience, Martina and Kelly teachers were considered proficient in their PCK related to students' difficulties at least once during their 5 years in the classroom. In other words, these teachers learned about their students' difficulties by direct experience and by applying the teaching
strategies from the professional development available from ASIST and from their districts.

Contrastingly, none of the other 4 participants who had lower numbers of ELL students experienced a shift toward a proficient orientation in this area of PCK during the three years encompassed by this study. These findings point to a threshold for PCK change associated with the number of ELL students present in the classroom, as well as with the onset and length of their experience teaching ELL students. The two teachers who taught moderate numbers of ELL students can substantiate the existence of this threshold with respect to the number of ELL students. Cindy and Jim, who taught moderate numbers of ELL students, experienced a decline for this area of PCK in years 3 and 5. A rival explanation may be responsible for the decline in the PCK: In their respective schools these teachers had to contend with other pressures associated with school improvement plans. The emphasis on test scores and uniformity of instruction among the different teachers may also help explain the shift in PCK these two teachers experienced in years 3 and 5. Nonetheless, it is worth considering the fact that Kelly, who also had to contend with a school improvement school plan in Years 3 and 5 had a proficient PCK score by the end of Year 5. Likewise, Martina, who to a lesser extent, experienced assessment pressures in years 3 and 5 experienced a shift to a basic orientation of PCK in year 5. Therefore, high percentages of ELL students, at least during the initial year of teaching played a role in the participants' development of PCK related to considering student difficulties with science concepts. These finding agree with the model of PCK proposed by
Grossman (1990) who recognized the essential role of context on the development of PCK. Teachers who had consistently high numbers of ELL students were able to adapt to the academic and language needs of their students. In other words, Martina and Kelly developed their PCK related to student learning by interacting with their ELL students in the context of the classroom. Nonetheless, it would be shortsighted to attribute teacher learning solely to the interactions that occurred as a result of daily classroom interactions. In this study, additional factors were uncovered throughout the data analysis and merit careful consideration.

The second factor worth considering in elucidating both the fluctuations in PCK experienced by Martina and Kelly is the opportunity for professional development they had available at their school and district. For teachers who initially taught high percentages of ELL students the support provided by the ASIST program in the form of professional development, mentoring and opportunities to reflect on their practice played a major part in shaping their PCK. Additionally affordances such as professional development opportunities focused on teaching strategies for ELL students and the availability of teacher artifacts (i.e., curriculum maps and inquiry curriculum) were also present and contributed to their professional learning. Whereas the analysis of data revealed that teachers with lower percentages of ELL students also grappled with trying to help these students, the pressure to focus on the success of these students may not have been as imminent in school and classroom contexts with lower percentages of ELL students. Specifically, in school with lower numbers of ELL students, the administrators and other teachers may not have been as focused in taking
measures to ensure the success of ELL students. Thus, in school with lower percentages of ELL students, teachers had less resources and opportunities for professional development focused on ELL strategies.

This work also revealed that the teachers' PCK about student learning and the frequency of reported and observed implementation of inquiry fluctuated with changes in content, context, and students. These findings agree with Grossman's (2004) model about the contextual nature of PCK, and with findings by Dejong et al. (2005), King et al. (2001), Lederman and Flick (2003), and Nielsen (2008), on the role of content knowledge on other areas of PCK. An interpretation of these findings through the lens of CHAT indicates that when teachers interact with the context of the classroom and school they undergo a process of transformation involving internal thought processing which in turn produces an adjustment response that allows teachers to become members of the community of practice (Engeström, 1999; Wenger, 1998). Thus, when the teachers in this study experienced changes and contradictions pertaining to content and context, they adjusted gradually to the new conditions. This period of adjustment impacted their PCK and practices. To illustrate this finding, this discussion will now examine the changes in the PCK of teachers who experienced changes in content knowledge and context.

An examination of the PCK and practices of the four teachers who moved to new schools sometime during the duration of the study (i.e., Martina, Cindy, Jim, and Alana) conformed to CHAT’s explanation for teacher professional learning. Similarly, teachers who did not change schools, (i.e. Kelly, and Enid)
but instead experienced changes in the grade level or subject also faced changes in their PCK and practices. Thus the implication from this finding is that for all six early career science teachers in this study, contextual stability with regards to their teaching assignment played a role in the development of PCK related to content, inquiry and students' needs.

Data analysis revealed that 4 participants (i.e., Martina, Kelly, Alana and Enid) increased their PCK for understanding of inquiry; however, only Martina's PCK changed from basic to proficient after participating in the induction program for one year. For Kelly the shift occurred in Year 3, whereas for Alana and Enid, the shift was identified in Year 5. This finding points to a synergistic effect of several factors (i.e., implementing and modifying lessons, teaching other colleagues how to use inquiry-based curriculum, and working with reform-minded colleagues). In other words, teachers came to understand inquiry by designing and implementing inquiry activities. One salient characteristic of Martina was her willingness to immediately incorporate the inquiry activities from the ASIST workshops in her classroom. Kelly and Alana implemented the activities from the FOSS inquiry curriculum and this helped them practice inquiry in the classroom; however, both teachers indicated dissatisfaction with the limitations and prescribed nature of the activities. When Kelly became active in modifying the kits and teaching her colleagues how to implement inquiry her PCK for understanding inquiry shifted from limited to basic. Conversely, Alana and Enid experienced a shift in their understanding of inquiry when they worked with reformed-minded mentors in Year 5.
Yet another noteworthy finding from this research pertains to the fact that when teachers implemented inquiry practices, their students engaged in three or more language domains and in the contextualized use of science vocabulary terms. The findings affirm the importance of science specific induction support focused on inquiry practices for early career science teachers; particularly teachers responsible for students who are trying to master science content and academic language proficiency (Lemke, 1990; Roth & Duit, 2003). Findings also support the importance of professional development that focuses on strategies to help ELL students in the content area. The implication from these findings is that induction programs for early career science teachers who work with ELL students should include science inquiry and either SDAEI or SIOP strategies. The analysis of the data demonstrated a clear trend for concurrent engagement of students with more language domains and contextualized vocabulary used during inquiry activities. Consequently, supporting early career teachers requires quality, sustained professional development and a reform-based school culture that provides teachers with inquiry curriculum and a supportive group of peers and administrators who also understand the importance of reform-based science teaching in urban classrooms.

**Discussion of affordances and constraints.** In terms of induction support the findings concur with previous research reports by Luft (2009) based on the larger database that included all 30 ASIST teachers. In her study, Luft concluded that participation in science specific induction had a positive impact on teachers' implementation of inquiry activities. An examination of the data
revealed that Martina, Kelly, Cindy and Alana were observed implementing more inquiry in Years 1 and 3 than in Year 5. This finding indicates that although through ASIST teachers received the professional development and support they needed to implement inquiry, by Year 5 factors related to the school context had a negative impact on the participants' implementation of inquiry. Moreover, the results of this dissertation research also concur with Grossman and Thompson (2004) who posited that a combination of professional development focused on inquiry and the availability of curriculum made a difference on teachers' implementation of inquiry.

An important aspect of the support provided by ASIST was the interaction between the teachers and the ASIST mentors. Although the mentors did not deal directly with the views teachers expressed about their students, including deficit views, the help they provided with the implementation of inquiry practices played an important role in building the teachers' understanding of inquiry. By providing support in the design of inquiry lessons as well as feedback after each observation conducted in Year 1 of the study, the mentors helped teachers develop their ability to implement inquiry in the classroom.

The analysis of the data revealed that three of the teachers expressed deficit ideology about their ELL students. For Kelly, the support received from ASIST, the availability of inquiry curriculum and the professional development she received from her district helped her develop her ability to implement inquiry in her classroom. Although her frame may not have changed, the fact is that as she implemented inquiry, her students had opportunities to make sense of
vocabulary and engage in academic language domains while constructing their own understanding of inquiry.

