Fall 2013

Science Classroom Discourse for Fourth Grade English Language Learners' Scientific Literacy Development

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Entitled Science Classroom Discourse for Fourth Grade English Language Learners’ Scientific Literacy Development.

For the degree of Doctor of Philosophy

Is approved by the final examining committee:

Luciana de Oliveira
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Tony Silva

John Staver

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Approved by Major Professor(s): Luciana de Oliveira

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Head of the Graduate Program Date
SCIENCE CLASSROOM DISCOURSE FOR FOURTH GRADE ENGLISH LANGUAGE LEARNERS’ SCIENTIFIC LITERACY DEVELOPMENT

A Dissertation
Submitted to the Faculty
of
Purdue University
by
Shu-Wen Lan

In Partial Fulfillment of the
Requirements for the Degree
of
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ABSTRACT

Lan, Shu-Wen. Ph.D., Purdue University, December 2013. Science Classroom Discourse for Fourth Grade English Language Learners’ Scientific Literacy Development. Major Professor: Luciana de Oliveira.

Recent research has shown that the construction of science knowledge involves students’ development of science understanding and science language, particularly as it relates to intertextual connections to science terminology and concepts that teachers and students make in science classroom discourse. However, up to now, there is little research exploring this development in upper elementary students, including English Language Learners (ELLs). Through a qualitative case study of a fourth grade science classroom with ELLs, this research project investigated science classroom discourse, using the frameworks of Systemic Functional Linguistics (SFL) discourse analysis and intertextual analysis, to understand the nature of science classroom discourse and challenges for ELLs as well as support the teacher provided or lack thereof in response to the identified challenges. Specifically, this study focused on the kinds of intertextuality and language that the teacher and students drew on to connect to science terminology and concepts emphasized in science texts and science classroom discourse.

The SFL discourse analysis of the observed science classroom discourse showed that much of the teacher’s science teaching was guided by the science textbook. In order for students to meet the textual demands of the science textbook, the teacher
drew on everyday knowledge and language, i.e., Intertextuality to Recounting Events, to connect between science and everyday knowledge and to move between science and everyday language in her presentation and explanation of the textbook content and language. The teacher used text-dependent questions to question students about the textbook passages presented and explained earlier. These questions posed particular challenges to ELLs. The intertextual analyses of student responses to text-dependent questions revealed that most students learned which kinds of intertextuality and language, i.e., ones tightly fitting the textbook content and language or Intertextuality to Written Texts, were more likely to get their responses accepted and acknowledged by the teacher. In contrast, the focal ELL often intuitively drew on everyday knowledge and language, i.e., Intertextuality to Recounting Events, to construct her personal assumptions or opinions in response to questions and offered ideas unexpected by the teacher and classmates. These intertextual analyses showed that the focal ELL appeared to be unaware of the teacher’s implicit or implied expectations for the kinds of intertextuality and language by which to accomplish the advanced science literacy task of answering text-dependent questions. This study highlights that all students, and especially ELLs, need instructional support from teachers in learning to develop new ways of participating in science classroom discourse and answering text-dependent questions that correspond to teachers’ expectations. These findings and analyses were used to provide pedagogical implications and suggestions for teachers working with ELLs in upper elementary mainstream science classrooms and teacher educators.
CHAPTER 1. INTRODUCTION

Learning and understanding science is highly dependent on students’ comprehension of science written texts. Moreover, written texts, a fundamental tool in teaching and learning science, do not exist in isolation. Rather, they are surrounded by classroom talk. Classroom talk is a primary medium through which students learn and understand science terminology and concepts emphasized in science written texts (e.g., science textbooks). When moving among different types of texts, spoken and written, teacher and students construct science classroom discourse in which students gradually develop their disciplinary knowledge and disciplinary-specific language, i.e., scientific literacy (Gibbons, 1999; Lemke, 1989; Wells, 1994).

In becoming scientifically literate, students need to move among texts and to make sense of any text by connecting it to other texts. Such connections can be considered as intertextual connections or intertextuality (Lemke, 1992; Shuart-Faris & Bloom, 2004). Intertextuality, as emphasized by Varelas, Pappas, & Rife (2006), can serve “as important catalysts in developing scientific understanding and typical scientific registers” (p. 638). This essential role of intertextuality in students’ learning of science knowledge and science language (i.e., scientific literacy development) has motivated research in the identification, classification, and interpretation of intertextuality in science classroom discourse (e.g., Gibbons, 1999, 2006; Lemke, 1990, 1992; Pappas, Varelas,
Barry, & Rife, 2003). Inspired by this area of research, the dissertation study presented here is an investigation of science classroom discourse with particular focus on intertextual connections made by teacher and students, including English Language Learners (ELLs), in one fourth grade science classroom in an Indiana elementary school.

1.1 The Need for an Investigation of Science Classroom Discourse for Upper Elementary Students, including ELLs, in Indiana

Schools in Indiana have recently witnessed a growing population of English language learners (ELLs), students who speak a language other than English at home. Indiana had the third highest rate of growth (408%) in the number of ELLs in the entire U.S., whereas the overall enrollment in Indiana K-12 schools declined 5 percent between 1994-1995 and 2004-2005 (NCELA, 2006). Given the increasing number of ELLs in Indiana K-12 schools, teachers need resources and assistance to support these students. ELLs at varying English proficiency levels are placed in mainstream English-medium classrooms with their native English-speaking peers, which constitutes the current mainstream classroom context (Levinson, Bucher, Harvey, Martinez, Perez, Skiba, Harria, Cowan, & Chung, 2007; Li, 2013). The majority of our teachers in U.S. schools are monolingual English speakers and come into mainstream classrooms with limited experience of working with culturally and linguistically diverse students (Zeichner, 1994). Although many mainstream content-area teachers in Indiana K-12 schools have not had university coursework on the integration of language and content instruction (e.g., subject-specific instructional support for ELLs) in teacher preparation courses, they, nevertheless, face students who are learning English as a new language and studying subjects at the same time (de Oliveira & Pereira, 2008). However, there is a dearth of
research into the content-area literacy challenges encountered by the increasing number of ELLs in mainstream classrooms in Indiana.

In most mainstream classrooms in Indiana today, many ELLs are faced with the literacy challenges of developing their disciplinary knowledge and discipline-specific language. ELLs placed in mainstream classrooms can be “Redesignated Fluent English Proficient” (R FEP) who entered school speaking limited English but who have improved their language skills, passed local English proficiency tests, achieved a certain level of English proficiency (levels 4 and 5 in a 1-5 scale), and left the Limited English Proficient (LEP)/ELL subgroup under No Child Left Behind (Menken, 2008). These former ELLs or R FEPs attend mainstream English-medium classes alongside native speakers of English and no longer receive language services and instructional language support. Although ELLs rapidly acquire everyday English and appropriately use it in their daily communication, they still need extended time and continuing instructional support to develop academic English for school subject learning (Cummins, 2000). In other words, long before ELLs are well-prepared for academic English, they have been placed in mainstream content-area classrooms and expected to learn school subjects through English as a medium.

The consequence of this placement is especially relevant in science because learning science is highly dependent on students’ development of academic English, comprehension of science texts, and participation in science classroom discourse (de Oliveira, 2010; Lee & Buxton, 2013). Analysis of science classroom discourse emphasizes how the language used in talking science is different from the language students use in their daily life (Lemke, 1989). The gap between science and everyday
language presents obstacles to students comprehending science texts, making intertextual connections, and participating and/or engaging in science classroom discourse. This gap grows even wider for ELLs learning English as their second or third language and learning school subjects, including science, in a language other than their home language (Lee & Buxton, 2013).

For ELLs mainstreamed in science classrooms, their unfamiliarity with the discipline-specific language of science has led to the linguistic and academic challenges of comprehending science textbooks (Fang & Schleppegrell, 2008) and speaking with their native English-speaking teachers and peers during science classroom discussions (Lee, 2002). Once students reach upper elementary grades (grades 3-5, ages 8-10), the language and literacy challenges of school science dramatically increase (Fang, Lamme, & Pringle, 2010). Upper elementary students and especially ELLs face a marked increase in the challenges presented by literacy tasks that are specific to science, such as making sense of more advanced science texts (e.g., science textbooks) and science classroom talk that go beyond their familiar everyday knowledge, everyday language, and personal narratives (Carrasquillo, Kucer, & Abrams, 2004; Ciechanowski, 2006). de Oliveira & Dodds (2010), for example, noted that ELLs placed in Indiana upper elementary mainstream science classrooms often encounter the underlying problem of processing the academic English expected by the scientific literacy task of reading science textbooks. Noticing many upper elementary ELLs’ limited participation and interactions during science classroom discussions, other researchers have detailed the linguistic, social, and cultural challenges ELLs encounter as participants in mainstream science classroom
discourse (Ciechanowski, 2009; Gibbons, 2003; Hawkins, & Nicoletti, 2008). However, more work needs to be done in this area.

The placement of the increasing number of ELLs in elementary mainstream classrooms also raises important questions about the preparation of elementary mainstream teachers to work with ELLs, as noted by de Jong, Harper, & Coady (2013). Recent work has called for preparation of upper elementary school teachers to effectively support their students and especially ELLs in discussing the meaning of science texts and making connections to texts in face of the reading challenges presented (Bryce, 2011; de Oliveira & Dodds, 2010; Fang, Lamme, & Pringle, 2010). But providing this instructional support is dependent on understanding the nature of both the support and the challenges encountered by the diverse students in a mainstream science classroom context (Gibbons, 2006). Because there is still a lack of empirical research in this area, further research is needed to investigate the existing upper elementary science classroom discourse and understand how students, including ELLs, are supported and challenged in this discourse through which they establish intertextuality connections--connections which deeply influence their scientific literacy development. A close examination of this development in upper elementary students and especially ELLs is very much needed. My interest in these issues was sparked by my experience in the Language Dissection Science Lesson Project (LDSLP) and my experience of being an international graduate student in the United States and enabled me to investigate the above described issues in more detail.
1.2 My Experience in the Language Dissection Science Lesson Project and Being an International Graduate Student

These issues were evident to me because of my work with Dr. de Oliveira in the Language Dissection Science Lesson Project (LDSLP) and my experience of being an international graduate student in the United States. In order for a fourth grade teacher to support her students, including ELLs, in meeting the textual demands posed by fourth grade science textbooks, Dr. de Oliveira cooperated with the teacher to integrate the language dissection approach in science classes: engaging students to “dissect” the language of science textbooks and to focus on the key language patterns in science textbooks. As a research assistant, I observed this fourth grade science classroom with a diverse student population, and I experienced first hand the literacy challenges of upper elementary science classroom discourse to students and especially the ELLs placed in this mainstream science classroom. Although these mainstreamed ELLs had achieved a certain level of English proficiency (levels 4 and 5 on a scale of 1-5), they at times appeared to be confused about the teacher’s instruction, responded to the teacher’s questions with some irrelevant answers, or stayed quiet during whole-class discussions. During the process of observing the science classroom, I noticed the obvious difficulties the ELLs had in participating in science classroom discourse, and I became interested in how exactly mainstream science classroom discourse supports and challenges fourth grade students’ and particularly ELLs’ learning of science from classroom discourse.

Another reason for my particular attention to ELLs’ participation in mainstream science classroom discourse is my language shock, culture shock, and especially study shock from being an international graduate student. As a non-native English-speaking
graduate student, I came to the university in the U.S. with my different learning style and non-mainstream language and cultural backgrounds. I was particularly overwhelmed by the course requirement of participating in classroom discussions during the first few semesters. Each course syllabus requires students to participate in class; participation here means to contribute ideas to classroom discussions. In contrast, class participation in my previous education system means to listen attentively to instructors’ lectures, take detailed notes from lectures, and remain silent in classrooms. To keep raising one’s hands and sharing ideas without instructors’ questions is regarded as disrespectful of teachers’ authority or, even worse, as challenging teachers’ authority. But here, in U.S. mainstream classrooms, students are expected to actively talk about the assigned course readings and share their ideas even without instructors’ questions. Such a mismatch of the expected ways of classroom participation between me and my native English-speaking professors and peers resulted in my uncomfortable classroom experiences. My own struggle with the academic literacy demands of participating in English-speaking mainstream classroom discourse has deepened my empathy for the mainstreamed ELLs’ struggles.

Through my work observing the fourth grade science classroom with ELLs and empathy for this specific group of students, I have come to understand more fully some of the academic literacy demands faced by upper elementary students and especially ELLs in mainstream science classrooms. Specifically, for my dissertation study, I focused on native English-speaking students and ELLs mainstreamed to upper elementary classrooms, and to explore the nature of science classroom discourse as well as how science classroom discourse supports and challenges their learning of science from classroom discourse.
1.3 Overview of the Study

Given the increasing number of ELLs in Indiana schools and the importance of intertextuality in science classroom discourse to students’ scientific literacy development, as stated above, the present study has been designed to explore the nature of science classroom discourse and how science classroom discourse offers opportunities and demands for upper elementary students’, including ELLs’, learning science from classroom discourse. Specifically this study aims to examine how teacher and students, including ELLs, construct their intertextual connections to science terminology and concepts emphasized in science texts and classroom talk in one fourth grade science classroom in an Indiana elementary school.

My intertextual investigation in this study is prompted by Lemke’s and Gibbons’s work, grounded upon Systemic Functional Linguistics (SFL) discourse analysis. Both Lemke’s (1990) investigation of secondary science classroom discourse in the U.S. and Gibbons’s (1998) investigation of fifth grade science classroom discourse in Australia have demonstrated the value of drawing on SFL to do intertextual investigation of science classroom discourse. I am able to further this work by focusing on fourth grade science classroom discourse with students, including ELLs, in Indiana by investigating how teacher and students linguistically built up intertextuality as a resource to interpret, to discuss science texts, and to work on toward using students’ less familiar science language. Simultaneously, with reference to the work of Pappas, Varelas, and their colleagues (e.g., Pappas, Varelas, Barry, & Rife, 2003), I also identify the different kinds of intertextuality used by teacher and students in science classroom discourse. Taking together their ideas on intertextuality in science classroom discourse (i.e., the work of
I have conducted two levels of intertextual analysis: macro-level intertextual analysis (to identify the kinds of intertextuality) and micro-level intertextual analysis (to take a close look at the language used to construct intertextuality). Through these two levels of intertextual analysis, I have been able to trace intertextuality in science classroom discourse, which is vital for me to better understand and describe the construction of science knowledge in the observed science classroom discourse and the support as well as challenge students and particularly ELLs face in making the intertextual connections in the ways the construction of science knowledge expects.

The overall goal of this study is to investigate the construction of science knowledge in science classroom discourse in one fourth grade science classroom in Indiana. This study takes a close look at how science classroom discourse supports and challenges upper elementary students’ and ELLs’ development of science understanding and science language, more specifically their intertextual connections to science terminology and concepts emphasized in science texts and science classroom discourse. One important aspect of this study is that it provides recommendations for teachers to better understand how to foster productive disciplinary engagement in science, through description of science classroom discourse and support as well as challenges students, including ELLs, encounter when constructing science knowledge in science classroom discourse. A detailed account of one fourth grade mainstream science classroom discourse provides a sense of the complexity of being ELLs and an upper elementary mainstream teacher of ELLs. The detailed description can also lead teacher educators and professional development providers to make careful judgments for how to enhance
teachers’ expertise and knowledge for scaffolding *all* students’ learning science from classroom discourse and their scientific literacy development.

### 1.4 Research Questions

This study addresses the issues presented above by answering the following research questions: (1) What is the nature of science classroom discourse? (2) What challenges for ELLs can be identified in science classroom discourse? What support does the teacher provide (or not) in response to the identified challenges? I conducted a qualitative case study of one fourth grade science classroom, with SFL discourse analysis and macro-level and micro-level intertextual analysis, to investigate the nature of science classroom discourse and to understand how science classroom discourse supports and challenges the scientific literacy development of students, including ELLs. More specifically, this study aims to investigate how teacher and students, including ELLs, construct their intertextual connections to science terminology and concepts emphasized in science texts and classroom talk. Such science terminology and concepts are featured prominently in science texts (e.g., science textbooks) which are read and referred to in science lessons and often are the focus for classroom talk. Therefore, “science classroom discourse” in this study specifically refers to “the different types of spoken and written texts encountered and/or produced by teacher and students to make sense of science terminology and concepts in science texts and classroom talk”. In addition, I select to study fourth grade, because at this grade level, there is a decline in the literacy achievement of students, known as the “fourth-grade slump” (Chall, Jacobs, & Baldwin, 1990) caused by challenging literacy tasks encountered in more advanced science discourse and science classroom discussions (Fang et al., 2010; de Oliveira, 2010).
1.5 Outline of the Study

In this chapter, I have introduced the topic of this dissertation, discussed my rationale for this study, offered some information about the theoretical approaches which inform this study, and stated the research questions which guide this study.

Chapter Two presents a review of pertinent studies in several areas. The chapter begins by focusing on learning science from classroom discourse. This is followed by a review of intertextuality in science classroom discourse. The chapter then discusses intertextuality as a resource for students’ and especially ELLs’ learning science. The chapter also discusses literature on the need for immediate attention to the scientific literacy demands on upper elementary students, including ELLs. The chapter ends with a synthesis of the key studies which help frame the present study by laying out a methodological stance for exploring intertextual connections made by teacher and students in science classroom discourse.