Another important affordance available to some of the teachers was the availability of reform-minded colleagues at the school sites. Whether these colleagues worked with the teachers as part of the district induction program or informally, as a result of daily interactions with the participants, they played an important role in the professional growth of the participants. These colleagues met with the participants informally within the context of the school, while planning lessons. At times, they met in the more formal context of a PLC.

For Alana, the presence of a reform-based, more experienced teacher in her PLC encouraged her to implement inquiry with her ELL students. Unlike Kelly and Alana, Jim, who had a recurrent conflict derived from the differences between the students he taught during his student teaching experience and the students he encountered at his inservice placement, did not learn to value inquiry as a way to help his ELL students. The ASIST mentors helped Jim with matters related to inquiry and classroom management, but not necessarily with his views about the students. At the school where Jim taught, there was never a reform-minded mentor figure that could help him confront his views about student expectations and the implications for classroom practice. Although Jim participated in a mandatory PLC at his school during years 3 and 5, he did not work with a reform-minded colleague who encouraged him to implement inquiry. Consequently, he learned to implement teacher-centered practices and was observed enacting what Haberman (1991) called the pedagogy of poverty.
The case of Jim indicates that ASIST alone did not succeed in changing Jim's views of his students. The combination of science specific induction support, inquiry based curriculum and the presence of a reform-based colleague in a school context that valued inquiry could have resulted in a different outcome. This finding concurs with similar reports by Entman (1993) regarding the use of frames to interpret contradictions and dilemmas in teaching, as well as with the findings by Achiestein and Barret (2004). However, the findings disagree in that although two of the teachers persisted in their deficit ideology, they came to understand that inquiry was a valuable practice for helping ELL students succeed in science and improve their academic English proficiency. These findings have implications for the design of future science specific induction support programs and for administrators who make decisions that impact the professional learning of early career teachers in urban school. Nonetheless, these findings are preliminary and future research that examines data from the interaction between the teachers and their mentors as well as feedback from the ASIST mentors is needed to ascertain the role of each factor on teachers' understanding of the importance of inquiry implementation in science classes that serve ELL students.

Besides opportunities for professional development, another affordance that impacted teacher learning was the availability of curriculum maps and inquiry-based curriculum. The presence of these resources played a role on the implementation of inquiry practices for the teachers in the middle school settings as well as for Enid who taught high school. In her case, the availability of inquiry based chemistry curriculum facilitated her implementation of inquiry in Year 3.
Conversely, the absence of these resources had a negative influence on teacher practices.

The findings of this study also revealed that school culture impacted teachers' implementation of inquiry. This finding concurs with previous studies (Avramidou & Zembal-Saul, 2010; Grossman & Thompson 2004; McGinnis et al. 2004). Furthermore, the timing of these circumstances is also a factor worth considering, as teachers who did not have access to inquiry curriculum at their school-site in their first year of teaching implemented less inquiry over the 5 years of the study. Contrasting ly, when teachers had access to inquiry-based curriculum and worked at schools where colleagues and administrators supported inquiry, they implemented more inquiry over the same 5 year period. As Luft (2007) explained, initial years in the classroom "impact the formation of philosophies, knowledge bases, dispositions, and abilities that will guide future growth".

All six teachers in this study adjusted their teaching to different degrees to comply with the prevailing school culture. This finding concurs with previous studies by Bianchini and Cavazos (2007) and McGinnis et al. (2004) who reported that early career teachers learned to implement inquiry with their ELL students through teaching and reflecting, and by participating in PLCs. The finding has implications regarding the importance of supporting reform-based practices at the school site. Particularly, when the implementation of inquiry, as evidenced by the data from this study and supported by previous studies (Lee, 2002, 2004; Lee & Fradd, 1998) indicated that inquiry implementation also
fostered the implementation of reading, writing, listening and speaking among students.

Unfortunately, the data also revealed that teachers who adopted teacher-centered practices valued by their colleagues and administrators, learned to create classrooms that were not responsive to the needs of their students and in particular, to their ELL students. Under these circumstances, inquiry was not valued and teachers learned to adopt practices that were teacher-centered and provided fewer opportunities for the implementation of academic English skills.

Two participants, Jim and Cindy, experienced a decline in their understanding of inquiry during years 3 and 5 of the study. Unlike the other 4 teachers, Jim and Cindy worked at schools where the administration imposed school wide improvement plans focused solely on increasing student scores in standardized assessment. In addition, neither teacher worked with reform-minded colleagues at their school site. Through their trajectory, they did not encounter a fertile ground to cultivate their knowledge of inquiry.

Similarly, pressures related to high stakes testing influenced teachers' PCK and inquiry practices. This finding concurs with previous findings by Roehrig and Luft (2005) and by Saka et al. (2009). For Jim, Cindy, and to certain degree for Martina, the pressure associated with district assessment had ramifications that affected what they taught and how they constructed their own professional repertoire of practices. Unfortunately, the structure of current standardized assessments de-emphasizes the importance of inquiry as an effective way to help students achieve scientific and academic literacy. Thus the culture of the
department and school was of paramount importance for the development of reform-based practices among the participants.

In this section, the findings of the study were interpreted through the lens of CHAT. The major findings pertained to changes in the PCK related to student learning and inquiry practices. The results of this study indicated that through a combination of affordances such as the support from ASIST, district professional development and the availability of reform-based colleagues and mentors all six participants experienced changes in their PCK related to student learning and inquiry practices. These changes were associated with changes in the implementation of inquiry practices. When teachers implemented inquiry, their students engaged in at least three out of four language domains. For teachers who expressed deficit ideology the induction support, reform-minded colleagues and the availability of inquiry-based curriculum helped them adopt inquiry practices in their classroom with ELL students. Sociocultural factors related to the culture of the school, assessment pressures and school regulations also impacted teachers’ PCK and professional learning. The findings of this study have implications for preservice and induction programs that prepare and support qualified science teachers of ELL students in urban schools across the United States.

At the school level, the findings help illuminate the types of support that foster the development of reform-minded science teachers. For districts and policy makers, the study reaffirmed the importance of supporting student-centered teaching practices that support the achievement of ELL students. Furthermore, principals responsible for school improvement plans and for establishing the goals
of PLCs can also benefit from the findings and interpretations presented by this research.

**Implications and Directions for Future Research**

I close this chapter and conclude my dissertation with several implications for future research and efforts needed in preservice and inservice education:

1. There is a need for more preservice programs to help prepare early career teachers to serve the needs of diverse students. These programs can be more effective by offering carefully designed field experiences for their preservice teachers. During these experiences, preservice teachers need to work with diverse students, examine their work and identify ways in which they can help students construct their own understanding of science while engaging in academic language domains. Additionally, the preservice teachers need to be able to discuss their experiences with a reform-based educator or cooperating teachers who will help them reframe any deficit thinking about diverse students. In order to help preservice teachers reframe deficit ideology, the issue needs to be addressed explicitly by a knowledgeable educator, mentor or cooperating teacher.

2. More induction programs that emphasize the support of early career teachers at the school site can play an important role in preparing and retaining early career science teachers in urban schools. At the school site administrators and colleagues need to value inquiry as a practice to help ELL students achieve academic success and language proficiency.
Perhaps induction efforts need to include professional development opportunities for administrators. These professional development efforts should highlight the importance of school culture and administrative support for reform-based practices.

3. There is a need for science specific induction programs that include the teaching of inquiry and teaching strategies that help teachers implement strategies to help ELL students improve their language proficiency.

These programs need to make an effort to pair early career teachers with mentors who are knowledgeable about science content and about the academic language needs of ELL students. This form of support provides a means to prepare and retain early career science teachers. Consequently, in the future, I will continue to engage in research that will attempt to answer questions that emerged from this dissertation.

4. Principals play crucial role on the establishment of PLCs that foster inquiry based practices and allow groups of teachers to work with each other under the direction of an experienced, reform-minded colleague.