Chapter Three presents the qualitative case study method used to collect my data. I discuss the different data collected for this study. I also present the theories and methods for the analysis of the data. The chapter ends with an overview of the research questions and how they were addressed in this study.

Chapter Four provides a detailed description of how the teacher and students, including ELLs, constructed science knowledge in the earth science unit. In addition to the overall description of the earth science unit, the chapter focuses on the ways the teacher supported the construction of science knowledge through science classroom discourse, paying particular attention to the kinds of intertextuality and language used by the teacher and students to talk science. It also features the kinds of intertextuality and
language the teacher provided to teach the science textbook content and language in the observed science classroom discourse. In general, the chapter answers research question one.

Chapter Five presents evidence about the challenges for ELLs identified in the task of answering text-dependent questions in the teacher-led question-and-answer sessions for the review and reinforcement of the textbook passages. I focus on certain responses from one focal ELL which were often viewed as unexpected ideas by the teacher (and peers). Intertextual analyses of these unexpected ideas reveal that the focal ELL appeared to be unaware of the teacher’s implicit expectations or the kinds of intertextuality and language expected by the advanced science literacy task of answering text-dependent questions. This also highlights the need for the teacher to make explicit to students and especially ELLs her expectations for how student responses to the school-based task of answering text-dependent questions should be linguistically presented. In general, the chapter answers research question two.

Chapter Six discusses the key findings and analyses presented in Chapters Four and Five and offers some implications of the study to teachers, teacher educators, and/or professional development providers.
CHAPTER 2. LITERATURE REVIEW

In the first chapter, it was briefly noted that the construction of science knowledge involves students’ development of science understanding and science language, particularly as it relates to intertextual connections to science terminology and concepts that teacher and students make in science classroom discourse. However, little work has been done to explore this development in upper elementary students, including ELLs. This chapter continues that line of argument by reviewing several areas of the literature relevant to this present study. The first section focuses on learning science from classroom discourse (Section 2.1). This is followed by a review of intertextuality in science classroom discourse to establish its importance in teaching and learning science (Section 2.2). Section 2.3 then discusses intertextuality as a resource for students’ and especially ELLs’ learning science, followed by a discussion of research on intertextuality in read-alouds of science books in elementary science classrooms (Section 2.4). Section 2.5 reviews research highlighting the need for immediate attention to the scientific literacy demands on upper elementary students, including ELLs, particularly their reading of science textbooks, their development of science language, and their participation in science classroom discourse. Section 2.6 summarizes and discusses the key studies reviewed in this chapter. These frame the present study by highlighting the need to
explore intertextuality in science classroom discourse for upper elementary students and by laying out a methodological stance for exploring the intertextuality made by teacher and students in science classroom discourse.

2.1 Learning Science from Classroom Discourse

The first chapter indicated that central to students’ science learning is their learning to communicate in science. The conceptualization of learning science as learning to talk science has been proposed by Lemke (1983, 1990, 2001) and Wells (1999), among others. Classroom talk is the medium in which teacher and students comprehend, understand, and interpret science texts (Chang & Wells, 1988). Students use classroom talk to make sense of science texts and as a bridge to the unfamiliar written language of science texts (Maybin & Moss, 1993). Furthermore, there is evidence for the essential role that classroom talk plays in building a syntactic base that aids reading and writing science in school (Newton, 2002; Wellington & Osborne, 2001). Although the significance of classroom talk has long been recognized with respect to students’ literacy development in pre-school years, it is only in recent years that explicit acknowledgement has been given to the central role of classroom talk in students’ learning content areas such as science throughout their elementary and secondary school years (Wells, 1992; Corden, 2000).

The role of classroom talk in learning science has also been a topic of interest in recent reform efforts. These efforts have been motivated by the importance of learning to communicate in science between and among teacher and students and have included an increasing emphasis on learning science from classroom discourse. The National Science Education Standards (National Research Council, 1996) emphasizes “[Science teachers]
structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse. A fundamental aspect of a community of learners is communication” (p. 50). More recently, the new K-12 science standards, *Next Generation Science Standards* (NGSS), released in 2013, highlight the need for science teachers to actively encourage and support students’ and ELLs’ communication in science, particularly as it relates to their participation in science classroom discourse (Lee, Quinn, & Valdes, 2013). These recent science reform efforts, along with the recognized need to nurture communication in science between and among teacher and students, have presented opportunities for more research centered mainly on science classroom discourse and devoted to understanding classroom interaction in science classes.

Given the increasing recognition of classroom discourse in learning science, educators around the world have been interested in various issues surrounding science classroom discourse and in methods to investigate these issues (e.g., Kelly, 2007, 2008; Gibbons, 2006; Seah & Hart, 2007; Varelas & Pappas, 2012; Yerrick & Roth, 2005). In perhaps the most widely cited work on how discourse is constructed in science classrooms, Lemke (1990) drew on Systemic Functional Linguistics (SFL) to focus on how the teachers and students in secondary science classrooms used language to communicate scientific concepts and their conceptual relationships in talk. Lemke’s work began with the premise of SFL that language is a resource used by teachers and students to make meaning throughout their science classroom interactions. The focus of SFL, as emphasized by Christie & Unsworth (2000), is on “how people use language to make meanings with each other as they carry out the activities of their social lives. They do this through their selections from the sets of choices that are available in the language systems”
This linguistic theory of SFL links language with context, thereby highlighting the ways language choices contribute to the realization of context and construct meaning (realization means expression, see Eggins, 2004, for a review). In any context, language realizes (or expresses) three kinds of meaning: ideational meaning--what is happening, the content or topic of the text; interpersonal meaning--who is taking part, the social relationships of the people involved in the text; and textual meaning--what part the language is playing (Schleppegrell, 2004). These three meanings are present when language is used and their realization is dependent upon the contexts, such as a classroom. Using SFL, one can link language and meaning in discourse by identifying the language choices that realize these three kinds of meanings (Huang, 2004; Mohan & Huang, 2002). The language choices and context features offer researchers a set of functional linguistic tools to analyze discourse (Schleppegrell, 2012b).

SFL is a rigorous method of classroom discourse analysis and a theoretically coherent instrument used by researchers in the field of linguistics and education (e.g., Christie, 1995, 2002; Martin & Rose, 2003). This approach puts the focus on the content, helping to identify how language works to construct disciplinary knowledge in the contexts of school and classroom. SFL discourse analysis provides a useful tool to deconstruct the discipline-specific language of science, identify pertinent language choices, and discuss the particular language choices made by teacher and students in a specific context of science classroom. As seen in Lemke’s (1990) research on secondary school science classroom interactions, using classroom transcripts of oral classroom interactions and descriptions of the contexts in which these interactions occurred, Lemke described the teacher-student interaction patterns, including triadic dialogues (i.e.,
Initiation by teacher-Response by students-Evaluation by teacher/IRE), which are vital for constructing the “Episode Summaries” of the observed science classroom discourse (see Table 2.3 in Section 2.3, Section 3.4.1, and Appendix D for more detail). In addition to the teacher-student interaction patterns, Lemke’s analysis also identified the thematic patterns which comprise science classroom discourse. Thematic patterns, according to Lemke, refer to conceptual relationships, and they are constructed from semantic relations (e.g., antonym, synonym, hyponymy, and so on); for example, one thematic pattern of these scientific concepts Heat, Light, and Energy, commonly found in science textbooks, is that heat and light are two forms of energy, i.e., hyponymy or taxonomic relations. Lemke stated that it is the patterns of these semantic relationships which define science and that frequent difficulties in understanding the science content stem from differences in the semantic relationships held by the various individuals in the observed science class. As Lemke (1990) put it,

> In fact, the same scientific ideas can be expressed in many different ways, because the semantics of a language always allows us to use grammar and vocabulary in different ways to express the same meaning. The wording of a scientific argument may change from one book to the next, one teacher to the next, even one day to the next in the same classroom. But the semantic pattern, the pattern of relationships of meanings, always stays the same. That pattern is the scientific content of what we say or write. (p. x, emphasis in original)

Lemke’s observation and analysis of science classroom discourse highlights that the same scientific ideas can be linguistically expressed in a variety of ways. Science classroom discourse represents a specialized language that rests heavily upon scientific
concepts and their conceptual relationships or so-called thematic patterns that are not immediately apparent to students as novice science learners. The role of science teachers, Lemke argued, is to apprentice students into the use of new thematic patterns, or new ways of meaning patterns in science (i.e., science language). Yet it is often the case that these thematic patterns or the discipline-specific language of science used to express science concepts and their relationships (i.e., thematic patterns) are left implicit and some students fail to understand the scientific content, as noted in Lemke’s research. The discipline-specific language of science used to express science concepts and their relationships (i.e., thematic patterns), “like the language of each specialized field of human activity, had its own unique semantic patterns, its own specific ways of making meaning. For most people, if these ways are learned at all, they are learned in the dialogue of the science classroom” (Lemke, 1990, p. 1). That is, the discipline-specific language of science is generally learned in science classroom discourse and only with proper instructional support (de Oliveira, 2010; Fang, Lamme, & Pringle, 2010; Fradd & Lee, 1999; Schleppegrell, 2004).

Foundational skills in learning science, including the discipline-specific language for communicating in science, must be taught in ways that support students to participate in science classroom discourse. This discourse in talking science requires students to use discipline-specific language to talk about science content that is often found in students’ unfamiliar science texts (e.g., science textbooks). Lemke’s research (1989, 1990) highlighted the supporting role of the teacher in providing students with opportunities for extended talk using the discipline-specific language of science. In his year-long project which examined secondary school science classroom interactions,
Lemke focused on the teacher’s attempts to introduce science concepts, to gradually build up the conceptual relationships of technical terms, and to repeat them during teacher-student interactions. Focusing on the essential meaning introduced in students’ unfamiliar science texts (i.e. the key science terminology and concepts in science texts), the teacher tried to help students make relevant connections; students were observed to coordinate within and across the spoken and written texts in teacher-student interactions, together with the science texts that were read and referred to in the science class. The connections between and among these texts were identified by Lemke (1989, 1990) as intertextuality in science classroom discourse, which is vital for students’ learning to use discipline-specific language of science and to talk science. Studies of intertextuality in science classroom discourse will be further discussed in the next section.

2.2 Intertextuality in Science Classroom Discourse

Recognizing the essential role of intertextuality in teaching and learning science, the identification, classification, and interpretation of intertextuality in science classroom discourse has been an area of research (e.g., Bruna, Vann, & Escudero, 2007; Duff, 2004; Gibbons, 1998; Kumpulainen, Vasama, & Kangassalo, 2003; Lemke, 1990; Varelas & Pappas, 2012; Varelas, Pappas, & Rife, 2005; Wu, 2003). Much of this research has shed light on intertextual connections between science written texts and classroom talk because teaching and learning in science is highly dependent on reading science texts. In fact, the ability to read science texts has been defined by Norris & Phillips (2003) as a fundamental science literacy skill. Science texts (e.g., science textbooks), an essential component of classrooms, do not exist in isolation. Rather, they are surrounded by classroom talk. The construction of intertextual connections between science texts and
classroom talk is the generative context for teaching and learning science. Research topics, including the role of science texts in teaching and learning science, intertextual connections between science texts and classroom talk, and Lemke’s research on intertextuality in science classroom discourse, all speak to the intertwined issues of the importance of intertextuality in science classroom discourse for teaching and learning science. Studies of these research topics will be reviewed in the upcoming sections to establish the importance of intertextuality in science classroom discourse.

2.2.1 Science as Subject Matter: Text Dependence and Language Demands

In K-12 science education curriculum, textbooks have been shown to be dominant instructional devices which organize 75% to 90% of classroom instruction (Tyson & Woodward, 1989; Yore, Craig, & Maguire, 1998). Much of science teaching and learning has been textbook-centered with regard to the essential role played by textbooks in science instruction (Stinner, 1992). According to the results of a survey of 522 K-8 (kindergarten through eighth grade) teachers, the majority regarded science textbooks as effective instructional resources in support of their students’ learning science (Shymansky, Yore, & Good, 1991). Science textbooks were said to serve as a guideline for these surveyed teachers’ instructional choices and for the sequencing of learning activities in their science teaching. Students’ understanding of the subject matter is highly dependent on their ability to read science texts and especially science textbooks (Norris & Phillips, 2003). It is important to recognize that, although textbooks play the essential role in science teaching and learning, most teachers have noticed science textbooks they use are typically difficult for their students to read, understand, and learn from (Barton, Heidema, & Jordan, 2002; Vacca & Vacca, 2008).
Recognizing the need to understand the challenges students experience in learning from reading science textbooks, researchers have paid increasing attention to the reasons why students who have mastered basic reading skills still find reading science textbooks extremely difficult (Tyson & Woodward, 1989; Yager, 1983). Some students have trouble reading science textbooks because of a lack of background knowledge about the topics. In addition, it is now well recognized that a major challenge to students learning from reading science textbooks is the discipline-specific language through which science textbooks are written (Bryce, 2011; Ciechanowski, 2009), a language different from the language students use in their daily life. Significantly, accessing science textbook language is highly linked to the construction of science content knowledge. Thus, recent work has called for more specification on the discipline-specific language of science textbooks to better understand students’ literacy needs in comprehending school science textbooks (Kelly, 2007; Saul, 2004; Wellington & Osborne, 2001).

With regard to the delicate relationship between language and learning in science, more researchers have analyzed science textbooks to identify the distinctive language patterns characteristic of these textbooks. One overarching approach to the analysis of science textbooks is Systemic Functional Linguistics (SFL). SFL is a theory of language which highlights the relationship between language and context (Halliday & Matthiessen, 2004). The language choices and context features offer researchers a set of functional linguistic tools to address the differences between everyday language and academic language or “registers” (Fang, Schleppegrell, & Cox, 2006; Gebhard, Harman, & Seger, 2007; Schleppegrell, 2004). “A register is the constellation of lexical and grammatical features that characterizes particular uses of language” as defined by
Schleppegrell (2001, p. 431). Registers vary because what we do through language varies from context to context. The notion of registers (or linguistic variations), therefore, is used to map the relationship between the language choices and context features (Coffin & Donohue, 2012).

Using the constructs of register, much of SFL research has focused on describing and accounting for how language works in academic contexts. In the contexts of school and classroom, for example, academic registers represent those varieties of language characteristic of different disciplinary languages. Of all the context-area texts that students are likely to encounter at elementary and secondary school level, science is arguably the most challenging (Barton, Heidema, & Jordan, 2002; Carnine & Carnine, 2004). Extensive SFL research conducted in elementary and secondary school classrooms describes the unique language features used in science textbooks (e.g., de Oliveira, 2010; Fang & Schleppegrell, 2008; Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2001). Their analyses of school science textbooks of elementary and secondary level have identified and described the similar science textbook language features and the key language demands on elementary and secondary school students. Furthermore, their analyses have contributed to a greater emphasis on how the specific language features in school science textbooks (i.e., academic register of content area in science) is sharply different from the language students use in their daily life (i.e., everyday register). Table 2.1 outlines some register features that distinguish academic register of content area in science and everyday register on the basis of their SFL analyses of science textbooks of elementary and secondary school level (e.g., de Oliveira, 2010; Fang, 2008; Fang & Schleppegrell, 2008; Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2001, 2004).
With reference to their identified register differences, in this dissertation what I am calling *science language* refers to “the academic register of content area in science” and what I am calling *everyday language* refers to “the register of everyday knowledge and everyday life” (see Chapters 4, 5, and 6).

Table 2.1 *Some Register Differences between Science Language and Everyday Language*

<table>
<thead>
<tr>
<th>Academic register of content area in science (Science Language)</th>
<th>Everyday register (Everyday Language)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Field-specific vocabulary or technical terms and their definitions</td>
<td>• Everyday vocabulary</td>
</tr>
<tr>
<td>• Technical, long and complex nouns</td>
<td>• Generic and simple nouns</td>
</tr>
<tr>
<td>• Nominalizations</td>
<td>• Verbs, adjectives, or conjunctions</td>
</tr>
<tr>
<td>• Lexical and nonhuman Subjects</td>
<td>• Pronouns and human Subjects</td>
</tr>
</tbody>
</table>

The left-hand column of Table 2.1 summarizes the key language features found in science textbooks of elementary school and secondary levels from the SFL analyses of school science textbooks. The right-hand column of Table 2.1 contains the corresponding everyday language features. Comparing the features of language used in these two registers helps us see some register differences between science language and everyday language and the key language demands posed by science textbook passages on elementary and secondary school students. As indicated by the left-hand column of Table 2.1, science textbook authors typically organize and condense information through technical vocabulary words and their definitions, technical, long and complex nouns with pre- and post-modifiers, nominalizations, and lexical and nonhuman Subjects. For example, in the sentence extracted from a fourth grade science textbook “An air mass is a huge body of air that has nearly the same temperature and humidity” (Scott Foresman, 2006, p. 190), a technical, long and complex noun is given as the definition for the technical term “an air mass”: “*a huge body of air that has nearly the same temperature***
and humidity” (Lan & de Oliveira, in press). This technical, long and complex noun has as its head the noun body, a huge are pre-modifiers and of air that has nearly the same temperature and humidity are post-modifiers. Unlike students’ familiar everyday language (e.g., everyday vocabulary, generic and simple nouns), the packaged language through these nouns (i.e., the technical term, its definition, and the technical, long, and complex noun) is complex. Attempting to make sense of the technical term an air mass along with the wordy definition through the technical, long and complex noun a huge body of air that has nearly the same temperature and humidity, the demands of processing the packaged information within nouns significantly increased for students.