These PLCs will help create a school culture that values inquiry and provides a supportive atmosphere that fosters professional teacher learning for early career science teachers in urban schools.

The answers to the following questions emerged from this study and are worth pursuing:
1. What strategies and interventions at the preservice and inservice level allow early career science teachers to overcome deficit ideology?

2. How will the PCK of early career science teachers who participate in an induction program that provides science inquiry and ELL strategies develop over time?

The findings of this research study have implications for teacher educators, mentors, professional developers and administrators who strive to prepare, support and retain early career science teachers who are responsive to the needs of an increasingly diverse student population. There is a need for a concerted effort that aligns the preparation of reform-minded teachers with induction, mentoring and support of early career teachers during the initial five years in the classroom. At the school site, administrators can support the creation of PLCs that provide an opportunity for teachers to cultivate inquiry practices by engaging in meaningful discussions while examining students' work and sharing inquiry curriculum. These PLCs should be carefully designed, and should include reform-minded experienced teachers who encourage early career teachers to implement inquiry in their classroom. Additionally, and just as important, is the discussion of the needs and abilities of ELL students. Early career teachers need to go beyond implementing inquiry with their ELL students and transform their deficit ideology into views that foster inclusive classrooms that value the contributions of all students, regardless of their language proficiency or cultural
background. Educational researchers play an important role as they document the role of each of these efforts on teacher professional development.

Systemic, sustained and collaborative efforts are needed in order to advance the field of teacher professional learning. The field of teacher education recognizes the importance of preparing preservice and early career teachers to meet the needs of the increasing linguistically and culturally diverse students in the K-12 schools across the United States; however, there is also a need to move from acknowledgement to action. This action needs to be concerted and sustained. It must involve carefully designed preservice experiences and sustained, comprehensive induction programs that specifically tailored to build the capacity of early career science teachers.

At the school site, efforts to provide these teachers with a stable, supportive environment that includes: (a) mentors who are reform-minded science content experts, (b) a single subject that matches their content knowledge base, (c) a curriculum map and quality inquiry curriculum, (d) opportunity to work with other colleagues in a reform-oriented PLC. Lasting, self-sustaining reform can only occur by taking comprehensive steps toward a school culture that values a reform-based, student centered learning environment.
References


Richardson, L., & Simmons, P. (1994). Self-Q research method and analysis, teacher pedagogical philosophy interview: Theoretical background and samples of data. Athens, GA: Department of Science Education, University of Georgia.


Figure 1. Diagrammatic representation of integrated theoretical frameworks. The overarching CHAT framework subsumes the PCK framework. The central activity is teacher learning. Adapted from Engeström, Miettinen, and Punamaki, (1999).

Perspectives on activity theory. UK: Cambridge University Press.
To: Julie Luft  
EDB 204B  

From: Albert Kagan, Chair  
Institutional Review Board  

Date: 04/24/2006  

Committee Action: Renewal  
Renewal Date: 04/24/2006  
Review Type: Expedited F7  
IRB Protocol #: 0504002385  
Study Title: Exploring the Development of Beginning Secondary Science Teachers in Various Induction Programs  
Expiration Date: 04/23/2007  

The above-referenced protocol was given renewed approval following Expedited Review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval of ongoing research before the expiration noted above. Please allow sufficient time for reapproval. Research activity of any sort may not continue beyond the expiration date without committee approval. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study termination.
APPENDIX B

ARIZONA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD

APPLICATION
**ARIZONA STATE UNIVERSITY**

**APPLICATION FOR EXEMPT RESEARCH**

For Office Use Only:

Date Received:

HS Number:

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**PROTOCOL TITLE:**

Calibration Of a Language Inquiry Rubric.

**DATE OF REQUEST:**

October 30th, 2008

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<thead>
<tr>
<th><strong>PRINCIPAL INVESTIGATOR:</strong></th>
<th>Dr. Dale Baker, EdD</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Curriculum and Instruction</td>
</tr>
<tr>
<td><strong>CAMPUS ADDRESS:</strong></td>
<td>Payne 203, Mail Code 0911</td>
</tr>
<tr>
<td><strong>PHONE:</strong></td>
<td>480 965-6067</td>
</tr>
<tr>
<td><strong>E-MAIL:</strong></td>
<td><a href="mailto:DALE.BAKER@asu.edu">DALE.BAKER@asu.edu</a></td>
</tr>
</tbody>
</table>

**UNIVERSITY AFFILIATION:**

☐ Professor
☐ Associate Professor
☐ Assistant Professor
☐ Instructor
☐ Other: Please specify.

---

**CO-INVESTIGATOR:**

Irasema Materassi

**DEPARTMENT/CENTER:**

Curriculum and Instruction

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Payne 204, Mail Code 1011

**PHONE:**

480 540-7336

**E-MAIL:**

Irasema.Materassi@asu.edu

**UNIVERSITY AFFILIATION:**

☐ Professor
☐ Associate Professor
☐ Assistant Professor
☐ Instructor
☐ Other: Please specify. Research Assistant

---

**CO-INVESTIGATOR:**

**DEPARTMENT/CENTER:**

**CAMPUS ADDRESS:**

(include campus mail code)

**PHONE:**

**EMAIL:**

Please specify.
1. Provide a brief description of the background, purpose, and design of your research. Avoid using technical terms and jargon. Be sure to list all of the means you will use to collect data (e.g. tests, surveys, interviews, observations, existing data). Provide a short description of the tests, instruments, or measures and attach copies of all instruments and cover letters for review. If you need more than a few paragraphs, please attach additional sheets. FOR ALL OF THE QUESTIONS, WRITE YOUR ANSWERS ON THE APPLICATION RATHER THAN JUST SAYING SEE ATTACHED.

The purpose of this study is to calibrate a language and inquiry rubric. The rubric was designed to evaluate the materials and classroom practices of pre-service and beginning science teachers working in settings with high numbers of English language Learners (ELLs). One of the researchers in the creator of the rubric and the classroom instructor for the elementary science methods class whose students will be involved in the calibration.

All of the students will participate in the calibration activity. Only data from those students who give permission by signing the consent form will be used for publication or conferences. Participants’ names will be kept confidential by substituting them with numbers. The electronic list of names with assigned numbers will be kept in a data room and all files containing names will be destroyed three years after the last publication. The calibration will take place during regular classroom time as part of the peer teaching activities of the science methods class. The pre-service teachers involved in this activity will use the rubric to evaluate the quality and type of inquiry and language practices fostered by their fellow classmates during a 15 minute lesson. Two students will evaluate each peer using the above mentioned rubric. Following the evaluation, the students will discuss and justify their evaluation, come to a consensus and write a paragraph explaining how they determined the final score. The final score on the lesson will be determined by the instructor using a different, pre-calibrated rubric.

Students will receive copies of their peer evaluation and explanation for scoring. The instructor will provide each student with feedback regarding their lesson plan using a second rubric. Students will receive a copy of the final version of the instrument, and will be able to use it and share it with other pre-service and beginning teachers if they so desire.

The Language and Inquiry rubric (LIR) rates teaching materials regarding the type of activity and the use of languages skills. The categories on the horizontal heading of the rubric allow the evaluator to rate the practices regarding the type of inquiry activity (open, directed, guided), procedural activity or student project. The left side of the rubric identifies the language practices and preponderance of vocabulary used by the students and teacher during the activity.
**RECRUITMENT**

2. Describe how you will recruit participants (attach a copy of recruitment materials). All 21 ASU students enrolled in BLE 420 during the Fall 2008 Semester will be asked to participate in the rubric calibration during the regularly scheduled lesson reflection activity. They will be provided with an individual consent letter accepting or refusing the use of their evaluations for the purpose of research publication and conference presentations. The calibration activity will take place on November 10, 2008.

**PROJECT FUNDING**

The cost of photocopying the rubric will be provided by the course instructor. Not other costs will be incurred during this project.