Another pervasive language feature of science textbooks is nominalization, a grammatical resource for the construction of nouns (Fang, Schleppegrell, & Cox, 2006). Nominalization refers to the expression as a noun of what would in everyday language be presented as a verb, an adjective, or a conjunction (de Oliveira, 2010). Science textbook writers commonly use nominalization, which involves turning verbs like weather, erode, and deposit, into nouns (e.g., weathering, erosion, and deposition) to pack more meaning into the sentences of science textbook passages. In the textbook passages extracted from Earth’s Changing Surface unit (see Figure 2.1), for example, the nouns weathering, erosion, and deposition are nominalizations used to refer to the three natural processes being described and explained in the earth science unit (nominalizations are boldfaced in Figure 2.1).
Weathering

“…Rocks in Earth’s crust are slowly broken down into smaller pieces in a process called weathering. Many factors can cause weathering. There are two types of weathering, chemical weathering and physical weathering.”

Erosion

“Gravity, wind, water, and ice can all move pieces of weathered rock. The process of carrying away weathered bits of rock is called erosion…”

Deposition

“…The forces that carry away bits of weathered rock during erosion must drop them somewhere else. This laying down of pieces of rock is called deposition. Sometimes deposition happens slowly, and other times it (deposition) happens very fast.”

Figure 2.1 Text excerpt from Earth’s Changing Surface unit (Buckley, Miller, Padilla, Thornton, Wiggins, & Wysession, 2012, pp. 168-171)

In Figure 2.1, these nominalizations, including weathering, erosion, and deposition, are used to construct dense explanations of the three natural processes which cause change to the earth’s surface. By turning verbs into nouns, the science textbook writers can place the nouns in the position of Subject, allowing writers to package information into a noun (through nominalization) used in succeeding sentences for further explanation. In Deposition, for example, the verb “must drop them somewhere else” is introduced in the textbook passage. Then, the nominalization “This laying down pieces of rock” is used as the noun in the Subject position for the definition of the (technical) nominalization “deposition.” In the next sentence, “deposition” is used as a nominalization to refer to the natural process being described and defined in the previous
two sentences. Also as a noun in the Subject position, “deposition” now readily lends itself to further explanation (i.e., deposition can sometimes happen slowly or very fast). Nominalization is a powerful linguistic resource commonly used by science textbook writers to densely package information into science texts (de Oliveira, 2010; Unsworth, 1999). Understanding nominalizations in science textbook passages is challenging for students as novice readers of this kind of discipline-specific language.

Also noteworthy of the text examples in Figure 2.1 is that the sentence Subjects in these passages tend to be not only nominalized but also lexical and lengthy (e.g., *The forces that carry away bits of weathered rock during erosion, This laying down of pieces of rock, deposition*). These sentence Subjects illuminate that school science textbooks commonly have subject-position nouns characterized by technical terms, technical, long, and complex nouns with pre- and post-modifiers, and nominalizations. This is sharply different from everyday language where Subjects are typically pronouns and human Subjects (e.g., *I, you, he, she, it*). Unlike everyday language which sounds interactive and involving (e.g., daily conversations with friends), in part because of its use of pronouns and human Subjects, school science textbook passages sound much more formal, objective, and impersonal. The use of lexical and nonhuman Subjects enables science textbook writers to put specific focus on the “things” or natural phenomena to enhance objectivity and thereby to present and organize science information formally, objectively, and impersonally.

Regarding these unique language features of elementary and secondary school science textbooks (see Table 2.1 and the above paragraphs), the SFL literacy researchers identified how science textbooks use language in specialized ways, sharply different from
the everyday language of many students. Such differences between a science register and an everyday register may present obstacles to students’ full comprehension of science textbooks. One of the goals of these SFL literacy researchers is to make visible the working of school science textbook language in support of teachers and students’ becoming critically aware of the differences between everyday language and science language (de Oliveira, 2010; Fang & Schleppegrell, 2008; Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2004). Their work suggests it would be useful for teachers to engage students in carefully crafted activities about how certain language features like nouns, for example, are used in science textbook passages. Students could identify the nouns and analyze how the science textbook author uses nouns to present and organize information. The increasing linguistic awareness and better understanding of how information is presented and organized in science textbooks can empower teachers and students to deal with the reading challenges and to engage more effectively in the advanced science literacy tasks of making sense of school science textbook passages.

In addition to the recognized need to increase awareness of the differences between everyday language and science language used in science textbooks, some SFL literacy researchers further identified the need to promote classroom talk that takes around science texts (e.g., Gibbons, 1998, 1999; Lemke, 1989, 1990). Science texts such as science textbooks do not exist in isolation; rather, they are surrounded by classroom talk, including teachers’ textbook instruction, teacher-led discussions, and dialogues between teacher and students and among peers. With the significant role of science textbooks in teaching and learning science, students’ ability to negotiate meaning through classroom talk such as textbook instruction (i.e., teachers’ explanation, presentation, and
review and reinforcement of textbook content) becomes a crucial skill in students learning science from classroom discourse (Lemke, 1989, 1990). Classroom talk that takes place around science texts is essential for students as a bridge between their everyday language and their learning of science language (Gibbons, 2009; Wells, 1994). Furthermore, science texts and classroom talk, as illustrated by Wells (1994), “can complement and enrich each other through an exploitation of the intertextual relationships between them” (p. 10). Wells explains that teachers and students build intertextual connections between the words of science texts and students’ other already familiar ways of speaking to support students to better comprehend science texts. Studies of intertextual connections between science texts and classroom talk will be reviewed in the next section.

2.2.2 Intertextual Connections between Science Texts and Classroom Talk

The construction of intertextuality between text and talk is characterized as potential sites for students’ learning of their unfamiliar ways of meaning, constructing meaning from the written language of school content-area texts. As Wells (1994) puts it:

For it is when participants (students) move back and forth between text and talk, using each mode to contextualize the other, and both modes as tools to make sense of the activity in which they are engaged…it is here, in this interpretation of talk, text, and action in relation to particular activities, that, I want to suggest, students are best able to undertake what I have called the semantic apprenticeship into the various ways of knowing. (p. 10)

Wells presents a view of students’ learning of their unfamiliar ways of meaning (e.g., the written language of content-area texts) as a process of apprenticeship, where students
(apprentices) collaborate in the construction of the intertextual connections between text and talk with teachers (experts). Wells then provides an example from the classroom interactions between the teacher and the nine-year-old students to illustrate their construction of intertextual connections between text and talk. In his presented example, the teacher offered the paraphrases, explanations, and concrete examples in teacher talk which provided bridges to the abstract language and concepts of written texts for the students. The teacher, as described by Wells (1994), “has enabled the students to bring their own experience, whether first-hand or tv-mediated, to contextualize the less familiar language of the written texts” (p. 11). It is the teacher in the role of expert to support the students’ construction of intertextual connections between text and talk, thereby recontextualizing the abstract language and meaning of written texts in the students’ more familiar everyday language.

The role of teachers in the construction of intertextual connections between text and talk is also highlighted in a study by Gaskins, Satlow, Hyson, Ostertag, & Six (1994). In drawing on the middle school science classroom interactions, they provided evidence with which to identify the supporting role of teachers in the joint construction of intertextual connections between science texts and classroom talk. These middle school teachers (grades 6-8) drew on some strategies, including employing every-pupil-responses activities, encouraging collaboration, and teaching students how to search science texts and how to organize information explicitly. Along with these strategies which promoted the classroom talk about science texts, the teachers encouraged their students to bring their own background knowledge, directed them to search the science
texts such as science textbooks, and then engaged them in classroom talk about science
texts during the science unit of the human body and solving real health problems.

As with the emphasis on the construction of intertextual connections between
text and talk in science classroom discourse, more educators recognize the importance of
intertextual connections between science texts and classroom talk in teaching and
learning science. As Lemke (1989) asserts, “the principle of intertextuality tells us that
what any written or spoken words say to us depend on what we bring to reading or
hearing them” (p. 138). Following the principle of intertextuality, teachers are
encouraged to plan classroom talk which enables students to bring their own experiences
and interpretation to science texts (e.g., Gaskins et al, 1994) and to “talk their way to
comprehension” (Lemke, 1989, p. 140). Namely, when students move back and forth
between science texts and classroom talk, they construct intertextual connections to
unfamiliar science terminology and concepts highlighted in science texts and thereby
they gradually develop their disciplinary knowledge and discipline-specific language.

There are now an increasing number of researchers studying the intertextual
connections between text and talk in different content-area classroom contexts (e.g.,
Bloom & Egan-Robertson (1993) on reading; Oyler & Barry (1996) on language arts;
chemistry). Lemke’s work has been seminal in drawing on SFL to explore how teacher
and students linguistically develop intertextual connections in science classroom
discourse. Lemke suggested teachers promote intertextual connections between science
texts and classroom talk by showing students how to translate between their familiar way
(everyday language located in their everyday life) and a less familiar way (science
language used in science textbooks). The next section will detail Lemke’s research on intertextuality in science classroom discourse, identifying the importance of translating back and forth between everyday language and science language in the construction of intertextuality in science classroom discourse.

2.2.3 Lemke’s Research on Intertextuality in Science Classroom Discourse

A landmark for discourse studies in science education is Lemke’s research (1990, 1992) on intertextuality in science classroom discourse. In his year-long project which examined secondary school science classroom interactions, Lemke drew on Systemic Functional Linguistics (SFL) to explore how teachers and students linguistically developed intertextual connections in science classroom discourse, thereby highlighting how the teachers and students translated between everyday language and science language in their intertextuality between science texts and classroom talk. Rather than focusing on which spoken and written texts were linked intertextually, Lemke (1992) shed more light on the fundamental question: “how linguistically do we establish that topics are the same, even when wordings may be different, and in what ways “the same”? (p. 258). Lemke’s observation of the secondary science classrooms showed that the same scientific ideas were expressed by the teachers and by the students in a variety of ways or in different registers. By means of SFL analysis of the spoken and written texts encountered and produced by the teacher and students, Lemke (1990, 1992) looked specifically at how the teachers and students used the different words, phrases, and language to talk about the same “thing” (i.e., scientific ideas) or build up the same thematic pattern. Table 2.2 presents examples from Lemke’s research (1990, 1992) illustrating how the teachers and students linguistically developed intertextual
connections in science classroom discourse. The four texts excerpted from teacher-student interactions in the secondary science classroom were analyzed to have the same thematic pattern.

Table 2.2 *Instances of Intertextuality in Science Classroom Discourse*

<table>
<thead>
<tr>
<th>Context</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spoken by Teacher (March 19)</td>
<td>(1) What happened was, more than likely, <em>the crust was pushed up</em>, we say that it’s <em>uplifted</em>. And that’s why we find these <em>marine fossils</em> up on high mountains.</td>
</tr>
<tr>
<td>Spoken by Teacher (March 20)</td>
<td>(2) And we were talking about <em>fossils</em>, that are used as evidence, that <em>the earth’s crust has been moved</em>. Now what did we say about these <em>fossils</em>, how do they help us…know that, uh, <em>the earth’s crust has been moved</em>?</td>
</tr>
<tr>
<td>Spoken by Student</td>
<td>(3) Like, if y’find <em>fish fossils</em> on top of a mountain, you know that once there was water…up there, ‘n the <em>land moved</em> or somethin’.</td>
</tr>
<tr>
<td>Written on Board by Teacher</td>
<td>(4) <em>Marine fossils</em> are found in mountains of high elevation. This suggests that <em>the crust</em> has been <em>uplifted</em>.</td>
</tr>
</tbody>
</table>

(Adapted from Lemke, 1990, p. 87-88; Lemke, 1992, p. 261)

These four texts in Table 2.2 share the same scientific idea or thematic pattern (i.e., marine fossils found in mountains indicate the uplifting of earth’s crust) though they occurred during various parts of lessons in the same class on two consecutive days: on March 19th, the teacher introduced the thematic pattern--finding marine fossils on high mountains leads to the conclusion that the crust has been uplifted--in Text (1); on the next day, the teacher focused on the same thematic pattern by reviewing the previous lesson and asking the question in Text (2), the student’s answer in Text (3) repeated the same thematic pattern, and the teacher wrote down Text (4), read it aloud, and suggested students copy it into their science notebooks. The teacher and students repeated the same thematic pattern (or the same scientific content) from text to text by using some thematic development strategies such as thematically related Teacher Question--Text (2), marking
old information through a written text--Text (4), and repetition with variation. Thematic development strategies, according to Lemke (1990), are the specific techniques used by teachers and students to build up intertextual connections to scientific terminology and concepts.

In addition to the thematic development strategies noted above, Lemke’s observation and analysis highlights that the same scientific ideas can be expressed in a variety of ways or different registers. A close look at the four texts in Table 2.2 reveals that different words were used by the teacher and students to represent the same scientific content: marine fossils/fish fossils; the earth’s crust/crust/land; uplifted/pushed up/moved. The teacher and students continually moved back and forth between everyday language and science language while talking about the same scientific content or building up the intertextuality from text to text. Drawing on SFL to closely look at the different language choices, Lemke highlighted that everyday language and science language were used together by the teacher and students in complementary ways to make sense of the scientific content. These two registers (science language and everyday language) do not need to be in opposition but can in fact enhance each other in building up intertextuality in science classroom discourse.

A critical element in the construction of such interaction of the two registers is the supporting role of teachers in bridging between everyday and science language. Without teacher support, students might only rely on their commonsense reasoning from daily life experience and past learning to build a narrow range of intertextual connections, which might pose barriers to students’ full understanding of the lesson content (Oyler & Barry, 1996), not to mention students’ being able to negotiate meaning through textbook
instruction and discussion. Students are most comfortable understanding what is explained to them in their familiar language and discussing ideas with everyday language, not with science language (Ciechanowski, 2009); therefore, most students at first will not readily take up science language in the same way that teachers or science written texts use it. Lemke suggested that teachers who belong to a community of people who already speak the language of science have the better position from which to model how to translate back and forth between everyday and science language. Lemke’s (1990) work suggests that it would be useful for teachers to engage students in such “translation practice” and he suggested “Teachers should express all semantic relations among terms, and all conceptual relationships for each topic, in ordinary colloquial language as well as in scientific language, insofar as possible, and clearly signal when they are using each” (Lemke, 1990, p. 172-173). As we can see in Text 1, Text 2, and Text 4 of Table 2.2, the teacher continued consciously to model everyday and science language while talking about the same scientific content and therefore provided the students with multiple avenues to access the scientific content and to learn that the same scientific content can be expressed in a variety of ways (i.e., in both everyday and science language).

The brief review in Section 2.2 has revealed three main points which impact on the present study. The first is that with science texts (e.g., science textbooks) having such a significant role in teaching and learning science, there has been more SFL analysis of science textbooks for supporting teachers and students to develop a certain linguistic awareness of the differences between everyday language and the science language of science textbooks. In addition to the recognized need to increase awareness of the differences between everyday and science language, the second point is that some SFL
literacy researchers have further suggested the need to promote classroom talk that takes around science texts and therefore can build intertextual connections between science texts and classroom talk. These intertextual connections are the generative context for students’ learning unfamiliar ways of meaning, constructing meaning from school science textbooks. The third point concerns Lemke’s research on intertextuality in science classroom discourse in which Lemke drew on SFL to explore how teachers and students linguistically developed intertextual connections between talk and text. His observations and analysis identified how the teacher and students continually translated back and forth between everyday language and science language in their construction of intertextuality in science classroom discourse (see Table 2.2). Such “translation practice” or register shifts between everyday and science language during the construction of intertextuality in science classroom discourse are vital for students learning science from classroom discourse. This will be discussed as a resource for students’ and ELLs’ learning science in the upcoming sections.

2.3 Bridging between Everyday and Science Language: Intertextuality as a Resource for Students’ and Especially ELLs’ Learning Science

Bridging between everyday and science language is advocated as a way for teachers to support their students’ establishing intertextual connections to scientific concepts and the conceptual relationships highlighted in science texts (Lemke, 1989, 1990). Gibbons (1998, 1999, 2003, 2006) applied these insights into her research, focusing on how science classroom discourse supports upper elementary students from diverse linguistic and cultural backgrounds to move from their personal ways of making meanings toward more technical, subject-specific ways of talking science. Ninety-two
percent of the students in Gibbons’s researched two fifth-grade science classrooms in Australia were ELLs; these focal ELLs appeared fluent in conversational English but were less familiar with the discipline-specific language of school science. Drawing on Lemke’s ideas on intertextuality, Gibbons analyzed the spoken interactions and students’ written texts to illustrate how the observed teachers provided linguistic support for students, particularly ELLs, in talking about what was being learned in both colloquial and scientific English; the students could thus use intertextuality as a resource for their development of disciplinary knowledge and discipline-specific language of science.