3. How is the research project funded? (A copy of the grant application(s) must be provided prior to IRB approval. For funded projects, researchers also need to submit a copy of their human subjects training certification: http://researchintegrity.asu.edu/irb/training/)

- [x] Research is **not funded** (Go to question 4)
- [ ] Funding decision is pending
- [ ] Research is **funded**

a) What is the source of funding or potential funding? (Check all that apply)

- [ ] Federal
- [ ] Private Foundation
- [ ] Department Funds
- [ ] Subcontract
- [ ] Fellowship
- [ ] Other

b) Please list the name(s) of the sponsor(s):

c) What is the Project grant number and title (for example NIH grant number)?

d) What is the ASU account number/project number?

e) Identify the institution(s) administering the grant(s):

**STUDY POPULATION- If you are doing data analysis only, please write DA.**

4. Indicate the **total number of participants** that you plan to include or enroll in your study. 21

<table>
<thead>
<tr>
<th>Indicate the age range of the participants that you</th>
<th>22 to 54</th>
</tr>
</thead>
</table>

241
### SUPPLEMENTAL MATERIALS

5. Attach a copy of the following items as applicable to your study (Please check the ones that are attached):

- [x] Research Methods (Research design, Data Source, Sampling strategy, etc.)
- [x] Any Letters (cover letters or information letters), Recruitment Materials, Questionnaires, etc. which will be distributed to participants
- [ ] If the research is conducted off-site, provide a permission letter where applicable
- [ ] If the research is part of a proposal submitted for external funding, submit a copy of the FULL proposal

Note: The information should be in sufficient detail so IRB can determine if the study can be classified as EXEMPT under Federal Regulations 45CFR46.101(b).

### DATA USE

6. How will the data be used? (Check all that apply)

- [x] Dissertation
- [ ] Thesis
- [ ] Results released to participants/parents
- [ ] Results released to agency or organization
- [ ] Other (please describe):
- [x] Publication/journal article
- [ ] Undergraduate honors project
- [ ] Results released to employer or school
- [x] Conferences/presentations

### EXEMPT STATUS

7. Identify which of the 6 federal exemption categories below applies to your research proposal and explain

why the proposed research meets the category. Federal law 45 CFR 46.101(b) identifies the following EXEMPT categories. Check all that apply to your research and provide comments as to how your research falls into the category.

SPECIAL NOTE: The exemptions at 45 CFR 46.101(b) do not apply to research involving prisoners. The exemption at 45 CFR 46.101(b)(2), for research involving survey or interview procedures or observation of public behavior, does not apply to research with children, except for research involving observations of public behavior when the investigator(s) do not participate in the activities being observed.

- [x] (7.1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Please provide an explanation as to how your research falls into this category:

Part of the prescribed curriculum for the elementary science methods course involves becoming proficient in the creation and use of rubrics to evaluate different classroom activities. The curriculum also involves evaluating science inquiry and the implementation of classroom activities that foster proficiency in the areas of reading, writing, speaking and listening. By observing their peers present lessons, the pre-service teachers identify critical elements of pedagogy that are essential in teaching science to English language learners. By using the rubric and discussing their rating with peers, the pre-service teachers engage in reflective practices that enhance their pedagogical content knowledge.

- [ ] (7.2) Research involving the use of educational tests (cognitive, diagnostic, aptitude,
Please provide an explanation as to how your research falls into this category:

<table>
<thead>
<tr>
<th>(7.3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:</th>
</tr>
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<tbody>
<tr>
<td>(i) The human subjects are elected or appointed public officials or candidates for public office; or</td>
</tr>
<tr>
<td>(ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.</td>
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</table>

Please provide an explanation as to how your research falls into this category:

<table>
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<tr>
<th>(7.4) Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.</th>
</tr>
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<tbody>
<tr>
<td>Note-Please review the OHRP Guidance on Research Involving Coded Private Information or Biological Specimens: <a href="http://www.hhs.gov/ohrp/humansubjects/guidance/cdebiol.pdf">http://www.hhs.gov/ohrp/humansubjects/guidance/cdebiol.pdf</a></td>
</tr>
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Please provide an explanation as to how your research falls into this category:

<table>
<thead>
<tr>
<th>(7.5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine:</th>
</tr>
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<tbody>
<tr>
<td>(i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.</td>
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</tbody>
</table>

(Generally does not apply to the university setting)

Please provide an explanation as to how your research falls into this category:

<table>
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<tr>
<th>(7.6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.</th>
</tr>
</thead>
</table>

Please provide an explanation as to how your research falls into this category:

**PPRINCIPAL INVESTIGATOR**
In making this application, I certify that I have read and understand the ASU Procedures for the Review of Human Subjects Research and that I intend to comply with the letter and spirit of the University Policy. I may begin research when the Institutional Review Board gives notice of its approval. I must inform the IRB of ANY changes in method or procedure that may conceivably alter the exempt status of the project. **I also agree and understand that records of the participants will be kept for at least three (3) years after the completion of the research**

Name (first, middle initial, last):

Signature: Date:

<table>
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<th>FOR OFFICE USE:</th>
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<tr>
<td>This application has been reviewed by the Arizona State University IRB:</td>
</tr>
<tr>
<td>□ Exempt       Category/Categories:</td>
</tr>
<tr>
<td>□ Approved     Deferred to other review</td>
</tr>
<tr>
<td>□ Deferred to other review Recommended that investigator submit for expedited or Full Board review.</td>
</tr>
</tbody>
</table>

Authorizing Signature: Date:

X
TITLE
Exploring the Development of Beginning Secondary Science Teachers in Various Induction Programs

I am being asked to read the following material to ensure that I am informed of the nature of this research study and of how I will participate in it, if I consent to do so. Signing this form will indicate that I have been so informed and that I give my consent. Federal regulations require written informed consent prior to the participation in this research study so that I can know the nature and the risks of my participation and can decide to participate or not participate in a free and informed manner.

PURPOSE
I am being invited to voluntarily participate for two more years in the above titled research project. The purpose of this project is to identify how different induction programs affect the implementation of inquiry instruction, a new teacher’s pedagogical philosophies, and beliefs about teaching.

SELECTION
I am being invited to participate because I am a secondary science teacher in my fourth year of teaching, and I have participated in three earlier years of data collection. Approximately 16 subjects will be enrolled in this project.

PROCEDURE
If I agree to participate, I will be asked to consent to two interviews (verbal or written) about my pedagogical philosophies and content knowledge, completing an interview about my views of teaching science, filling out a personal questionnaire once, and I will be observed 4 times and contacted 8 times randomly during the year to discuss my classroom instruction. The interviews and questionnaires will take approximately 4-5 hours at the beginning and end of the school year. All interviews will be audiorecorded. During the classroom visits, notes will be made about my teaching. Following the visits or during another time, I will be asked about my other lessons during the week. Other than scheduling the visit, talking about my instruction, and possibly collecting materials about the lesson, there will not be additional time. In addition, at the end of the year each participant can meet with a member of the research team to review the participant’s collected data. During this meeting, we will share the results and implications of the collected data.

Collected data will be kept for one year after the last analysis and publication of the data. At this time, electronic data will be erased and paper documents will be shredded.

RISKS and BENEFITS
There are no known risks or benefits.

CONFIDENTIALITY
Names will not be used in the transcription or in the written report. Once interviews are collected they will be numbered and a pseudonym (false name) given. This pseudonym will

[Signature]

Date 4/30/07 - 5/3/07
be used in the publication. The data collected will be kept for one year after the last analysis and publication, then data will be destroyed.

PARTICIPANT COSTS and SUBJECT COMPENSATION
There will be no cost to me for participating except for 19 hours of my time. I understand that I will be compensated $400 for my participation. Participants who leave the study will be paid according to their participation ($100 for the end of the year interview). I can obtain further information from Julie Luft, Ph.D., at 480.965.0170.

AUTHORIZATION
Before giving my consent by signing the form, the methods, the inconveniences, risks, and benefits have been explained to me and my questions have been answered. I understand that I may ask questions at any time and that I am free to withdraw from the project at any time without causing bad feelings. My participation is this project may be ended by the investigator for reasons that would be explained. New information developed during the course of the study which may affect my willingness to continue in this research project will be given to me as it becomes available. I understand that this consent form will be filed in an area designated by the Human Subjects Committee with access restricted to the principal investigator, Julie Luft Ph.D., or authorized representative of the Science Education Department. I understand that I do not give up any of my legal rights by signing this form. A copy of this signed consent will be given to me.

Subject’s Signature ___________________________ Date ________________

By signing below, I consent to be audio taped.

Subject’s Signature ___________________________ Date ________________

Investigator’s Affidavit
I have carefully explained to the subject the nature of the above project. I hereby certify that to the best of my knowledge the persons signing this consent form understand clearly the nature, demands, benefits, and risks involved in his/her participation and his/her signature is legally valid. A medical problem or language or educational barrier has not precluded this understanding.

Signature of the Investigator ___________________________ Date ________________

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board through the ASU Research Compliance Office at (480) 965-6788.
Observation Protocol (100506)

I. Background Information

Teacher Name: ___________________________ School: _______________
Subject Observed: _____________________________ Grade Level: ______
Observation is (circle one) in-field/ out-of-field based on major & content
Start Time: _______ End Time: ______ Date :______ 
Schedule Type Trad (45-60mins) _____ Block (60-over) ______
# of classroom meetings a week 5______ 2-4 __________
Observer: _______________________ Observation # (circle one) : 1 2 3 4
Number of students in class ____

Brief description of students in class:

Socio-Economic Status
M/F Ratio
school uniforms
ethnic breakdown
etc

Protocol regarding the observational coding:
• The first priority should be to take notes about the lesson. This will be recorded under III.
  Description of events over time.
• Record the most salient event during the 5 minute data collection periods. For example, students may work individually and the may work in groups. If they spend more time individually, then code the 5 minute segment as individual.
• Under cognitive activity, code what happens and not the intent of the lesson.
• At the end of the lesson code the 10 items for “quality” of instruction.
• Try to observe a variety of classes that represent the content areas that are taught.

II. Contextual Background and Activities

A. Objective for lesson (ask teacher before observing):

B. How does lesson fit in the current context of instruction (e.g. connection to previous and other lessons)?

C. Classroom setting: (space, seating arrangements, room for the lesson, if desks are fixed or moveable, posters (science vs. non-science), student work, is it conducive to lab work (or teaching science) etc. Include a diagram).

D. Any relevant details about the time, day, students, or teacher that you think are important? Include diagram. (i.e.: teacher bad day, day before spring break, pep rally previous hour, etc.)

III. Description of events over time (indicate time when the activity changes)
<table>
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<th>65-70</th>
<th>70-75</th>
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<th>85-90</th>
<th>90-95</th>
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</tbody>
</table>

Make sure that you describe the activity. If you can collect artifacts.

**IV. Evaluation of the class in 5-minute increments**
Code the prevalent activity during the 5-minute increment (3+ minutes out of the 5).

<table>
<thead>
<tr>
<th>Time in minutes</th>
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<th>10-15</th>
<th>15-20</th>
<th>20-25</th>
<th>25-30</th>
<th>30-35</th>
<th>35-40</th>
<th>40-45</th>
<th>45-50</th>
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</tbody>
</table>

**Key ---Note: Type of Instruction - requires two codes: type of activity and organization (Ind, Group etc.)**

<table>
<thead>
<tr>
<th>Activity codes</th>
<th>RP</th>
<th>SR</th>
<th>TB</th>
<th>WK</th>
<th>SP</th>
<th>V</th>
<th>HA</th>
<th>HC</th>
<th>FT</th>
<th>AD</th>
<th>Q</th>
<th>I</th>
<th>NS</th>
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<tbody>
<tr>
<td>B</td>
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<tr>
<td>Lec</td>
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<td>RT</td>
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<td>RH</td>
<td>teacher-led review – homework/previous day</td>
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<td>RI</td>
<td>teacher-led review – in-class assignment</td>
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<td>LI</td>
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<td>NS</td>
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</tbody>
</table>
Cognitive Activity – This should be coded for the students who are participating (not for the intention of the lesson)

1. Receipt of Knowledge--(i.e., lecture, reading textbook, etc.) Students are getting the information from either a teacher or book. This generally includes listening to a lecture, going over homework or watching the teacher verify a concept through a demonstration or working problems at the board. The critical feature is that students are not doing anything with the information.

2. Application of Procedural Knowledge--Students apply their knowledge (from Bloom’s taxonomy: Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place.). This typically involves students using what they have learned, doing worksheets, practicing problems, or building skills. The critical feature is simple application of information or practicing a skill.

3. Knowledge Representation--organizing, describing, categorizing. Students manipulate information. This is a step beyond application. Students are re-organizing, categorizing, or attempting to represent what they have learned in a different way – for example, generating a chart or graph from their data, drawing diagrams to represent molecular behavior, concept mapping.

4. Knowledge Construction--higher order thinking, generating, inventing, solving problems, revising, etc. Students create new meaning. Students might be generating ideas, or solving novel problems. For example generating patterns across three different data sets, drawing their own conclusions, articulating an opinion in a discussion or debate.

5. Other--e.g. classroom disruption, no science in the lesson, administrative activity

This instrument is to be completed following the observation of classroom instruction. Prior to instruction, the observer will review planning for the lesson with the teacher. During the lesson, the observer will write an anecdotal narrative describing the lesson and then complete the instrument. Each of the ten items should be rated “globally”; the descriptors are possible descriptors not required as a check-off list.

Score descriptions:

<table>
<thead>
<tr>
<th>Organization Codes</th>
<th>Student Attention to Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td>WG whole group</td>
<td>LE low attention, 80% or more of the students off-task. Most students are obviously off-task – heads on desks, staring out of the window, chatting with neighbors, etc.</td>
</tr>
<tr>
<td>SG small group</td>
<td>ME medium attention, 50% of students are attending to the lesson.</td>
</tr>
<tr>
<td>CL cooperative learning (ex: roles, individual accountability, etc.)</td>
<td>HE high attention, 80% or more of the students are attending to the lesson. Most students are engaged with the activity at hand – taking notes or looking at the teacher during lecture, writing on the worksheet, most students are volunteering ideas during a discussion, all student are engaged in small group discussions even without the presence of the teacher</td>
</tr>
<tr>
<td>Ind individually on assignments</td>
<td></td>
</tr>
</tbody>
</table>

251
### Points:
Teacher and student are bolded -- indicating who should be the primary consideration in the coding.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Practice could have been included in the lesson, but wasn’t</td>
</tr>
<tr>
<td>1</td>
<td>Some attempt is made at the item</td>
</tr>
<tr>
<td>2</td>
<td>Elements of the item are clearly present, but not fully carried out</td>
</tr>
<tr>
<td>3</td>
<td>Areas in the item of good quality, but there is room for improvement</td>
</tr>
<tr>
<td>4</td>
<td>Highest level of quality evident in this item</td>
</tr>
<tr>
<td>N/A</td>
<td>Practice was not included and was not appropriate for the lesson</td>
</tr>
</tbody>
</table>

#### 1. This lesson encouraged students to seek and value various modes of investigation or problem solving. (Focus: Habits of Mind)

<table>
<thead>
<tr>
<th>Teacher:</th>
<th>Student:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presented open-ended questions</td>
<td>Discussed problem-solving strategies</td>
</tr>
<tr>
<td>Encouraged discussion of alternative explanations</td>
<td>Posed questions and relevant means for investigating</td>
</tr>
<tr>
<td>Presented inquiry opportunities for students</td>
<td>Shared ideas about investigations</td>
</tr>
<tr>
<td>Provided alternative learning strategies</td>
<td></td>
</tr>
</tbody>
</table>