Gibbons (2006), using classroom transcripts of spoken classroom interactions and descriptions of the contexts in which these interactions occurred, built “Episode Summaries.” Table 2.3 provides an example of the Episode Summaries which were used by Gibbons to document the teaching and learning activities in the observed science classrooms and provided a holistic perspective on her collected classroom observation data. In addition to the overall description of the observed science classrooms, this broad analysis through Episode Summaries was used to illustrate how particular patterns of classroom interactions related to students’ learning science and to provide a contextual frame for examining and interpreting the excerpts of the classroom discourse for in-depth analysis (i.e., SFL discourse analysis or SFL discourse analysis with Episode Summaries).
Table 2.3 *Instances of Episode Summaries*

<table>
<thead>
<tr>
<th>Classroom 1</th>
<th>HOW</th>
<th>WHAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. Teaching/learning processes</strong></td>
<td><strong>Dominant participant and interaction structures</strong></td>
<td><strong>Mode/degree of context-embeddedness</strong></td>
</tr>
<tr>
<td>LESSON 1</td>
<td>T/Class: IRF</td>
<td>Spoken</td>
</tr>
<tr>
<td>1 Introduction to Unit</td>
<td>T sets problem (how to get a pin out of a glass of water)</td>
<td>T/Class: Dialogic</td>
</tr>
<tr>
<td>2 Discussion of problem</td>
<td>Pairs: Participatory</td>
<td>Spoken</td>
</tr>
<tr>
<td>3 Sharing of solutions</td>
<td>Ss suggest solutions to class</td>
<td>T/Class: Dialogic</td>
</tr>
<tr>
<td>4 Sharing of prior knowledge of magnets</td>
<td>T/Class: Dialogic</td>
<td>Spoken: Construction based on previous experience. T writes up suggestions as concept map.</td>
</tr>
</tbody>
</table>

(Excerpted from Gibbons 2006, p. 277)

On the basis of the broad analysis of her collected classroom discourse data through Episode Summaries (see Table 2.3), Gibbons described that the teachers in the observed science classrooms planned the classroom talk through three-stage classroom activities: (a) group-talking--doing a hands-on experiment in small groups; (b) teacher-guided reporting--recounting the actions and outcomes of the hands-on experiment to the whole class; (c) written reports--completing writing tasks in science journals. Using ideas from Lemke (1983, 1990, 1992), Gibbons (1999) provided a detailed account of the intertextual connections constructed by teachers and students during the second stage (i.e., teacher-guided reporting), showing their register shifts between everyday language and science language. Table 2.4 presents instances in which the students and teacher moved back and forth between everyday language and science language in communicating the scientific ideas--magnetic attraction and repulsion. During the teacher-guided reporting and recounting of the experiments on magnetic attraction and repulsion, the students first
drew on their familiar everyday language to express their firsthand experience of hands-on experiments; then the teacher recast and extended these students’ wordings into science language and everyday language.

Table 2.4 *Instances of Intertextuality and Register Shift*

<table>
<thead>
<tr>
<th>Students</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>it <em>sticks</em> together</td>
<td>like that (demonstrating)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>they <em>attracted</em> to each other</td>
</tr>
<tr>
<td>you can feel…that they’re not pushing…if we use the other side we can’t feel pushing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>when they were facing one way you felt the magnets <em>attract</em></td>
</tr>
<tr>
<td></td>
<td>and <em>stick</em> together</td>
</tr>
<tr>
<td></td>
<td>when you turn one of the magnets around you felt it <em>repelling</em></td>
</tr>
<tr>
<td>or <em>pushing</em> away</td>
<td></td>
</tr>
</tbody>
</table>

(Adapted from Gibbons, 2006, p. 130)

In Table 2.4, the teacher recast her students’ statements that *magnets stick, not pushing* into statements that *magnets attract, repelling*. Drawing on Lemke’s intertextual analysis, Gibbons pointed out that the teacher’s recast version (the right two columns of Table 2.4) is “thematically related” to the student version (the left column of Table 2.4), along with the different words used to represent the same scientific content: *stick/attract; not pushing/repelling*. As the teacher developed and repeated the same thematic pattern or scientific content (i.e., magnetic attraction and repulsion), the teacher continually shifted back and forth between everyday and science language: *they stick together/they attracted each other; you can feel they’re not pushing/you felt it repelling*. Such
intertextual connections and register shifts construct what Gibbons called “bridging discourse,” which “meshes everyday and subject-specific ways of meaning, thus building on students’ prior knowledge and current language as a way of introducing them to new language” (Gibbons, 2009, p. 62). Bridging discourse allowed the teacher to use these students’ familiar everyday language as a way to bridge to and to enhance the intertextual connections to the students’ unfamiliar science knowledge and language. Continually shifting back and forth between everyday and science language, the teacher built up the intertextual connections and bridging discourse to ease the difficulties the students, including ELLs, encountered for their learning of disciplinary knowledge and science language. Bridging discourse, as Gibbons emphasized, is particularly relevant to ELLs’ successful learning of science language because learning can occur first in these students’ familiar everyday language as a basis for transition to less familiar science language.

The brief review of both Gibbons’s research and Lemke’s research has made a strong case that intertextuality in science classroom discourse is a central process for students’ and ELLs’ learning science from classroom discourse. During the process of constructing intertextuality, teachers and students continually move back and forth between everyday and science language. Thus, for Lemke and Gibbons as SFL educational linguists, an important issue linked to language and context is the register shifts between everyday and science language made by teachers and students to construct bridging discourse. This emerging issue resonates with some U.S. science education studies (e.g., Brown & Spang, 2007; Ciechanowski, 2006, 2009; Varelas, Pappas, & Rife, 2005; Varelas & Pappas, 2006). The series of studies examined the uses of bridging discourse for students, including ELLs, placed in U.S. elementary science classrooms.
Bridging discourse is labeled differently by different researchers. Brown and Spang (2007), for example, called it “double talk” and Varelas and Pappas (2006) called it “hybrid discourse.” The important point here is that these researchers all highlighted that the science teachers’ continued conscious attempts to model everyday and science language provided students, including ELLs, with multiple avenues to access scientific understanding. Simultaneously, the register shifts students made while talking science in both everyday and science language were also seen as a stretch for students’ particularly ELLs’, development of disciplinary knowledge and discipline-specific language of science. These relevant studies with emphasis on register shifts between everyday and science language in the construction of intertextuality in science classroom discourse will be further discussed in Section 2.4.

Also noteworthy of both Gibbons’s and Lemke’s research is their applications of SFL to analyze the spoken and written texts encountered and produced by teachers and students in classroom interactions and the extracts of science classroom discourse containing instances of intertextuality (i.e., micro-level intertextual analysis). This theoretical framework, which has already made some contributions to our understanding of science discourses (Martin, 1989; Halliday & Martin, 1993), links language choices with context features, enabling us to analyze science classroom discourse in terms of the language choices that construct meanings in particular contexts of teaching and learning (Halliday & Matthiessen, 2004). Both Lemke and Gibbons, using the classroom transcripts of spoken classroom interactions and descriptions of the contexts in which these interactions occurred, built Episode Summaries. This broad analysis of their observed science classroom discourse data through Episode Summaries documented the
teaching and learning activities and provided an overall description of the observed science classrooms. In addition, the Episode Summaries detailed the contextual information of teacher-student interactions related to student learning science and provided a context for later more detailed linguistic analysis, including their intertextual investigation (i.e., micro-level intertextual analysis). Drawing on the idea of Episode Summaries, grounded upon SFL discourse of science classrooms, the present study can thus document the teaching and learning activities of the observed science classroom, which will also help outline the major teaching and learning activities in the observed science unit (see Section 3.4.1, Table 4.1 and Appendix D for more detail). It is also important to note that Lemke’s and Gibbons’s research designs specified how to conduct SFL discourse analysis, although they did not specifically label their discourse analysis in term of “SFL discourse analysis.” Following their research designs, this present study draws on the broad analysis through Episode Summaries, which can provide a context for later more detailed linguistic analysis (e.g., micro-level intertextual analysis). Namely, my micro-level intertextual analysis is promoted by Lemke’s and Gibbons’s research designs and their intertextual investigation as shown in Table 2.2 and Table 2.4 (see Section 3.4.3 for more detail). The term--SFL discourse analysis--is used in this present study (as we can see in Chapters 2 and 3).

2.4 Register Shifts in the Reading and Discussions of Science Texts: Intertextuality in Read-Alouds of Science Information Books

While most research reviewed above has focused on register shifts occurring in spoken discourse, Varelas, Pappas, and their colleagues’ research has centered on register shifts teacher and students make in their reading and discussions of science information
books in elementary science classrooms (Pappas, Varelas, Barry, & Rife, 2003; Varelas & Pappas, 2006; Varelas, Pappas, & Rife, 2005). Gibbons (1999) suggested the need for research on intertextuality in science classroom discourse to include the register shifts that take place around the reading and discussions of written texts: “A study of mode shifting in such contexts would offer valuable insights into its role in mediating the use of literacy tools” (p. 202). Mode shifting in Gibbons’s (1999) research is equivalent to register shifting between science and everyday language in this study. Recognizing the importance of literacy tools such as textbooks or any science text in teaching and learning science, Wells (1994) has emphasized that “talk and text can complement and enrich each other through an exploitation of the intertextual relationships between them” (p. 10). As Wells found in his research, teachers and students build intertextual connections between the words of written texts and students’ other already familiar ways of speaking, which supports students to better understand their unfamiliar written texts.

Varelas, Pappas, and their colleagues observed that during the interactive read-alouds of science information books for the States of Matter and the Water Cycle, teachers encouraged the 1st- and 2nd-grade students from diverse linguistic and cultural backgrounds to make connections to these science information books (Pappas, Varelas, Barry, & Rife, 2003; Varelas & Pappas, 2006; Varelas, Pappas, & Rife, 2005). Unlike the traditional “read-aloud,” which views students’ initiation as digressions from the teacher’s agenda or from the written texts, the teachers encouraged their students to talk about the science information books. These findings highlight that classroom talk constructed around science texts provided these first and second graders opportunities of not only “reading aloud” but also “talking out” the written science texts with their
teachers and peers. During the interactive read-alouds of science information books, the teachers acknowledged their students’ initiation and then extended their initiation to make intertextual connection to other texts such as the books. In the elaboration on the students’ initiations, the teachers began the process of bridging what their first and second graders brought (i.e., their own personal experience, their familiar everyday language) to what they were given to read (i.e., information books, their less familiar science language). The teachers enabled these first and second grade diverse students to bring their familiar everyday language to contextualize their less familiar science language of science information books. Along with the teachers’ instructional support, these students actively drew on their knowledge of other texts such as poems, songs, or TV programs and their personal experiences to reflect on the abstract meanings they encountered in their unfamiliar science information books, thereby moving back and forth between their familiar everyday language and their unfamiliar science language.

Varelas and her colleagues’ studies brought into consideration that classroom talk constructed around science texts can be an ideal venue for exploring intertextuality that teacher and students make in science classroom discourse. Their studies identified a typology of intertextuality in first- and second-grade science classrooms with a large population of ELLs. Through constant comparative analysis of the intertextual connections jointly made by students and teachers, Varelas and her colleagues developed four major categories of intertextual connections, as Table 2.5 shows:
Table 2.5 *Categories of Intertextuality*

<table>
<thead>
<tr>
<th>Category</th>
<th>Intertextual Connections to</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>written texts (e.g., science information books, science textbooks), other texts that are orally shared (e.g., poems, rhymes, sayings and songs), other media (e.g., video clips), and prior classroom discourse</td>
</tr>
<tr>
<td>II</td>
<td>hands-on explorations (e.g., the recounting of actions, outcomes, and interpretations)</td>
</tr>
<tr>
<td>III</td>
<td>recounting events (e.g., recounting specific events and recounting generalized events)</td>
</tr>
<tr>
<td>IV</td>
<td>“implicit” generalized events</td>
</tr>
</tbody>
</table>

(Adapted from Varelas & Pappas, 2006, p. 216-219; Pappas, Varelas, Barry, & Rife, 2003, p. 443)

Varelas, Pappas, and their colleagues’ four major categories of intertextuality provide us with a glimpse of the ongoing sources of intertextuality used by the teachers and students in their comprehension and discussion of science texts in two urban elementary science classrooms. As seen in Table 2.5, the first major category has to do with connections to written texts, other orally shared texts, other media, and prior classroom discourse. The second major category has to do with connections to hands-on explorations. The third major category includes recounts of events that teachers and/or students have experienced. This category has been differentiated into two sub-categories—recounting specific events and recounting generalized events because the events may be specific ones referring to a particular time that something happened, or generalized ones, referring to a set of habitual experiences and habitual actions. The fourth major category involves connections to events that speakers do not explicitly identify but imply.

Exploring the different kinds of intertextual connections that unfolded in urban elementary science classrooms provides evidence that the young urban students (six and seven years old) could learn to communicate scientific ideas introduced and highlighted in their unfamiliar science texts and to negotiate meaning through their read-alouds of
science information books. Recognizing the value of intertextual analysis, Varelas, Pappas, & Rife (2005) pointed out the essential use of intertextual analysis:

Examining intertextuality allows us to appreciate the funds of knowledge…that young urban children bring to the class along with the teacher’s role in legitimizing and using these funds to facilitate the building of new understandings or elaborate prior understandings…**intertextuality takes place as a negotiated dance among teacher, children, and texts in the construction of knowledge.** (p. 142)

Their categorizations of intertextuality in their studies illuminate the potential of intertextual analysis in the classroom talk about science texts and have influenced other researchers’ classification and categorization of intertextuality in science classrooms. For example, Kumpulainen, Vasama, & Kangassalo’s (2003) consulted these four categories to develop their typology of the intertextuality of children’s science-related explanations in a first-grade science classroom in Finland. Nevertheless, despite the increasing attention to the need to promote intertextuality in elementary science classroom discourse with young students (1st and 2nd graders), including ELLs, little is known about the existing science classroom discourse and intertextuality for students, including ELLs, mainstreamed to upper elementary science classrooms in the U.S., who are faced with dramatically increased scientific literacy demands. The next section will review studies highlighting the need for immediate attention to the science learning of upper elementary students and particularly ELLs.
2.5 Need for Immediate Attention to Learning Science of Upper Elementary Students and Particularly ELLs

In the U.S., state accountability systems have long emphasized performance in upper elementary grades (grades 3-5) as the indicator of elementary school success, and the passage of No Child Left Behind Act (NCLB) of 2001 heightened this emphasis, requiring high-stakes testing and adding sanctions for schools not making adequate yearly progress (Bielenberg & Fillmore, 2005). Once students reach upper elementary grades, the language and literacy challenges of school dramatically increase (Carrasquillo, Kucer, & Abrams, 2004). Upper elementary students (grades 3-5, ages 8-10) face a marked increase in the challenges presented by literacy tasks that are specific to science, such as making sense of science textbooks and science classroom talk that go beyond their familiar everyday language, literacy, and personal narratives (Ciechanowski, 2006; Fang, Lamme, & Pringle, 2010). The language of school science instruction, science classroom talk, and science textbooks evolves to markedly dense, complex, and technical language (Kelly, 2007; Yerrick & Roth, 2005). It is also noted that fourth and fifth graders are expected to encounter a wide range of vocabulary, especially more use of technical terms and concepts, which are often found in science textbooks and not found in students’ daily life (de Oliveira, 2010; Fang, 2008; Fang, Lamme, & Pringle, 2010).

Recent work has called for the preparation of elementary school teachers to effectively support their students to meet the academic language and literacy demands of reading textbooks in science (Bryce, 2011; Ciechanowski, 2009; de Oliveira & Dodds, 2010; Lee, 2002). Effective support is needed because starting from the fourth grade, there is a decline in the literacy achievement of all students in U.S. elementary schools,
known as the “fourth-grade slump” (Chall, Jacobs, & Baldwin, 1990). Much has been done to ameliorate the “fourth-grade slump,” but little is known about what demands and opportunities mainstream science classroom discourse presents to fourth grade students, including ELLs. Fradd & Lee (1999), researching teachers’ tacit assumptions about their diverse students’ prior knowledge and literacy skills, claim that:

By the time students arrive in fourth grade, many skills are assumed and therefore not taught. Foundational skills, including the language and literacy for communicating science, and a recognition of what science is, cannot be assumed, but must be assessed and taught in ways that motivate students to participate. (p. 19)

Teachers’ tacit assumptions add even more pressure to upper elementary students and especially ELLs mainstreamed to science classrooms. In addition, research has shown that, even though ELLs rapidly acquire everyday English and appropriately use it in here-and-now contexts, they still need extended time and more instructional support to develop academic English in school science learning (de Oliveira, 2007; Schleppegrell, 2004). Compared to their English-speaking peers, ELLs are less likely to participate in science classroom talk because they need extended time to catch up on the grade expectations of academic English required for science text comprehension and classroom discussions (Lee & Buxton, 2010). In this context, the instructional support of science language and literacy needed for upper elementary students’ and ELLs’ mainstream science classroom participation is particularly concerning (Ballenger, 2005; de Oliveira & Dodds, 2010; Fillmore & Snow, 2000; Lee & Luykx, 2006).
The particular concern for effective instructional support for upper elementary students’ and ELLs’ participation in science classroom discourse is very much in alignment with recent science reform efforts. Regarding the new K-12 science standards, *Next Generation Science Standards* (NGSS), Lee, Quinn, & Valdes (2013) argued that the acts of learning and doing science and engineering as envisioned in these NGSS standards will promote both science learning and language learning for students and especially ELLs. For this to happen, though, requires shifts for science teaching. In contrast to their current role as good lecturer only, the new role of science teachers, they argued, is to actively encourage and support science language use and participation by students, especially ELLs, in science classroom discourse even when students’ English is flawed. A changing role for science teachers in support of all students, including ELLs, to participate in science classroom discourse is illustrated by Lee, Quinn, & Valdes (2013) as the following:

Teachers implementing these practices need both understanding of the practices and strategies to include all students regardless of English proficiency. The classroom culture of discourse must be developed and supported. Teachers need to ensure that all voices are respected, even as the process reveals limitations of a model or explanation, or “flawed” use of language. For all students, the emphasis should be on making meaning, on hearing and understanding the contributions of others, and on communicating their own ideas in a common effort to build [science] understanding. (p. 225)

In order to provide appropriate instructional support for upper elementary students’ and ELLs’ participation in science classroom discourse and their
communication in science, there is a need for teachers and researchers of ELLs to examine how mainstream science classroom discourse is constructed to offer opportunities and demands for students’ and ELLs’ intertextual connections; for, as noted above, it is when students move back and forth from the different types of spoken and written texts and build up intertextual connections to texts that they can be gradually apprenticed into science language and literacy through teacher-student interactions (Gibbons, 1999; Lemke, 1990; Varelas, Pappas, & Rife, 2005; Wells, 1994).

2.6 Insights from Previous Research Framing the Present Study

This chapter has reviewed several areas of the literature which are relevant to the present study. The ability of students to communicate in science has been recognized as an area of interest and concern (Lemke, 1983, 1990, 2001; Wells, 1999). Much of the research in this area has highlighted the importance of classroom talk in students’ science learning and centered mainly on learning science from classroom discourse, particularly as it relates to intertextual connections teachers and students make in science classroom discourse. Classroom talk is the medium in which teachers and students comprehend, understand, and interpret science texts. With science textbooks having such a significant role in teaching and learning science, some SFL literacy researchers analyzing science textbooks have made visible the working of school science textbook language in support of teachers and students’ becoming critically aware of the register differences between everyday language and science language. In addition, some literacy researchers have suggested the need to promote classroom talk that takes place around science texts and to explore intertextual connections that teachers and students make in their reading and discussions of science texts. Classroom talk constructed around science texts can be an
ideal venue for exploring intertextuality in science classroom discourse. During the process of constructing intertextuality in science classroom discourse, teachers and students continually move back and forth between everyday and science language, as noted in Lemke’s research. Such intertextual connections and register shifts between everyday and science language construct bridging discourse, essential for supporting all students, including ELLs, to develop their science understanding and science language.

Furthermore, this Chapter 2 literature review has suggested the need for immediate attention to the scientific literacy demands on upper elementary students and especially ELLs. Upper elementary students, including ELLs, face a marked increase in the challenges presented by scientific literacy tasks, such as making sense of the increasingly dense and complex science texts and science classroom talk. However, little is known about how upper elementary teachers engage their students, including ELLs, in science classroom discourse. Research is needed to explore the current teaching practices, particularly how science classroom discourse offers opportunities and demands (or support and challenge) for upper elementary students’ and ELLs’ intertextual connections to science terminology and concepts introduced and highlighted in science texts and science classroom discourse. Therefore, to address this need, the present study examines how science classroom discourse supports and challenges upper elementary students’ and ELLs’ development of science understanding and science language, more specifically, their intertextual connections to science terminology and concepts highlighted in science texts and classroom talk.

It is also important to note that the intertextual investigation in this present study is prompted by Lemke’s and Gibbons’s work, grounded upon SFL discourse analysis.
Both Lemke’s (1990) investigation of secondary science classroom discourse in the U.S. and Gibbons’s (1999) investigation of fifth grade science classroom discourse in Australia have demonstrated the value of drawing on SFL to do intertextual investigation of science classroom discourse. I intend to further this work by focusing on the fourth grade science classroom discourse for upper elementary students, including ELLs, in the U.S. Using SFL discourse analysis and register shift between everyday and science language, this present study investigates how teacher and students linguistically build up the same thematic patterns, construct bridging discourse, and use intertextuality as resources to interpret, to discuss science texts, and to familiarize students with their less familiar science language. Simultaneously, with reference to the work of Varelas and her colleagues and their identified four major categories of intertextuality (see Table 2.5), this present study identifies the sources of intertextuality used by teacher and students. Juxtaposing their ideas on intertextuality (i.e., the work of Lemke, Gibbons, and Varelas, et al.), this present study has two levels of intertextual analysis: micro-level analysis to take a close look at the language used to construct intertextuality and macro-level analysis to classify and categorize the sources of intertextuality in the science classroom discourse (see Chapter 3 for more detail).

Through descriptions from my research of science classroom discourse and how science classroom discourse supports and challenges upper elementary students’ learning science from classroom discourse, particularly intertextual connections made by teacher and students, I will suggest some instructional approaches for teachers to better understand how to foster productive disciplinary engagement in science. A detailed account of the fourth grade mainstream classroom discourse can provide a sense of the
complexity of being upper elementary students, ELLs, and a teacher in today’s diverse classrooms. The detailed descriptions can also lead teacher educators and professional development providers to make careful judgments for ensuring teachers’ expertise and knowledge for scaffolding upper elementary students’ learning science from classroom discourse, particularly their participation and engagement. Ultimately, through this present study, I plan to influence future professional development efforts by suggesting some instructional approaches for teachers, teacher educators, and professional development providers to provide instructional support for upper elementary students’, especially ELLs’, learning science from science classroom discourse.
CHAPTER 3. METHOD

This chapter is concerned with the methodology of the study. The first main section presents the research design and discusses qualitative case study method which has informed the study. Section 3.2 provides descriptions of the context, research site, and participants for this qualitative case study. Section 3.3 discusses roles of the researcher. Section 3.4 presents the data collection methods, followed by Section 3.5 which presents discussions of how the data were analyzed. Section 3.6 offers a summary of the chapter.

3.1 Qualitative Case Study

The research design of this study was a qualitative case study of one fourth grade science classroom with mainstreamed English Language Learners (ELLs). Research design is the plan and structure of the investigation used to obtain evidence to answer research questions (McMillan & Schumacher, 1993). The questions which form the investigative purpose of the research (i.e., research questions) help determine the research design or the approach the researcher will take. The present study centers on two research questions: (1) What is the nature of science classroom discourse? (2) What challenges for ELLs can be identified in science classroom discourse? What support does the teacher provide (or not) in response to the identified challenges? Because the research questions guiding this study required data from one fourth-grade science classroom with
mainstreamed ELLs, qualitative data collection procedures, including observations and interviews, needed to be carried out at one research site. Qualitative case study method, as emphasized by Baxter & Jack (2008), provides tools for researchers to study a complex phenomenon within its contexts. A qualitative case study method was selected for this present study because of its focus on investigating one case and gaining in-depth understandings into educational practice and its contextual meanings for one case (Baxter & Jack, 2008; Merriam, 1998).

A case study, as defined by Merriam, is an intensive, holistic description and analysis of a single, bounded unit. Referring back to the research purpose and questions, careful consideration at the point of selecting context, research site, and participants helps build boundaries around a case (Stake, 1995). Thus, along with my research purpose and questions, the present study utilized a qualitative case study method and I purposefully selected the context, research site, and participants to create the boundaries around the case. I will further detail the present study boundaries--the selected context, research site, and participants--in Section 3.2.

3.2 Context, Research Site, Participants

3.2.1 Context

The context for this study is an elementary school in Indiana. Among states with a high ELL enrollment, while the overall enrollment in Indiana schools declined 5 percent between 1994-1995 and 2004-2005, Indiana had the third highest rate of growth (408%) in the number of ELLs in the entire U.S. (NCELA, 2006). The dramatic increase in cultural and linguistic diversity among students in Indiana schools requires urgent attention. In order to better understand this student population, I collected data in a
fourth grade mainstream science classroom in an Indiana elementary school. The fourth grade was chosen because at this grade level, students are faced with the dramatically increased literacy demands that go beyond their familiar language, literacy, and personal narrative (Carraquillo, Kucer, & Abrams, 2004; de Oliveira, 2010). My targeted ELLs were thus the fourth grade ELLs at their varying English proficiency levels placed into the chosen classroom. Along with the criteria of selecting the context, I purposefully selected my research site—Mrs. Dixon’s fourth grade mainstream class at Cornfield Elementary School (all names of the school, the teacher participant, the student participants, and the university are pseudonyms), which will be further described respectively in the next section.

3.2.2 Research Site

Mrs. Dixon’s fourth grade mainstream class was situated in Cornfield Elementary School, an Indiana public elementary school which, according to information available through the web site for the school and the district, had approximately 40% culturally and linguistically diverse students and 60% white students. Many of the ELLs in Cornfield Elementary include children of immigrants and international graduate students. Cornfield Elementary is located near Midwestern University, where the international student population is ranked second largest among U.S. public universities. Midwestern University enrolled 8,562 international students in fall 2012, and 39 percent of these students were pursuing graduate degrees (these statistics were obtained from the Fall 2012 International Student and Scholar Enrollment & Statistical Report.) A great number of these international graduates bring their children with them to the U.S., and their children enroll in the elementary and secondary schools near their university. Thus,
many of the ELLs at Cornfield Elementary School come from families whose parents are associated with Midwestern University. The population of culturally and linguistically diverse students at Cornfield Elementary, especially those from Asia, keeps growing. As shown in the Cornfield Elementary student ethnicity statistics (see Table 3.1), 23 percent of the culturally and linguistically diverse students are from Asia (statistics were obtained from Indiana Department of Education, 2010-2011).

Table 3.1 *Cornfield Elementary Students by Ethnicity*

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>This school</th>
<th>State average</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>64%</td>
<td>73%</td>
</tr>
<tr>
<td>Asian</td>
<td>23%</td>
<td>2%</td>
</tr>
<tr>
<td>Multiracial</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Black</td>
<td>4%</td>
<td>12%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Parents of immigrant Asian students and Asian Americans tend to give extra academic training to their children outside of school (Carraquillo & Rodriguez, 1995). Despite the extra academic support, immigrant Asian students often appear to be less verbal and expressive at social occasions, including teacher-student interactions, and they are often left out of the mainstream classroom talk (Duff, 2001). The immigrant Asian students are said to be more accustomed to structured and passive learning conditions (e.g., teacher-lecture classrooms) than to active classroom participation and discussion characteristic of U.S. classrooms (Yao, 1985). Being concerned about “silently struggling” immigrant Asian students mainstreamed to the U.S. schools and ELLs from different ethnic backgrounds, as my research site, I selected Cornfield Elementary School, where ELLs, primarily Asian immigrant students, comprise over one fourth of the student population. At the recommendation and with assistance of Dr. de Oliveira, I chose to observe Mrs. Dixon’s fourth grade science class with mainstreamed ELLs. The
participants of this observed science classroom, including the teacher and students will be further described in Section 3.2.3.

3.2.3 Participants

Teacher. I chose to observe the fourth grade teacher at Cornfield Elementary School because Mrs. Dixon was recommended to me by Dr. de Oliveira as a good teacher in the upper elementary grades who utilized a rich array of literacy strategies to make learning exciting for children and keep children involved in her classroom. Mrs. Dixon consistently had ELLs in her classroom and was always seeking more opportunities to learn more about strategies for improving her instruction of these students. Furthermore, Dr. de Oliveira had worked with Mrs. Dixon on other occasions and found her to be open to research opportunities. In my initial conversations with the teacher, Mrs. Dixon appeared open to my study and welcomed me into her classroom. Furthermore, my early visits demonstrated Mrs. Dixon’s literacy strategies in engaging her students in challenging literacy tasks, such as reading the science textbook and writing answers to science textbook questions. Mrs. Dixon has been teaching fourth grade at Cornfield Elementary since 2002. She holds a bachelor’s degree and the teaching license in elementary education and a master’s degree with a focus on Literacy & Language Education.

Students. At the beginning of the study, I targeted the Asian-origin ELLs at their varying English proficiency levels. Out of a total of twenty-five students in Mrs. Dixon’s classroom, with Mrs. Dixon’s help, I originally selected focal ELLs (n=5) for more focused observation and artifact collection (e.g., their written responses on the science textbooks and their science lesson worksheets). Information on these five focal ELLs’
pseudonyms, home language spoken with their family, English language proficiency is presented in Table 3.2:

Table 3.2  Information on the Focal ELLs

<table>
<thead>
<tr>
<th>Focal ELLs</th>
<th>Home language spoken</th>
<th>English language proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ying</td>
<td>Mandarin Chinese</td>
<td>Level 4</td>
</tr>
<tr>
<td>Enlai</td>
<td>Mandarin Chinese &amp; English</td>
<td>Level 5</td>
</tr>
<tr>
<td>Hyun</td>
<td>Korean &amp; English</td>
<td>Level 5</td>
</tr>
<tr>
<td>Ankor</td>
<td>Korean &amp; English</td>
<td>Level 5</td>
</tr>
<tr>
<td>Dishita</td>
<td>Hindi (India) &amp; English</td>
<td>Level 5</td>
</tr>
</tbody>
</table>

Later, during the months of data collection, the teacher told me in both formal interviews and informal interviews (i.e., personal conversations) that she was particularly puzzled and concerned about Ying’s disruptive and distracted classroom behaviors. Ying was said to constantly interrupt the flow of classroom discourse by persistently asking questions about the content just presented and explained earlier. Puzzled by Ying’s constant questions and interruptions, Mrs. Dixon considered her a constant interrupter in their classroom discussions. I thus followed this focal ELL (Ying), observed her more closely, and gathered much more data on her (see Chapters 4 and 5 for more detail).

Additionally, it is important to note that pseudonyms were selected to identify all the participants in the present study, including the teacher and students. In addition to the above mentioned pseudonyms for the five focal ELLs (see Table 3.2), the pseudonyms of some students who contributed to the observed science classroom discourse in the present study, which I use in the result chapters (Chapters 4 and 5), are Sandy, Hector, Emma, Gina, Paula, Sara, Tufan, Bill, Amy, Lucas, Jack, Claire, Carol, and Chin. Some students appeared to be more vocal than others in the observed science classroom discourse in this present study.
3.3 Roles of the Researcher

Part of my interest in mainstreamed ELLs in the elementary grades stems from my own background: my work with Dr. de Oliveira in the Language Dissection Science Lessons Project (LDSLP) and my study shock from being an international graduate student in the United States. Dr. de Oliveira cooperated with Mrs. Dixon in LDSLP to help students learn to “dissect” the language used and to talk about the key linguistic patterns in the science textbooks. As a research assistant, I collected and transcribed the interview and observation data. My work in this project allowed me to observe a fourth grade science classroom with a diverse student population and to notice the academic literacy demands faced by the students, particularly the ELLs placed in the mainstream classroom. Although these ELLs had achieved a certain level of English proficiency (level 4 and/or level 5 on a scale of 1-5) and took classes with their English-speaking peers without any additional language services, they often appeared to be confused about the teacher’s instructions and questions, responded with some irrelevant answers, or stayed quiet during whole-class discussions. Thus, observing these ELLs’ struggles in the mainstream science classroom led me to research the teaching and learning of mainstreamed ELLs in elementary science classrooms.

Another reason for my particular attention to ELLs in mainstream classrooms is my own study shock from being an international graduate student. As a non-native English-speaking graduate student, I came to the university in the U.S. with my different learning style and non-mainstream linguistic and cultural backgrounds. I vigorously pursued my studies, but I came to realize the hard truth—even after a decade of intensive study in English and a high score in the Test of English as a Foreign Language (TOEFL),
I had difficulties participating in mainstream classroom discussions. Very often, I was so overwhelmed by my English-speaking professors’ and peers’ eloquence as well as my own anxiety of speaking up in class and making connections to the assigned course readings that I could hardly get a word out. My own struggle with the academic literacy demands of participating in English-speaking mainstream classroom discourse has deepened my empathy for the mainstreamed ELLs’ struggles.

3.4 Data Collection

3.4.1 Classroom Observations

Classroom observations were the primary source of data collection. When discussing the frequency of my classroom observations for this present study, Mrs. Dixon expressed her preference for my weekly two to three visits to her science class from mid-September to mid-December of 2011. Classroom observations were conducted two or three times a week from mid-September to mid-December of 2011. During these four months of data collection, I contacted the teacher personally or via email at least one week in advance to decide on the appropriate dates for my next week’s classroom observations. Mrs. Dixon’s science class was usually held from 12:45 to approximately 1:45 on Monday, Tuesday, and Wednesday afternoons, in the same classroom in which the classes’ other subjects were taught. In order not to interrupt the dynamics of classroom activities in their consecutive courses, I usually observed their whole afternoon section (i.e., 12:30-2:30: Reading Aloud Story for 15 minutes, Science for 60 minutes, and Social Studies for 45 minutes; approximately 2-3 hours per visit). During the four months of data collection from mid-September to mid-December of 2011, I observed three science units, including one incomplete unit of the nature of science from
September 9 to October 3 (6 visits), one complete unit of earth science from October 4 to November 16 (14 visits), and one incomplete unit of energy, heat, electricity from November 23 to December 14 (6 visits). My observation schedule resulted in approximately 13 weeks of observation (i.e., 26 visits and 65 hours of observation; 39 hours of recorded science classroom observations). In addition, it is important to note that I focused on the classroom observation data of the earth science unit among these three observed science units to answer research questions in results chapters (i.e., Chapters 4 and 5) due to its complete classroom observation data set in contrast to the other two incomplete science units.