#### 2. Teacher encouraged students to be reflective about their learning. (Focus: Metacognition)

<table>
<thead>
<tr>
<th>Teacher:</th>
<th>Student:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encouraged students to explain in their own words both what and how they learned</td>
<td>Discussed what they understood from class and how they learned it</td>
</tr>
<tr>
<td></td>
<td>Identified anything unclear to them</td>
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<tr>
<td></td>
<td>Reflected on and evaluated their own progress toward understanding.</td>
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</tbody>
</table>

*Note: Consider both the teacher and student for the score*
3. Interactions reflected collaborative working relationships and productive discourse among students and between teacher and students. (Focus: Student discourse and collaboration)  

<table>
<thead>
<tr>
<th>Teacher:</th>
<th>Student:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organized students for group work</td>
<td>Worked collaboratively or cooperatively to accomplish work relevant to the task</td>
</tr>
<tr>
<td>Interacted with the small groups</td>
<td>Exchanged ideas related to the lesson with peers and teacher</td>
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<tr>
<td>Provided clear outcomes for groups</td>
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</tbody>
</table>

4. Intellectual rigor, constructive criticism, and the challenging of ideas were valued. (Focus: Teachers & students rigorously challenged ideas)  

<table>
<thead>
<tr>
<th>Teacher:</th>
<th>Student:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encouraged input and challenged students’ ideas</td>
<td>Provided evidence-based arguments</td>
</tr>
<tr>
<td>Was non-judgmental of student opinions</td>
<td>Listened critically to others’ explanations</td>
</tr>
<tr>
<td>Solicited alternative explanations</td>
<td>Discussed/challenged others’ explanations</td>
</tr>
</tbody>
</table>

5. The instructional strategies and activities probed students’ existing knowledge and preconceptions. (Focus: Student pre- and mis-conceptions)  

<table>
<thead>
<tr>
<th>Teacher:</th>
<th>Student:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-assessed students for their thinking and knowledge</td>
<td>Expressed ideas even when incorrect or different from the ideas of other students</td>
</tr>
<tr>
<td>Helped students confront or build on their ideas</td>
<td>Responded to the ideas of other students</td>
</tr>
<tr>
<td>Refocused lesson based on students ideas to meet needs</td>
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</tr>
</tbody>
</table>

6. The lesson promoted strongly coherent conceptual understanding in the context of clear learning goals. (Focus: Conceptual thinking)  

<table>
<thead>
<tr>
<th>Teacher:</th>
<th>Student:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asked higher level questions</td>
<td>Asked and answered higher level questions</td>
</tr>
<tr>
<td>Encouraged students to extend concepts and skills</td>
<td>Related subordinate ideas to broader concepts</td>
</tr>
<tr>
<td>Related integral ideas to broader concepts</td>
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</tbody>
</table>
Part A: Determine Teaching Status: The goal of the study is to follow teachers that are teaching science at the secondary level (7-12). If you have a question whether the teacher fits this criterion after speaking with them, ask Julie.

1. Determine if they are still teaching or not. If they are not, proceed to Part B. If they meet the criteria and are willing to continue with the study, Proceed to Part C.

Part B: No longer Teaching: We really can't ask more than 3-4 questions, as these people are not the focus of our study. We can do something with this data - later. This shouldn't last more than 5-10 minutes.

Interviewer: I just have 4 quick questions about your current status and your decision to leave. Would you mind answering these? They will be audio-taped - if that is OK with you?

1. If you are not teaching, what are you currently doing as an occupation? (Make notes on this and we will label these when the data come in.)

2. Why did you leave teaching?

3. Do you think that you will ever return to teaching? When would that be? Why would this be an option?

4. How did your now experience as a classroom teacher impact your view of education?

Part C: Teaching
Follow the protocol for interviews. General questions (at this time – update any information on teaching assignment), Beliefs, Nature of Science (NOS), and PCK. Teachers at the end of the interview will be asked to answer a PK sheet and complete 2 concept maps. The concept maps are as follows: 1) with the original words on the list; and 2) Teachers add 10 more words to the original 10 (20 words total).

(If doing a face-to-face interview, have teachers complete the 1st concept map prior to the interview and the 2nd with 20 words at the end)
1. Updated contact information

2. Are you at the same school you were at last time we talked to you? If not what school are you at? What did you teach? Why did you change schools?

3. What was the best part of the year as a science teacher?  
   *Probe: If there is no mention of instruction: What have you been most pleased with instructionally this year?*

4. What was the most frustrating aspect of your year as a science teacher?

5. What is the most rewarding part of your teaching?

6. Were you satisfied with your teaching this year? If so, why? If not, why?

7. How was this year’s teaching experience different from the previous Years?  
   *Probes – teaching community, school support, instruction, administration.*

8. What new responsibilities did you have this year, (e.g., department head, mentor). Can you tell me about these responsibilities (get information)

9. What advice would you give to new teachers about the first two Years in the classroom? Advice to mentors? Advice to principals?

10. At this point in your career, what aspects of your undergraduate or preparation program have been useful to you (why?) and what has not?

12. What kinds of professional development activities did you participate in this year? (e.g., workshops, graduate degree programs (get start date)) Why are you engaging in these activities (probe to see if the activities are mandated, if teachers elect to do these things, or if they are paid)  
   *How useful were these activities to you as a science teacher?*  
   *What are your plans for this summer? Courses, institutes, or workshops. Ideas for fun and exciting science lessons, etc. (probe about why the teacher is taking these courses and what they hope to get out of them)*

13. Will you be returning to teaching this year?  
   *Yes*  
   *a. If not returning to teaching: When was this decision made, what factors influenced this decision?*  
   *b. If returning to teaching: What are you looking forward to most next year, in terms of teaching science.*  
   *c. If a new position: where will you be teaching next year? Name of the school?*

14. Is there anything else you would like to tell us about the last few Years in terms of being a science teacher?
<table>
<thead>
<tr>
<th>Participant</th>
<th>Interviewer</th>
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<tbody>
<tr>
<td>Induction Group</td>
<td>T1/T2/T3/T4/T5/T6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date</th>
<th>DSS Recording Time</th>
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</table>

1. What do you think constitutes a good lesson in science?

2. Can you briefly describe a lesson or unit you taught that you thought was successful?

3. What did you consider when planning your lesson/unit?

*If not explicitly mentioned – use the following probes*

i. Did you consider prior knowledge? If so, how?

ii. Did you consider variations in students’ approaches to learning? If so, how?

iii. Did you consider students’ difficulty with specific science concepts (misconceptions)? If so, how?

iv. Is this a good example of inquiry in science? Why or Why not? If not, how would you change this lesson to reflect inquiry?
## Category 1: Knowledge of Student Learning in Science