During my classroom observation data collection, I employed nonparticipant observation in Mrs. Dixon’s classroom to observe teacher-student interactions. Nonparticipant observation allows the researcher to remain as an accepted outsider, observing and recording the interactions (Merriam & Associates, 2002). From an etic perspective, I remained attentive to the teacher-student interactions and captured as much of the observed science classroom discourse as possible. Such nonparticipant observation was particularly useful when I was concerned to describe the complexity beneath the task of participating in classroom discourse and answering text-dependent questions for minority students (i.e., mainstreamed ELLs) that otherwise we take for granted. Furthermore, these classroom observations were audio-taped with two recorders set up in Mrs. Dixon’s classroom which allowed the best pickup of voices. To supplement the recordings, I, as a nonparticipant observer, took detailed field notes during each science lesson, writing down the names of the speakers as they spoke and noting their discourse as accurately as possible. Field notes were taken and analytic memos, including my
thoughts and questions generated from the classroom observations, were written to help develop questions as the interview guide for my interviews with the teacher at the end of each science unit.

During the classroom observation data collection, I collected various types of spoken and written texts understood and produced by the teacher and students. In addition to the spoken texts (i.e., audiotapes of the oral classroom observation data), another data source was written texts encountered by students (e.g., the written instructional materials such as the textbook passages) and/or produced by them (e.g., the student written responses to the textbook questions or questions on each lesson worksheet). I also took photos of written texts I could not photocopy such as posters and drawings. These written instructional materials and student-generated texts provided insights into students’ science understanding as well as the demands posed by the assigned texts. More specifically, having these written instructional materials and student-generated texts helped the researcher to take a close look at what science language was being presented to the fourth-grade students and what science language these students were expected to understand and produce.

3.4.2 Interviews with the Teacher

I interviewed the teacher both informally and formally throughout the course of the present study. Initially, I interviewed the teacher informally (i.e., personal conversations without audio recorder) when deciding whether to choose her classroom as the site for my study. Shortly before I began the classroom observations, I interviewed her again to talk about general issues such as the frequency of my classroom observations, her teaching strategies and activities in science class, and her students, particularly the
mainstreamed ELLs (see Appendix A). I also carried out six formal interviews with the teacher which were scheduled and audiotaped at the beginning and end of my observations of the three science units. These formal interviews were semi-structured and included an interview guide of structured questions used to collect specific information (Bernard, 2000). In the semi-structured interview at the beginning of each science unit, the teacher was asked about her perspectives on the particular science unit as well as her pedagogical plans in support of her students’ learning of this unit (see Appendix B). As for the semi-structured interview at the end of each science unit, the teacher was asked to talk about her impressions of students’ overall performance and especially the mainstreamed ELLs’ performance in participating in the observed science classroom discussions and classroom activities (see Appendix C). Once I began the classroom observations in mid-September, some of our informal interviews were brief intervals (maybe 5 minutes or so) when we had a chance to talk between classes during my observed afternoon sections. During these informal interviews, I learned about the observed day’s specific science activities, the teacher’s planning, and/or the specific incidents that had occurred with the teacher and students. Following these formal and informal interviews with the teacher, I wrote field notes as soon as possible.

These formal and informal interviews with the teacher provided insights into the teacher’s perspectives on the particular science unit and on how her students were supported and challenged to learn the particular science unit. These perspectives shaped how the teacher integrated instructional support and thereby deeply influenced the intertextuality in the observed science classroom discourse (see Sections 4.1 and 4.2). With reference to teacher interview data, I selected the extracts of classroom discourse
containing instances of intertextuality and illustrated the different kinds of intertextuality used by the teacher and students. In addition, teacher interview data (e.g., the teacher’s impression over students’ and especially ELLs’ performance in participating in classroom discourse) guided me to follow one focal ELL because of the teacher’s concern about her distracted and disruptive classroom behaviors and to explore this ELL’s unexpected ideas (see Sections 5.1, 5.2, and 5.3), which enabled me to describe the challenges for ELLs in the observed science classroom discourse.

### 3.4.3 Extracts of Classroom Discourse Containing Instances of Intertextuality

A researcher who handles an extensive amount of classroom observation data has to make selective choices to better enhance one’s argument (Christie, 1995, 2002; Gibbons, 2003). Thus, it does not make sense to simply list all the intertextual connections made by the teacher and students in the observed classroom discourse. Rather, with one goal in mind, to address the study’s two research questions, I selected the extracts of classroom discourse which contain instances of intertextuality, with reference to the teacher interview data. These instances illustrate the different kinds of intertextuality used by the teacher, students, and the focal ELL when they talked and wrote science in the observed science classroom discourse.

### 3.5 Data Analysis

#### 3.5.1 Systemic Functional Linguistics (SFL) Discourse Analysis

SFL discourse analysis was used in this study to look within and across the various types of classroom observation data, including the extracts of classroom discourse containing instances of intertextuality and the written texts encountered and produced by students in the observed science classes. Before beginning the SFL
discourse analysis, the classroom observation data collected on audiotapes were transcribed, typed into a word-processing program, and printed for examination. The transcription process was supplemented by the field notes taken during the observations. By using field notes, I was able to identify the speakers as they spoke and fill in some of the interactions such as the teacher’s dramatic gestures during her explanations of some key science concepts.

SFL discourse analysis was selected to examine the various types of classroom observation data collected in this study because it offers a means of exploring meaning in language and discourse data (Schleppegrell, 2012b). Schleppegrell notes that “Deciding how to approach authentic language in context, in spoken or written form, is often a challenging task. SFL offers a ‘way in’ by providing concrete tools for exploring language comprehensively and for making sense of discourse data” (p. 29). Reviewing the studies that have used SFL to explore meaning in classroom discourse data, Schleppegrell further highlights the value of drawing on SFL discourse analysis to explore how teachers and students construct disciplinary knowledge through classroom discourse. Recognizing the value of this approach, the present study examines the observed science classroom discourse from the perspective of systemic functional linguistics, which views language as a resource from which knowledge is constructed (Halliday, 1994).

The chosen theoretical framework of SFL allowed me to carry out a discourse analysis by examining the spoken and written texts encountered and produced by the teacher and students in terms of their particular language choices and how these choices combined to help them construct science knowledge in particular contexts of teaching.
and learning (see Halliday & Matthiessen, 2004). To capture the detailed information about the particular contexts of teaching and learning, I first consulted the classroom transcripts together with my field notes and built “Episode Summaries” of each observed science class. The Episode Summaries were grounded upon Lemke’s (1990) and Gibbons’s (2006) SFL discourse analysis of science classrooms, including Gibbons’s suggested format (see Sections 2.1 and 2.3). While constructing the Episode Summaries, the classroom transcripts were reviewed for: (1) instructional segment (e.g., reviewing, reading textbook passage, watching BrainPOP), (2) activity/dominant participation and interaction structure (e.g., Initiation-Response-Evaluation/IRE, discussion), (3) modes used by the teacher and students to communicate science ideas (e.g., spoken, written, pictorial), and (4) constructed science knowledge (e.g., the key science terminology and concepts). Appendix D presents an example of the Episode Summaries constructed from the observed science classroom discourse of Mrs. Dixon’s earth science unit. This type of data analysis, based on SFL discourse analysis, is the primary analysis to respond to my first research question (i.e., What is the nature of science classroom discourse?) because it offered a holistic perspective of particular contexts of teaching and learning as well as science knowledge constructed in the observed science classroom discourse. In addition, the Episode Summaries, based on SFL discourse analysis, enabled me to describe the major teaching and learning activities and the thematic patterns of the particular science unit (see Table 4.1 and Figure 4.1 in Section 4.1); such information reveals the nature of science classroom discourse.

Furthermore, with reference to the identified context features, patterns of teacher-student interactions, and constructed science knowledge from the Episode
Summaries, I drew on SFL to identify the language patterns in the written texts encountered and produced by students, teacher support (i.e., teacher talk), and student talk. Analysis of these written texts was conducted using the SFL discourse analysis approach to deconstruct the discipline-specific language, identify pertinent language patterns, and discuss the potential challenges these unique features presented for Mrs. Dixon’s students. This detailed linguistic analysis was also conducted for the examples of teacher support (i.e., teacher talk) and student talk, including the extracts of classroom discourse containing instances of intertextuality. These instances reveal specific language resources used by the teacher to support students’ comprehension of the written texts and their construction of science knowledge (see Section 4.2). In addition, the SFL discourse analysis of the teacher talk and student talk (such as their responses to the text-dependent questions) highlights the different kinds of language used by the teacher, students, and especially the ELLs to respond to the questions, which reveal the particular challenges for the ELLs in the observed science classroom discourse (see Section 5.3 for more detail).

SFL discourse analysis of the various types of classroom observation data enabled me to link the identified context features and language choices and thereby to address the nature of science classroom discourse: the disparity that existed between the discipline-specific language of science in the written texts encountered by students (e.g. the textbook) and students’ familiar everyday language, and the particular kinds of intertextuality used by the teacher in support of students’ comprehension of the written texts. SFL discourse analysis of the classroom observation data also enabled me to address the identified challenges for ELLs by analyzing and describing the different kinds
of language used by the teacher, students, and the focal ELL when talking and writing science to respond to the text-dependent questions.

3.5.2 Preliminary Data Analysis of Teacher Interview Data

The teacher interview data in the present study involves both informal and formal interview data. In addition to the informal interviews (i.e., personal conversations without audio recorder), I carried out six scheduled, formal interviews, one at the beginning and one at the end of each of the three science units. Each formal interview was audiotaped and subsequently transcribed. Then a preliminary data analysis was done along with Merriam’s (1998) suggested procedures for all the teacher interview data: I first reviewed the six interview transcripts, totaling 60 double-spaced pages, together with the field notes taken after both informal and formal interviews. Second, several times I carefully read through all the interview data, including the interview transcripts and field notes. Recurrent issues were identified through these multiple readings. Then, emergent categories and themes were written up. Next, the recurrent issues that had been previously identified in the interview data were cross checked with the classroom observation data. This enabled me to explore the teacher’s perspectives on the particular science unit, her instructional support integrated into the observed science classroom discourse, and her impression of students’ and especially ELLs’ participation, vital for selecting the extracts of classroom discourse containing instances of intertextuality.

3.5.3 Macro-Level and Micro-Level Intertextual Analysis

The classroom observation data were also examined for instances of intertextuality. As mentioned in Sections 3.4.2 and 3.4.3, the teacher interview data were taken up as reference points to select the extracts of classroom discourse containing
instances of intertextuality. These extracts were then analyzed at two levels: macro-level intertextual analysis to classify and categorize the sources of intertextuality and micro-level intertextual analysis to take a closer look at the language used to construct intertextuality.

My macro-level intertextual analysis is prompted by the work of Varelas and her colleagues (e.g., Varelas & Pappas, 2006; Varelas, Pappas, & Rife, 2005; see Chapter 2 for more detail). With reference to their identified four major categories of intertextuality (see Table 3.3), I identified, classified, and interpreted the instances of intertextual connections the teacher and students--particularly ELLs--used in their construction of science knowledge. Especially noteworthy of the macro-level intertextual analysis is that I identified and discussed the different kinds of intertextuality used by the teacher and students when talking and writing science in the observed science classes (see Chapters 4 and 5 for more detail).

<table>
<thead>
<tr>
<th>Category</th>
<th>Intertextual Connections to</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>written texts (e.g., textbook passages, student written responses to textbook questions and questions of each lesson worksheet)</td>
</tr>
<tr>
<td>II</td>
<td>hands-on explorations (e.g., the recounting of actions, outcomes, and interpretations)</td>
</tr>
<tr>
<td>III</td>
<td>recounting events (e.g., recounting specific events and recounting generalized events)</td>
</tr>
<tr>
<td>IV</td>
<td>“implicit” generalized events</td>
</tr>
</tbody>
</table>

(Adapted from Varelas & Pappas, 2006, p. 216-219; Pappas, Varelas, Barry, & Rife, 2003, p. 443)

My micro-level intertextual analysis is based on SFL, which links language features with their realization of particular contexts, enabling us to see language as a set of language choices for making meaning (Halliday & Matthiessen, 2004). Language choices along with context features offer a set of functional linguistic tools to recognize
the appropriateness of language choices in a specific context. Among the functional linguistic tools, transitivity analysis based on SFL was selected in this study as the micro-level intertextual analysis because of its focus on how the content (i.e., science knowledge) is presented through the language choices made by the teacher and students. Transitivity analysis is used to analyze the patterns of Participants and Processes.

Participants are linguistically expressed through nouns. Processes, what Participants are doing or how they are described, are linguistically expressed through verbs.

The various types of Processes are divided by Martin & Rose (2003) and Fang & Schleppegrell (2008) into four major categories: doing, being, sensing, and saying.

Doing Processes represent physical actions in the real world (e.g., Helen drove me home). Being Processes express attributes (e.g., Helen is short), equivalence (e.g., Helen is the president), and possessions (e.g., Helen owns a car). Sensing Processes refer to processes of perception (e.g., I saw Helen), cognition (e.g., I thought that Helen was coming), and affection (e.g., I liked what Helen said). Saying Processes express processes of communication (e.g., Helen said she was tired). Regarding the patterns of Participants, Participants that occur as Subject of the sentence, and Processes, the transitivity analyses in Chapters 4 and 5 (see Table 4.4, Table 4.6, Table 5.2, & Table 5.3) highlight the different language choices made by the teacher and students and make explicit the specific language patterns of teacher support (i.e., teacher talk) and student talk to construct the content of science classroom discourse. Such transitivity analyses also draw attention to the kinds of language in science classroom discourse that challenged students and especially ELLs.
Once identified through the macro-level and/or micro level intertextual analysis, I compared and contrasted the sources of intertextuality and/or the particular language patterns of intertextuality to highlight the preferred sources and linguistic features for the identified intertextual instances made by the teacher, students, and ELLs. By drawing on macro-level and/or micro-level intertextual analysis, I was able to trace intertextuality in the science classroom discourse. This was vital for me to better understand the nature of the observed science classroom discourse and the teacher support integrated in their construction of science knowledge through classroom discourse as well as the challenges students and especially ELLs faced in making the connections in the way science knowledge construction through classroom discourse required.

3.5.4 Constant Comparative Analysis

Due to the interrelatedness of my two research questions, constant comparative analytic method outlined by Glaser and Strauss (1967) in the development of grounded theory was the technique I employed. With this method I was able to compare all the identified recurrent issues, themes, patterns, and categories across my collected research data, including the various classroom observation data and teacher interview data. Constantly comparing the results from the SFL discourse analysis, preliminary data analysis, and intertextual analysis enabled me to identify the convergent and divergent components (Glaser & Strauss, 1967). These components were the elements for constructing my understandings and descriptions of the nature of the observed science classroom discourse and the challenges for ELLs in the observed science classroom as well as the support the teacher provided (or not) in response to the identified challenges.
3.6 Summary

This chapter has presented this study’s research design—qualitative case study as well as described in detail the context, research site, and participants for this study. This chapter also discusses roles of the researcher and the frameworks which guided the data collection and data analysis. Table 3.4 provides an overview of this study’s research questions, data sources, and outcomes.
Table 3.4 Overview of Dissertation Study

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Analyzed</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| 1. What is the nature of science classroom discourse? | • Interviews with the teacher  
- interview transcripts  
- field notes  
*Preliminary Data Analysis* | • Description of the teacher’s perspectives on the particular science unit, pedagogical plans, and instructional support |
| | • Observations of the fourth grade science classroom:  
- oral classroom observation data collected on audiotapes  
- written texts encountered and produced by students  
- extracts of classroom discourse containing instances of intertextuality  
*SFL Discourse Analysis with Episode Summaries (transitivity analysis)*  
*Intertextual Analysis to focus on the instances of intertextuality* | • Description of context features, patterns of teacher-students interactions, and their constructed science knowledge  
• SFL discourse analysis of written texts (e.g., the textbook) to note language features that might pose challenges to students  
• Description of the different kinds of intertextuality and language in teacher support (teacher talk) and student talk |
| 2. What challenges for ELLs can be identified in science classroom discourse? What support does the teacher provide (or not) in response to the identified challenges? | • Interviews with the teacher  
- interview transcripts  
- field notes  
*Preliminary Data Analysis* | • Description of the teacher’s impression over students’ and especially ELLs’ performance in participating in the observed science classroom discourse |
| | • Observations of the fourth grade science classroom:  
- oral classroom observation data collected on audiotapes  
- written texts encountered and produced by students  
- extracts of classroom discourse containing instances of intertextuality  
*SFL Discourse Analysis (transitivity analysis)*  
*Intertextual Analysis to focus on the instances of intertextuality* | • Identification of the focal ELL with reference to the teacher interview data  
• Description of the different kinds of intertextuality and language drawn by the teacher, students, and especially the focal ELL when talking and writing science  
• Description of the challenges for the focal ELL in the observed science classroom discourse and the support the teacher provided (or not) in response to the identified challenges |

This table shows the two research questions that guided this study, the data sources analyzed, and the outcomes of the data analysis. These data sources enabled me to address the research questions over the next three chapters. Chapter 4 presents data and
analysis about the nature of science classroom discourse in Mrs. Dixon’s mainstream science classroom as the participants constructed science knowledge through the observed science classroom discourse in “The Earth’s Changing Surface” unit. Next, Chapter 5 provides data and analysis about what challenges for ELLs were identified in the observed science classroom discourse in the earth science unit and what support the teacher provided (or not) in response to the identified challenges. Finally, Chapter 6 places all the data and analysis into a larger picture, connecting it to other research and literature and highlighting major findings.
CHAPTER 4. THE NATURE OF SCIENCE CLASSROOM DISCOURSE IN THE EARTH’S CHANGING SURFACE UNIT

This chapter offers a detailed look at how Mrs. Dixon and her fourth grade students, including mainstreamed English Language Learners (ELLs), taught and learned about the earth’s changing surface in the earth science unit. As discussed in Chapter 2, the construction of science knowledge involves students’ development of science understanding and science language, particularly as it relates to intertextual connections to science terminology and concepts that teacher and students make in science classroom discourse. This chapter examines the ways the teacher supported the construction of science knowledge through classroom discourse, paying particular attention to the kinds of intertextuality and language used by the teacher and students to communicate scientific ideas. The discussion of Mrs. Dixon’s earth science unit in this chapter, therefore, focuses on the nature of science classroom with emphasis on the kinds of intertextuality and language in teacher support through science classroom discourse. This chapter addresses my first research question: “What is the nature of science classroom discourse for Mrs. Dixon’s earth’s changing surface unit?”

The first section of the chapter describes the particular teaching and learning contexts of Mrs. Dixon’s earth’s changing surface unit. To capture the detailed
information about the particular teaching and learning contexts, Section 4.1 contains
the teacher’s perspectives on this science unit, teaching and learning activities, and the
key science terminology and concepts being taught and learned (i.e., thematic patterns).
Such information contextualizes the subsequent description and discussion of the kinds of
support the teacher provided to students for understanding and connecting to the key
science terminology and concepts. Section 4.2 offers a detailed look at and exemplifies
the kinds of teacher support incorporated into science classroom discourse. Furthermore,
the section traces the kinds of intertextual connections and language dominating the
presented examples. The final section, Section 4.3, summarizes and discusses the
information of the above two sections, revealing the nature of the observed science
classroom discourse.

As explained in Chapter 3, the observed science classroom discourse is
analyzed at two levels: macro-level intertextual analysis to categorize the sources of
intertextuality and/or micro-level intertextual analysis to examine the language used to
construct intertextuality. The macro-level intertextual analysis is prompted by the work of
Varelas and her colleagues (e.g., Varelas & Pappas, 2006; Varelas, Pappas, & Rife, 2005).
With reference to their identified four major categories of intertextuality (see Table 3.3), I
traced the intertextual connections drawn by the teacher and students and identified the
primary kinds of intertextuality used to talk science. My micro-level intertextual analysis
(mainly transitivity analysis) is based on systemic functional linguistics (SFL), which
focuses on language features and their realization of particular contexts and sees language
not as a set of rules to be followed but rather as a set of language choices for making
meaning (Halliday & Matthiessen, 2004). The purpose of the micro-level analysis of
science classroom discourse is to establish that it is the use of language in context which makes meaning. This functional linguistic view of language enables us to recognize the appropriateness of language choices in a specific context. Furthermore, these language choices along with context features offer a set of functional linguistic tools to make explicit the language features of the presented examples of teacher support. Moreover, the micro-level intertextual analysis illustrates language choices made by the teacher and students in their intertextual connections to the key science terminology and concepts highlighted in the science texts and science classroom discourse.

4.1 Teaching and Learning Contexts

To capture the detailed information about particular teaching and learning contexts of Mrs. Dixon’s earth’s changing surface unit, I begin by presenting the teacher’s perspectives on this unit, then include teaching and learning activities, and finally introduce the key science terminology and concepts being taught and learned (i.e., thematic patterns). The information in this section details context for the subsequent description and discussion of the kinds of teacher support incorporated into the observed science classroom discourse in Section 4.2.

4.1.1 Teacher’s Perspectives

My rationale for starting with the teacher’s perspectives is because the teacher decided which unit to teach, which instructional goals to achieve, and which activities to include in support of her students’ science learning. According to Mrs. Dixon, instead of following the science textbook sequenced unit (i.e., Unit Two Technology and Design), she purposely chose Unit Five Earth’s Changing Surface due to its relevance to the social studies unit The Geography of Indiana. At that time Mrs. Dixon’s students were learning
in the social studies unit about the three main land regions of Indiana, including the Great Lake Plains, the Tipton Till Plains, and the Southern Hills and Lowlands, with emphasis on glacier formation and glacier movement across Indiana. Mrs. Dixon elaborated on how glaciers flattened the landscape of the Tipton Till Plains thousands of years ago, providing her students with concrete examples of how glaciers can change the earth’s surface. Recognizing the potential to enable her students’ understanding of the local to global land change (from the geography of Indiana to the earth’s changing surface), Mrs. Dixon selected Unit Five *Earth’s Changing Surface* to support her students connecting what they were learning in social studies with the new learning in science.

Mrs. Dixon used a variety of materials from teacher resources in the science textbook package. The textbook *Indiana Grade 4 Interactive Science* (Buckley, Miller, Padilla, Thornton, Wiggins, & Wysession, 2012) was new that school year. According to Mrs. Dixon, all fourth grade teachers received the science textbooks the first week of school–the same week their students arrived. Though she did not have abundant time to familiarize herself with the new science textbook, Mrs. Dixon said she planned to use it. She also planned to supplement the textbook instruction with experiments and short clips of BrainPOP science videos, which could provide her students with visual representations of the key science terminology and concepts being taught and learned. BrainPOP science videos are short animated movies (usually 3-5 minutes) aligned to local science educational standards. These curriculum-based videos are intended to explain science concepts to young students in support of teachers’ instruction. The following is what the teacher said about involving the textbook in the curriculum:
This is a brand-new textbook and this is the first year that I am using it. So really I am going one step a time. I mean I have ideas about what the chapter, I know what the chapter is about. I look ahead. But I am doing really a week ahead of time. And they have a lot of experiments in the book. So I am doing their experiments, plus I found some additional (experiments) as well. But we are reading through the book... And then you know sometimes there aren’t many visuals. I like the BrainPOP videos because they are really short. And they give good visuals to what we discussed if we are not to do any experiment that day. At least there is something besides the reading of textbook…

(Interview with teacher, 10/12/2011)

As planned, much Mrs. Dixon’s science teaching was guided by and based on the content of the textbook. The teacher’s instruction typically involved covering and discussing the textbook along with incorporating some short clips of BrainPOP science videos to support the textbook discussion. Mrs. Dixon emphasized developing her students’ comprehension of the textbook content. Thus, because the textbook was the dominant text in the discourse, the teaching and learning activities of this earth science unit were more or less related to the reading and discussing of textbook content. With reference to the Episode Summaries of Mrs. Dixon’s earth science unit, which documented the teaching and learning activities for each visit by the researcher (see Appendix D), Table 4.1 outlines the major teaching and learning activities with the reading of the textbook in bold, the key science terminology and concepts being taught and learned (i.e., thematic patterns), and the dates.
<table>
<thead>
<tr>
<th>Dates</th>
<th>Teaching and Learning Activities</th>
<th>Thematic Pattern</th>
</tr>
</thead>
</table>
| October 4, 2011 | • **Reading textbook on** *Glaciation*  
• Explaining glacier formation with textbook passage and textbook picture *From Snow to Ice*, and watching BrainPOP on *Glacier*  
• Creating Ice Cream Model to simulate how glaciers moved and formed the Indiana landscape                                                                                     | Glacier formation and movement                |
| October 10-11, 2011 | • **Reading textbook on** *Weathering* and having BrainPOP on *Weathering*  
• Experimenting on what soil is made of (guest speaker)                                                                                                                    | How weathering and erosion can change earth’s surface |
| October 12, 2011 | • **Reading textbook on** *Erosion and Deposition*, and watching BrainPOP on *Erosion*                                                                                                                                             | Processes of erosion and deposition            |
| October 17, 2011 | • Doing experiment listed in textbook: Students measured the mass of different types of damp soils (sandy soil and clay soil) to compare how much water each held                                                                          | Clay soil holds more water than sandy soil     |
| October 19, 2011 | • Reviewing what they had learned about soil  
• **Reading textbook on** *Crop Growth*  
• **Writing Lesson 2 Worksheet** and watching instructional video on *Soil, Weathering, Erosion*                                                                                  | Crop rotation in the growth of crop            |
| October 24, 2011 | • **Reading textbook on** *Tsunamis* and watching BrainPOP on *Tsunamis*  
• **Reading textbook on** *Landslides*  
• Reviewing the four natural rapid causes to earth’s changing surface                                                                                             | Earthquakes, volcanoes, tsunamis, and landslides |
| November 2 & 9, 2011 | • **Reading textbook on** *People and the Environment*  
• **Reading textbook on** *Pollution and Air Pollution* and watching BrainPOP on *Air Pollution*; discussing some facts about Air Pollution from the textbook and listing facts about Air Pollution  
• **Reading textbook on** *Water Pollution* and watching BrainPOP on *Water Pollution*; discussing some facts about Water Pollution | Some positive and negative ways in which people impact the environment |
from the textbook and listing facts about Water Pollution

- Looking back at the textbook passages specified by the teacher to review the ways to preserve our environment (e.g., national park to preserve our environment)

<table>
<thead>
<tr>
<th>November 11, 2011</th>
<th>Reading textbook on Nonrenewable Resources and How Resources Can Last Longer, watching BrainPOP on Fossil Fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Writing Unit 5 Review Questions in Textbook, and having instructional video on Weathering, Erosion, Deposition</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Writing Lesson 5 Worksheet</td>
</tr>
<tr>
<td></td>
<td>Writing Unit 5 Review Questions in Textbook</td>
</tr>
<tr>
<td></td>
<td>Having Classroom Performance System (CPS) to review Unit 5</td>
</tr>
</tbody>
</table>

| November 16, 2011 | Taking Unit 5 Test |

4.1.2 Teaching and Learning Activities

Mrs. Dixon began the earth science unit in early October and continued until mid-November. The progression from one topic to the next, along with the teaching and learning activities, is captured in Table 4.1, constructed from the Episode Summaries of Mrs. Dixon’s earth science unit (see Appendix D). As this table shows, most of the science unit classes involved reading and discussing the textbook content. Often, the teacher planned for the class to read a specific number of pages (typically 2-4) during the hour-long class. In their reading, the teacher first nominated students to read aloud; then she explained and discussed the science terminology and concepts highlighted in the textbook passage. She ended the reading activity with a teacher-led question and answer session in which she asked text-dependent questions that required students to provide evidence from the textbook’s relevant passages as they shared and justified their
responses. The text-dependent questions included the teacher’s self-prepared questions about the textbook and the questions at the end of each small section of textbook passages. At times, the teacher gave students several minutes to write down their responses, and then she asked for volunteering students to share their responses. Additionally, every two to three weeks, the teacher assigned students worksheet-science lesson review questions in Unit 5. Moreover, at the end of the unit, the teacher assigned students Unit 5 review questions provided by their science textbook to orally share and discuss in class. The day following the review, the teacher tested her students on Unit 5.

Throughout the teacher-led oral review sessions as noted above, Mrs. Dixon’s most common purpose for asking the various text-dependent questions was to reinforce the textbook content presented and explained earlier.

As Table 4.1 indicates, aside from these highlighted teaching and learning activities (i.e., their reading of textbook and answering text-dependent questions), in the earth science unit the students completed three major experiments and watched short clips of BrainPOP videos. The videos, by means of the animation and synchronized subtitles, reinforced information related to the science terminology and concepts being taught in the unit. After watching the video, Mrs. Dixon often orally reviewed the videos and asked her students to recall on the content. Also, the students conducted three major experiments during the earth science unit, one in which they created an ice cream model to simulate how glaciers moved and formed the Indiana landscape, another in which they observed what soil is made of, and a third in which they compared the water-holding capacity of clay and sandy soil. The experiments and their roles in the observed science classroom discourse will be more fully explained in the presented examples of teacher
support incorporated into science classroom discourse, Section 4.2.1 (Example 2) and Section 4.2.2 (Example 5) respectively.

4.1.3 Thematic Patterns

My goal in using Lemke’s (1990) construct of thematic patterns represented as concept maps was to present the science knowledge constructed by Mrs. Dixon and her students in the observed science classroom discourse, which is important to detail the teacher support for her students’ connecting to the science terminology and concepts in the observed discourse (see Section 4.2). An overview of the thematic patterns built by Mrs. Dixon and her students in the earth science unit is drawn following Lemke (1990) and shown in Figure 4.1. As this figure indicates, during most classes, Mrs. Dixon taught her students about the science terminology and concepts highlighted in the textbook passages they read, including glacier, glaciation, weathering, erosion, deposition, the four natural rapid causes to change earth’s surface (i.e., volcanoes, earthquakes, tsunamis, landslides), how humans change earth’s surface, pollution (kinds of pollution), and the natural resources (renewable and nonrenewable).
Figure 4.1. How does earth’s surface change?

In order for her students to construct their conceptual understanding of the science terminology and concepts highlighted in the textbook (as Figure 4.1 shows), Mrs. Dixon stated that her students needed opportunities to learn how the words and science content relate to each other. This would be achieved by the teacher support incorporated into the science classroom discourse, as stated by Mrs. Dixon:

It’s mostly the vocabulary and learning the differences between all of the words. Because there is so much information, it could get really confusing. You know we keep talking about each of these words, I would keep trying to have visuals and experiments to go along with it… I mean that’s gonna be most challenging. I mean for all students, not only the English Language Learners, all the students.

(Interview with teacher, 10/12/2011)
When asked how she supported all her students learning the field-specific vocabulary words, she stated that she would try to have BrainPOP videos to present the science terminology and concepts in visual format. Furthermore, the students would conduct related experiments. I observed that in most classes Mrs. Dixon put a lot of emphasis on using the textbook in support of her students’ construction of the science knowledge and language highlighted in this unit. Along with her explanation of the textbook content, the teacher at times recounted specific and generalized events from everyday experiences to bring in everyday knowledge and language, which most students could draw on to connect to the science terminology and concepts. In the next section, I will further discuss and provide evidence for how Mrs. Dixon incorporated her support into the observed science classroom discourse with her frequent use of the intertextuality of recounting events (i.e., everyday knowledge and everyday language). More specifically, accompanying the overview of the thematic patterns built by the teacher and students (see Figure 4.1), Section 4.2 will detail the kinds of support the teacher provided to her students to weave the thematic patterns into the classroom discourse, with emphasis on the different kinds of intertextual connections and language used by the teacher and students to talk science.

4.2 The Kinds of Teacher Support Incorporated into Science Classroom Discourse

Because teaching from, and with, the textbook was the dominant method of instruction in Mrs. Dixon’s science classes, much of her teaching was guided by and based on the science textbook, which was used by the teacher to construct her students’ science knowledge. But in doing so, the textbook, with its use of science language features, poses particular linguistic challenges to Mrs. Dixon’s students as novice readers
of this kind of discipline-specific language. Mrs. Dixon was conscious that the language used to construct the specialized science knowledge in the textbook passages (e.g., the field-specific vocabulary) sounded unfamiliar to her students’ everyday life. Thus, the science language was difficult for her fourth grade students to relate to. When the assigned textbook passages were read silently or aloud in class, most students were unable to understand the textbook passages with relative ease or go beyond understanding to make any intertextual connection to the textbook content.

The teacher’s frequent use of everyday knowledge and language, by connecting the things (concepts, ideas) the students already knew to the things they were learning, made the science terminology and concepts highlighted in the textbook more meaningful to her students. I selected the examples that arose from the observed science classroom discourse to illuminate the two major kinds of support Mrs. Dixon provided to her students. These examples are organized into two major kinds of teacher support:

1. **Register-switching between science and everyday vocabulary**

2. **Using metaphor and analogy directly related to everyday experiences**

   Note that in the examples listed below, both focal kinds of teacher support--their intertextual connections built in the science classroom discourse, and the different kinds of language encountered and used by the teacher and students in the context of teaching and learning science from the classroom discourse--are examined and discussed in more detail.

### 4.2.1 Register-switching between Science and Everyday Vocabulary

One of the greatest challenges in learning science is learning its technical vocabulary. As emphasized by the teacher in the interview, learning the field-specific
vocabulary was the most challenging literacy task encountered by her fourth grade students. In Mrs. Dixon’s earth science unit, the teacher supported her students’ understanding of the specialized vocabulary words by moving back and forth between the students’ more familiar everyday vocabulary and the targeted science vocabulary. I term this moving back and forth between everyday and science language “register-switching” in line with how this term is used in Systemic Functional Linguistics research, “a register is a constellation of lexical and grammatical features that characterizes particular uses of language” (Schleppegrell, 2001, p. 431). For the purposes of this present study, register-switching means switching between two registers of the same language (i.e., everyday language and science language, see Section 2.2.1 for more detail on register).

Both Lemke (1990, 1989) and Gibbons (2003, 2006) recognize the importance of “register-switching” between everyday and science language for diverse students’ learning of scientific concepts in science classroom discourse. Such register-switching are what Gibbons called “bridging discourse”, which “meshes everyday and subject-specific ways of meaning, thus building on students’ prior knowledge and current language as a way of introducing them to new language” (Gibbons, 2009, p. 62). Like Gibbons’s and Lemke’s work, I also show the observed teacher’s first kind of support as the practice of register-switching between the science and everyday vocabulary. Such practice includes unpacking nominalizations and substituting vocabulary as shown in the following three examples from the observed science classroom discourse.