<table>
<thead>
<tr>
<th>Elements</th>
<th>Limited</th>
<th>Basic</th>
<th>Proficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior knowledge</td>
<td>Teacher has limited or no acknowledgement of students’ prior knowledge, or is cognizant but does not incorporate it into lesson plans.</td>
<td>Teacher recognizes students’ prior knowledge and uses it in a limited way.</td>
<td>Teacher draws upon students’ prior knowledge and constructs lessons that build upon this knowledge.</td>
</tr>
<tr>
<td>Variations in students' approaches to learning</td>
<td>Teacher has limited or no consideration for variations in students’ approaches to learning, and frequently uses one type of approach to instruction.</td>
<td>Teacher acknowledges variations in students’ approaches to learning while planning lessons and uses different approaches without student contributions.</td>
<td>Teacher acknowledges variations in students’ approaches to learning and allows students various opportunities to engage in science learning in their own way.</td>
</tr>
<tr>
<td>Students' difficulties with specific science concepts</td>
<td>Teacher has limited understanding about students’ learning difficulties associated with lessons, and makes few or no attempts to minimize those difficulties during planning or instruction.</td>
<td>Teacher recognizes students’ learning difficulties and modifies the lesson to a limited degree.</td>
<td>Teacher considers students’ learning difficulties during the process of planning lessons and addresses these in the lesson.</td>
</tr>
<tr>
<td>Elements</td>
<td>Level</td>
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<tr>
<td>----------------------------------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited</td>
<td>Basic</td>
<td>Proficient</td>
</tr>
<tr>
<td>Scientific inquiry (Science-specific strategies)</td>
<td>Teacher implements a lesson that verifies a previously covered concept or directs the student in how to proceed through the lesson. None of the essential features of classroom inquiry are present (NRC, 2000).</td>
<td>Teacher adopts scientific inquiry for teaching lessons and addresses some (2-3) of the essential features of classroom inquiry, which includes having the learner: engage in scientifically oriented questions; give priority to evidence in responding to questions; formulate explanations from evidence; connect explanations to scientific knowledge; communicate and justify explanations.</td>
<td>Teacher adopts scientific inquiry for teaching lessons and incorporates most (4-5) of five essential features of classroom inquiry into lesson.</td>
</tr>
<tr>
<td>Representations</td>
<td>Teacher uses representations (e.g. illustrations, examples, models, analogies, and demonstration) and materials that are ineffective, scientifically inaccurate, or are not linked to students' knowledge or experience.</td>
<td>Teacher uses representations and materials that are pedagogically limited or scientifically undeveloped or limited, with an attempt to link to students' prior knowledge and experience.</td>
<td>Teacher uses representations that are pedagogically effective and scientifically accurate and are well-linked to students' prior knowledge and experience.</td>
</tr>
</tbody>
</table>
APPENDIX G

MONTHLY INTERVIEW
Weekly Update Coding Sheet - revised 102009 – Update 2-Yr 5

Teacher Name:   Interviewer:  
Grade/Subject: General Science  Date:  
Schedule Type Traditional ( < 60 mins) Block (> 60 mins)  
Class meets: Daily  2-4 days a week  
Update# 1 2 3 4 5 6 7 8 9mu  
Protocol:

Before
• Read participant file before calling participant --if you are not familiar with the participant.
• Call/e-mail ahead of time to set a time to talk. Follow-up frequently if you don’t get a response right within 48 hours.
• Decide which class to collect information on (refer to teacher’s schedule). Updates should reflect the composition of classes (e.g., 75% bio/ 25% physics=  6 interviews in biology and 2 interviews in physics).
• Make sure you have the audio recorder and that it is set correctly, and that you have checked the batteries.

During
• Have the teacher describe the lessons and clarify what they taught each day, how they taught it, the origin of the lesson, and what materials they used.
• Block schedule- code a block day for two days
• Type this review, if possible.
• Make sure you ask for the artifacts from the lessons at the end of the interview – establish how you will get these.

After
• Upload file to the computer, mark interview as complete, and file the update sheet. Check board indicating that interview was completed.

Interview questions (on even interviews, ask question 4)

1. How are things going in the classroom so far?
   a. As teacher talks about events, ask for more details.
   b. If good points are presented, ask about what is not going well? Or, if bad points are presented, as what is going well.
   c. How confident are you in your ability to motivate students? Assess their learning?
   d. Assess:

The goal of this probe is to capture the current issues for the teacher in terms of instruction

2. Have there been any changes in the professional development activities that you are engaging in since we last talked? If so—probe about the type of activity and the level participation (e.g., how often are you going, what are you doing in these meetings/events, serving as a mentor or beginning a mentee).

3. Have you taken on any new responsibilities since we last talked? If so, what are they? Were there any responsibilities that you declined this year? If so, what are they?

4. Is there any additional information that you would like to share regarding your teaching that we have not talked about, that would be helpful for us to know?
** How do you feel these lessons went? What did you like about them? What would you do differently? (Trying to get at changes they would make per the lesson/teaching, or perceived strengths of lesson/teaching. May also indicate supplies that are present in class)
<table>
<thead>
<tr>
<th>Lesson consisted of:</th>
<th>Mon</th>
<th>Tues</th>
<th>Wed</th>
<th>Thurs</th>
<th>Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Bell-work/Opening activity
- Teacher-led lecture without discussion
- Teacher-led class discussion
- Teacher directions
- Teacher-led demonstration
- Teacher-led simulation
- Teacher-led review activity - For test
- Teacher-led review activity - hwk/prev. day
- Teacher-led review activity of class assignment
- Inquiry laboratory/activity
- Guided inquiry laboratory/activity
- Directed inquiry laboratory/activities
- Verification laboratory/activity
- Process / skills laboratory/activity
- Student research project
- Students reading assigned material
- Students work/reading from a textbook
- Students complete a worksheet
- Student presentations
- Video/film/DVD
- Homework assigned
- Homework collected
- Out of class experience/field trip
- Admin task
- Non-science instruction
- Interruption
- No class
- Other

**Classroom organization:**

- Individual
- Whole group
- Small group, 2-4 students
- Cooperative learning
- Lesson from previous year
<table>
<thead>
<tr>
<th>Lesson consisted of:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bell-work/Opening activity</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led lecture without discussion</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led class discussion</td>
<td></td>
</tr>
<tr>
<td>• Teacher directions</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led demonstration</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led simulation</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led review activity- For test</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led review activity- hwk/prev. day</td>
<td></td>
</tr>
<tr>
<td>• Teacher-led review activity of class assignment</td>
<td></td>
</tr>
<tr>
<td>• Inquiry laboratory/activity</td>
<td></td>
</tr>
<tr>
<td>• Guided inquiry laboratory/activity</td>
<td></td>
</tr>
<tr>
<td>• Directed inquiry laboratory/activities</td>
<td></td>
</tr>
<tr>
<td>• Verification laboratory/activity</td>
<td></td>
</tr>
<tr>
<td>• Process / skills laboratory/activity</td>
<td></td>
</tr>
<tr>
<td>• Student research project</td>
<td></td>
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<tr>
<td>• Students reading assigned material</td>
<td></td>
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<tr>
<td>• Students work/reading from a textbook</td>
<td></td>
</tr>
<tr>
<td>• Students complete a worksheet</td>
<td></td>
</tr>
<tr>
<td>• Student presentations</td>
<td></td>
</tr>
<tr>
<td>• Video/film/DVD</td>
<td></td>
</tr>
<tr>
<td>• Homework assigned</td>
<td></td>
</tr>
</tbody>
</table>
- Homework collected
- Out of class experience/field trip
- Admin task
- Non-science instruction
- Interruption
- No class
- Other

Classroom organization:
- Individual
- Whole group
- Small group, 2-4 students
- Cooperative learning
- Lesson from previous year
- Lesson from published source
- Lesson is from school/district curriculum
- Lesson from mentor/colleague
- Lesson created by teacher
- Lesson from Internet
- Other

Materials/Technology used:
- Laboratory – Professional equipment
- Laboratory - Common items
- Computer - Internet
- Computer - Software
- Computer - PowerPoint
- Probeware
- Other
If a teacher uses an assessment, make sure to ask what they found out in terms of its use.

Examples of Other codes:

<table>
<thead>
<tr>
<th>Lesson Organization</th>
<th>Materials</th>
<th>Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addressing student concerns</td>
<td>Lab journals</td>
<td>Vee maps</td>
</tr>
<tr>
<td>Concept maps</td>
<td>Office supplies</td>
<td>Concept maps</td>
</tr>
<tr>
<td>Review (games)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Descriptions:

Under “Lesson consisted of”

Bell work – To get students settled and focused, lasting a short period of time (approximately 5-10 mins), and having a set procedure (e.g., copying information from the board).

Teacher-led lecture without discussion – When the purpose of dialogue is to disseminate information. It includes questions by teacher and answers by student. Used as verification by teacher.

Teacher-led class discussion – When purpose is to promote dialogue between teacher and student. In this dialogue questions are open-ended and lead to discussion, interaction, and brainstorming.

Teacher led review – For test – This activity allows the students to review for the test and may include games, review discussions, or written review activities.

Teacher-led demonstration – To provide students with a visual or auditory experience to see a phenomena or event that they would otherwise not observe. Demonstrations can be conceptual or teach a skill.

Teacher-led simulations- Students apply concepts, analyze situations, solve problems, or understand different points of view. Typically, situations, concepts or issues are provided in a condensed and simplified form.

Reading assigned material – Students are reading materials that the teacher copies off, school magazines related to science, or articles. This is not coded when reading a textbook.

Inquiry laboratory/activity – The students develop their own question to explore, along with determining the experiment and modes of data collection.

Guided inquiry/activity – The teacher provides the question, and the students are free to answer the question as they see fit.

Directed inquiry laboratory/activity – The teacher provides the question and the mechanism to answer the question.
**Verification laboratory/activity** – The students are told or know the concepts they will see during the activity. They follow written/verbal guidelines to identify the concept.

**Skill-based laboratory/activity** – The laboratory/activity involves the learning of some basic skill (e.g. learning measurement).

**Assignment** – Discussion is of an assignment to be done outside of class (e.g. homework).

**Administrative task** – Large amount of time is spent in taking care of administrative tasks (e.g. stamping journals without another activity going on).

**Non-science instruction** – Large amount of time is spent on instruction that is not related to science.

**Under “Classroom organization”**

**Individual** – Students are working individually on a task (e.g. worksheet). The only interaction is with the teacher.

**Whole group** – Students are groups together as a class. This is coded with lecture or class discussion.

**Group work 2-4 students** – Students work together in groups of 2-4.

**“Lesson from”** – This should be coded who regard to who or what supplied the lesson. For example if a mentor teacher supplies a textbook lesson, it is coded as a mentor teacher.

**Lesson from published source** – Lesson is from outside of the school or district.

**Under “Assessments used”**

**Lab journal/notebook/logbook** – Used to assess students but is not used just in the scientific sense of the term “lab journal”. Also used for questions, reflections, etc.
### Part One: Science Laboratory Activity Rubric

This rubric helps examine the type of science lab activity used by students during the lesson.

<table>
<thead>
<tr>
<th><strong>Teacher Centered</strong></th>
<th><strong>Student Centered</strong></th>
<th><strong>Student Centered</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verification Laboratory Activity:</strong> Students are involved in a lab activity that requires following a set of directions. There is one possible outcome that is known by the teacher e.g.: Students set up an experiment following a procedure to test one variable. &quot;Using the scientific method&quot;</td>
<td><strong>Directed Inquiry Activity:</strong> Students interpret phenomena. Directed Inquiry: Teacher presents a situation/question and provides the materials for students to investigate and come up with their own conclusions. e.g.: Students design an experiment in order to answer the question “What is the effect of solar radiation on the rate of oxygen production by Elodea?”</td>
<td><strong>Guided Inquiry Activity:</strong> Students have options to investigate a particular topic. They investigate an aspect of a larger problem. e.g.: The topic is environmental factors that influence the behavior of mealworms; students decide on the factor and design an experiment to study how the mealworms react under different moisture conditions.</td>
</tr>
<tr>
<td><strong>Open Ended Inquiry Activity:</strong> Students come up with their own question and design an experiment or project. Students may design and create a butterfly garden. Students integrate science knowledge to their lives and impact their school or community; design a product, answer their own question related to the natural world.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix H. Language Domains Rubric

 LANGUAGE DOMAIN RUBRIC  
Language and Inquiry Science Tool (LIST): A Rubric for Evaluating Early Career Science Teachers lesson Planning and Execution  

**Part Two: Language Domains Rubric**

This rubric helps examine the use of language skills or domains (reading, writing, listening, speaking) used during the lesson.

<table>
<thead>
<tr>
<th>1 Language Domain Used:</th>
<th>2 Language Domains Used:</th>
<th>3 Language Domains Used:</th>
<th>4 Language Domains Used:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lesson is based on one domain. Students read, write or listen to the teacher for most of the lesson. (Mark the box that applies.)</td>
<td>The students engage in the use of two language domains. For instance they may read a vignette about a problem and engage in a discussion regarding how to solve the problem. The order in which the domains are implemented is not considered. (Mark the box that applies.)</td>
<td>The students use a combination of three language domains. For example: Students may read a vignette about a problem and engage in a discussion regarding how to solve the problem and make a journal entry describing their plan of action. The order in which the domains are implemented is not considered. (Mark the box that applies)</td>
<td></td>
</tr>
<tr>
<td><strong>Reading</strong></td>
<td><strong>Reading</strong></td>
<td><strong>Reading</strong></td>
<td><strong>Writing/Listening/Speaking</strong></td>
</tr>
<tr>
<td><strong>Speaking</strong></td>
<td><strong>Speaking</strong></td>
<td><strong>Listening</strong></td>
<td><strong>Writing</strong></td>
</tr>
<tr>
<td><strong>Listening</strong></td>
<td><strong>Writing</strong></td>
<td><strong>Listening</strong></td>
<td><strong>Writing</strong></td>
</tr>
<tr>
<td><strong>Writing</strong></td>
<td><strong>Reading</strong></td>
<td><strong>Speaking</strong></td>
<td><strong>Reading</strong></td>
</tr>
<tr>
<td>Beginner: Preponderance of one vocabulary tier.</td>
<td>Tier One: Lesson contains mostly everyday words that indicate a lesson that is low in content. Caution: In the early grades (K-4) tier one words may take the place of tier three words e.g.: food in place of nutrient.</td>
<td>Tier Two: Lesson contains a large number (&gt;5) of action verbs that indicate student engagement with the context of science: measure, compare, evaluate, discuss.</td>
<td>Tier Three: Lesson contains a large number (&gt;10) of words that are specific to science. This activity involves complex vocabulary words: photosynthesis, gravity, atom, sedimentary rock.</td>
</tr>
<tr>
<td>Intermediate: Preponderance of two vocabulary tiers used throughout the activity</td>
<td>Tier One and Tier Two: A combination of common words and engagement on the part of the students. Lesson may be low in content. Caution: In early grades (K-4) tier one words may take the place of tier three words e.g.: food in place of nutrient.</td>
<td>Tier One and Tier Three: A combination of vocabulary words from the everyday language and science vocabulary. Little to no processing required on the part of the students e.g.: this may be a verification activity.</td>
<td>Tier Two and Tier Three: A combination of science specific words and the processing of the information that involves the use of the science specific vocabulary e.g.: students may be involved in making observations and analyzing the outcome of chemical reactions.</td>
</tr>
<tr>
<td>Proficient: There is a balance of all vocabulary tiers.</td>
<td>The activity involves using vocabulary from all three tiers. The students are using everyday language to help clarify complex vocabulary used in science by direct engagement and processing of the vocabulary in a meaningful context.</td>
<td></td>
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</tr>
</tbody>
</table>

The vocabulary tiers are based on the work of Beck and McKeown, M., (2002). The use of tier two vocabulary in this rubric indicates processing of information and student engagement during the lab activity.
Appendix H. LIST scoring sheet

Appendix F. LIST Observation Coding Matrix

<table>
<thead>
<tr>
<th>Verification</th>
<th>Directed Inquiry</th>
<th>Guided Inquiry</th>
<th>Open Ended/Challenge</th>
<th>Lesson Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inquiry</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>Writing</td>
<td>Speaking</td>
<td>Listening</td>
<td>Language Domains</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier One Vocabulary</td>
<td>Tier Two Vocabulary</td>
<td>Tier Three Vocabulary</td>
<td>Vocabulary Tiers Complexity Index</td>
<td>Language Tiers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

240