**Example 1.** Example 1 illustrates one instance of unpacking nominalization--certain nominalizations were explained by the teacher through identifying their constituent verbs with which the students, based on everyday experience, were more
familiar. Science textbook writers commonly use nominalization, which involves turning Processes, expressed by verbs like *weather*, *erode*, and *deposit*, into nouns (e.g., *weathering*, *erosion*, and *deposition*) to pack more meaning into the textbook passages (Unsworth, 1999). By turning verbs into nouns, science textbook writers can construct these nominalizations as nouns and nouns in the position of subject (Schleppegrell, 2001, p. 443). Nominalization allows science textbook writers to package a lot of information into a noun and then use this (e.g., a noun in the position of subject) in succeeding sentences for further explanation. Thus, science textbooks are densely packaged with information (de Oliveira, 2010; Unsworth, 1999). As we can see in the earth science textbook passages, certain nominalizations such as *weathering*, *erosion*, and *deposition* are used to construct dense explanations of the natural phenomena which cause change to the earth’s surface. The correspondence between these nominalizations and their constituent verbs is shown below:

<table>
<thead>
<tr>
<th>Verb</th>
<th>Nominalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>weather</td>
<td>weathering</td>
</tr>
<tr>
<td>erode</td>
<td>erosion</td>
</tr>
<tr>
<td>deposit</td>
<td>deposition</td>
</tr>
</tbody>
</table>

Another reason for using nominalization is to help structure a science text. We often explain something that happens by using verbs. But then we want to move the argument along, so we use a noun to condense what has already been explained by the verb. Nominalization, as emphasized by Schleppegrell (2001), “allows information that has already been presented to be summarized and re-presented as given in a following clause” (p. 443-444). We can see this is in the explanation of *Deposition* in the science textbook passage read aloud and discussed by Mrs. Dixon and her students (Buckley et
al., 2012, p. 171). Nominalization in this particular science textbook passage is used in two ways—to summarize the meanings built up in the previous clauses and to move the science discourse forward, as shown in Figure 4.2. Below, the nominalizations and words equated to “deposition” are boldfaced:

As parts of earth’s surface are broken down, other parts are built up.

The forces that carry away bits of weathered rock during erosion must drop them somewhere else. This laying down of pieces of rock is called deposition. Sometimes deposition happens slowly, and other times it happens very fast (Buckley et al., 2012, p. 171).

Figure 4.2. Use of nominalization in the fourth-grade science textbook.

In Figure 4.2, the first three clauses illustrate how the three natural phenomena weathering, erosion, deposition are related to each other (i.e., the actions of breaking down rock, carrying away of weathered rock, dropping bits of weathered rock somewhere else). In order to lead to the next step (i.e., explanation of “deposition”), the writer in the next clause begins with the long nominalization in the subject position “This laying down of pieces of rock.” As arrows in Figure 4.2 demonstrate, “This laying down of pieces of rock” is a nominalization derived from the verb “drop them (bits of weathered rock) somewhere else” and links back to the meanings built up in the previous clauses. The compacted meaning is then equated with another (technical) nominalization “deposition” by “is called,” the being Process in passive voice. Such a technical nominalization “deposition” is therefore made available for use in the ensuing explanation of deposition (i.e., duration of deposition can be long or short) without the need for a lengthy
reiteration of how deposition forms. As we can see in Figure 4.2, the writer’s repeated use of this technical nominalization “deposition” in the next clauses, “Sometimes deposition happens slowly, and other times it (deposition) happens very fast.” recapitulates what has been stated in the previous clauses and further becomes the noun in the subject position of the ensuing explanation (i.e., deposition happens slowly or very fast). Note, in these clauses, “it” also refers back to the technical nominalization “deposition”, as illustrated by the last arrow of Figure 4.2.

This kind of highly structured scientific writing with nominalization, as shown in Figure 4.2, helps package and structure information into just a few clauses in this particular science textbook passage. Such nominalization not only links back to what has been stated in the previous clauses but moves forward the succeeding clauses for the ensuing explanation, which is regarded as “a typical feature of academic prose that contributes to the density of school-based texts and to the kind of organization that is often described as more complex” (Schleppegrell, 2001, p. 444). Yet with these nominalizations packaging and structuring information into the science textbook passage, this science text is dense and may have presented significant comprehension challenges for Mrs. Dixon’s students. Nominalization is new to most students, even those with fluency in everyday English (i.e., the native English-speaking students and Level 4-5 ELLs in Mrs. Dixon’s classroom). Extract 4.1 illustrates how Mrs. Dixon supported her students unpacking nominalization in order to comprehend the textbook passage on deposition. The teacher’s unpacking the nominalization is underlined and boldfaced in Extract 4.1. Quotation marks in Extract 4.1 are used to surround the passage extracted from the science textbook used in Mrs. Dixon’s science classes. (The extract is a portion
of the classroom transcripts from the earth science unit audio recordings I collected in this research.)

Extract 4.1 (Example 1)

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Topic on Deposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Student (reading aloud)</td>
<td>“As parts of earth’s surface are broken down, other parts are built up. The forces that carry away bits of weathered rock during erosion must drop them somewhere else. This laying down of pieces of rock is called deposition. Sometimes deposition happens slowly, and other times it happens very fast.”</td>
</tr>
<tr>
<td>2</td>
<td>Teacher</td>
<td>Okay, who can tell me the word they see in that “deposition.” There is a word in there.</td>
</tr>
<tr>
<td>3</td>
<td>Students</td>
<td>Position?</td>
</tr>
<tr>
<td>4</td>
<td>Teacher</td>
<td>Position. And something else? Start with d…if you take something…</td>
</tr>
<tr>
<td>5</td>
<td>Students</td>
<td>Ooh…ooh [Students wave their hands]</td>
</tr>
<tr>
<td>6</td>
<td>Teacher</td>
<td>You take something and you pick it up and you place it somewhere else. <strong>Or like if I get 20 dollars check from Grandma for my birthday, and she says “I really want you to be wise with it and do something useful with that money”, I take that money and bring it to the bank and I do what with that? What is it?</strong></td>
</tr>
<tr>
<td>7</td>
<td>Students</td>
<td>De…</td>
</tr>
<tr>
<td>8</td>
<td>Teacher</td>
<td>Sandy?</td>
</tr>
<tr>
<td>9</td>
<td>Sandy</td>
<td>Deposit.</td>
</tr>
<tr>
<td>10</td>
<td>Teacher</td>
<td><strong>I deposit…You see the word deposit? What does deposit mean? What does deposit mean? If you deposit something,</strong></td>
</tr>
<tr>
<td>11</td>
<td>Hector</td>
<td>You take it and then you put it somewhere else.</td>
</tr>
<tr>
<td>12</td>
<td>Teacher</td>
<td><strong>Yeah. You take it and put it somewhere else,</strong> So now let’s read the sentence again. Emma, would you re-read it again?</td>
</tr>
<tr>
<td>13</td>
<td>Emma</td>
<td>“The forces that carry away bits of weathered rock during erosion must drop them somewhere else”</td>
</tr>
<tr>
<td>14</td>
<td>Teacher</td>
<td><strong>Drop them somewhere else,</strong> Keep going.</td>
</tr>
<tr>
<td>15</td>
<td>Emma</td>
<td>“This laying down of pieces of rock is called”</td>
</tr>
<tr>
<td>16</td>
<td>Teacher</td>
<td>Deposition. [Teacher models how to pronounce]</td>
</tr>
<tr>
<td>17</td>
<td>Emma</td>
<td>“Deposition. Sometimes deposition happens slowly, and other times it happens very fast.”</td>
</tr>
<tr>
<td>18</td>
<td>Teacher</td>
<td>Okay, so carry away bits of weathered rock during erosion…<strong>they have to be placed somewhere else,</strong> That makes sense-deposit somewhere else.</td>
</tr>
</tbody>
</table>

In this example, the teacher first nominated one student to read aloud the textbook passage on deposition (turn 1) and then asked students to identify one word within the vocabulary word *deposition* (turn 2). Some students intuitively answered
“position” in turn 3. The teacher then guided students to unpack the nominalization deposition and to identify its constituent verb “deposit” by giving some hints in turns 4-6, including the word beginning with d, the generalized meaning of the word you take something and you pick it up and you place it somewhere else, and especially the use of the word in the bank context. The teacher in turn 6 provided a recounting of a generalized event about the habitual experience of putting grandma’s birthday money in the bank (i.e., Intertextuality to Recounting Events; Intertextuality III). It was in the context of this recounting event intertextuality that the teacher asked students to identify the exact term for such action (i.e., putting grandma’s birthday money in the bank), and Sandy was supported to answer, “Deposit” in turn 9. After identifying the constituent verb “deposit” together with students, Mrs. Dixon posed another question to the class about what does “deposit” mean (turn 10). Hector responded immediately, “You take it and then you put it somewhere else” (turn 11). On the basis of the generalized meaning of the verb “deposit” with which students are more familiar (i.e., the habitual experience of depositing grandma’s birthday money in bank and the generalized meaning of “deposit”), the teacher led students to reread the textbook passage, highlighting the part of the textbook passage related to the constituent verb “deposit” from the nominalization “deposition” (i.e., drop them somewhere else; they have to be placed somewhere else; deposit somewhere else in turns 14 and 18).

In order for students to unpack the nominalization deposition, Mrs. Dixon guided students to identify its constituent verb deposit and connect to the more familiar, generalized meaning of the action. In doing so, the teacher provided a recounting of a generalized, possibly habitual event, “depositing grandma’s birthday money into a bank.”
Such commonsense concepts, associated with students’ everyday life experiences and everyday uses of language, that is, recounting event intertextuality (Intertextuality III) supported students to draw on their more familiar everyday knowledge and language to identify the target word’s constituent verb *deposit*, to understand the nominalization *deposition* based on its verb meaning, and to connect that verb meaning to the present content of the textbook passage on *deposition*. It is also important to note that Mrs. Dixon’s students seemed to have experience in going to the bank with their parents and/or guardians and depositing money. The students could apply their shared experience of everyday knowledge to what the teacher said in this example of teacher support. If it was in the different classroom context, this may not work as an example but for this classroom it did work as an example of teacher support. The teacher, through unpacking nominalization, guided her students to register-switch between the everyday, familiar vocabulary words and the target technical nominalizations.

**Example 2.** Example 2 illustrates one instance of substituting vocabulary when technical vocabulary words are explained by the teacher using more familiar everyday vocabulary words. Introducing the earth science unit, the teacher explained the interrelationship between the social studies and science topic—the glacier formation and movement across Indiana. As we can see in Extract 4.2, it was in the explanation of the retreat of glaciers in Indiana that the teacher first mentioned the focus vocabulary using science language *retreat*. She then substituted this focus vocabulary with everyday language *move back, go back* for *retreat*, thereby register-switching between the science and everyday vocabulary words (the focus vocabulary words are underlined and boldfaced in Extract 4.2):
In this example, the teacher first drew three main regions of Indiana on the board (i.e., Great Lake Plain, Tipton Till Plain, the Southern Hills and Lowlands). Then the teacher explained how the glaciers moved outward and then retreated in these three regions of Indiana (turn 1). In this explanation the focus vocabulary word *retreated* was first mentioned and then explained by the teacher through a more familiar vocabulary substitution: *moved back* (see the underlined and boldfaced words in turn 1). Responding to students’ uncertainty of what she had just said, the teacher repeated the focus vocabulary *retreated* and once more substituted the everyday vocabulary words *moved back* for the focus vocabulary word *retreated* (turn 3). The teacher in turn 4 guided the students to build individual models of how the glaciers moved and formed the Indiana landscape by creating an ice cream model.
landscape as the glaciers moved outward and then retreated; each student was guided to
draw the three regions of Indiana on the styrofoam plate and to use the ice cream as
glaciers, Oreo cookies as dark soils, and cotton candies as clay and boulders.

During the process of building the ice cream model, the teacher in turn 5 posed
a question to the class about where they should stop moving their ice cream (i.e., the
glacier in their simulation). Gina answered, “The beginning to the two thirds” (turn 6).
The teacher acknowledged Gina’s answer and further asked what would happen to the
glacier after it stopped moving in turn 7. Some students immediately shouted out
“Melting” in turn 8 and one student responded “It kind of moves back” in turn 10. The
teacher acknowledged this student’s answer and further stated, “Yeah, it retreats, it goes
back” (turn 11). It is important to note that the teacher register-switched the student’s use
of the everyday vocabulary words It kinds of moves back into the science vocabulary
word Yeah, it retreats and once more presented it in the everyday vocabulary words it
goes back. After that register-switching, continuing in turn 11, the teacher guided
students to carry out their simulation of glaciers, embedding the movement of glaciers in
the immediate and visual context (i.e., their moving ice cream to simulate how the glacier
moves outward and moves back) with the teacher’s use of focus vocabulary words in
everyday language: “So you are gonna take your glacier at the top of Indiana, you are
gonna move it down to the center of Indiana. And then you are gonna move it back.”

The science classroom discourse related to the focus vocabulary words from this
example of substituting vocabulary (i.e., the underlined and boldfaced vocabulary words
in turns 1, 3, 10, and 11 from Extract 4.2) has been transcribed using two columns as
shown in Table 4.2. These two columns are developed on the basis of SFL to highlight a
continuum between academic language (or more specifically science language featured in the science textbook) and everyday language (e.g., Gibbons, 2006; Lemke, 1989; Schleppegrell, 2004). The left-hand column of Table 4.2 contains the vocabulary words which have specialized meaning in science such as the science vocabulary highlighted by the teacher or textbook. The right-hand column of Table 4.2 contains the vocabulary words which are more familiar to students because these words are normally used in students’ everyday social lives. These vocabulary words are also part of students’ everyday knowledge. Along with these two columns, Table 4.2 sheds light on the register-switching between the science vocabulary word *retreat* and its everyday vocabulary words *move back, go back* constructed by the teacher and students in the observed science classroom discourse.

Table 4.2  *Register-switching between Science and Everyday Vocabulary: Retreat*

<table>
<thead>
<tr>
<th>Science Vocabulary</th>
<th>Everyday Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher: They actually <strong>retreated</strong>,</td>
<td>which means they <strong>moved back</strong>,</td>
</tr>
<tr>
<td>Teacher: So they <strong>retreated</strong>,</td>
<td>They <strong>moved back</strong></td>
</tr>
<tr>
<td>Student:</td>
<td>It kind of <strong>moves back</strong>,</td>
</tr>
<tr>
<td>Teacher: Yeah, it <strong>retreats</strong>,</td>
<td><strong>goes back</strong></td>
</tr>
<tr>
<td>Teacher:</td>
<td>And then you are gonna <strong>move</strong> it <strong>back</strong>.</td>
</tr>
</tbody>
</table>

It is clear from this table that most of the register-switching between science vocabulary and everyday vocabulary was done by the teacher. Mrs. Dixon constantly register-switched back and forth between the science vocabulary word *retreat* and its everyday vocabulary words *move back, go back* when she was explaining the glaciers’ movement in Indiana and guiding her students to build the ice cream model to simulate the movement. Such constant register-switching between the science and everyday vocabulary words has a significant role for linking science with students’ more familiar
everyday use of language. Lemke (1989) has suggested that it is through the more familiar and comfortable language of everyday speech that students reason themselves through the new scientific concepts to arrive at scientific understanding. As we can see in Table 4.2, the student selected the everyday vocabulary words *It kind of moves back* to answer the teacher’s question; the student’s language choice indicates that the student was more comfortable using not their unfamiliar targeted science vocabulary word *retreat* but the focus vocabulary in everyday language to express the new understanding of scientific concepts. Equally noteworthy is that at the beginning of learning new scientific concepts, there should be a great deal of teacher modeling of register-switching back and forth between science and everyday vocabulary in various contexts, just as what Mrs. Dixon did—she constantly register-switched between science and everyday vocabulary during her explanations and the experiments (hands-on simulations). Teachers who belong to a community of people who already speak the language of science have a better position from which to model how to register-switch back and forth between science and everyday language and thus to promote the practice of moving back and forth between two registers of the same language (i.e., science and everyday vocabulary words in English) when teaching a new science topic.

**Example 3.** Another instance of substituting vocabulary occurred when students discussed their ideas in their more familiar everyday vocabulary words. The teacher then substituted the science vocabulary words for the everyday vocabulary words, as shown in Example 3 (the focus vocabulary words are underlined and boldfaced in Extract 4.3):

Extract 4.3 (Example 3)

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Topic on People and the Environment</th>
</tr>
</thead>
</table>

*Example 3.*
In this example, the teacher posed a question to the class about some ways in which human activities affect the environment, to which some students answered with the human activities of cutting forests and hunting animals (turn 1). Dishita, one of the Level 5 ELLs from India, was concerned about the natural environment in which animals live and said, “if they cut down the forests, they also like cut down…there is a…I don’t know, like an animal house that they have cut down.” (turn 2). The teacher, in turn 3, for Dishita’s initiated use of the focus vocabulary in everyday vocabulary words an animal house, substituted the science vocabulary habitat. Agreeing on the teacher’s substitute of habitat, Dishita repeated the focus vocabulary habitat and yet she shifted back to her use of the everyday vocabulary words to elaborate on her idea: “They wouldn’t have places to live” (turn 4). Later the teacher, in turns 5 to 6, expanded on some ways human activities affect the environment by directing her students’ attention on the textbook picture, which illustrates that people changed the area by building a road in the middle of the wild forest. Together, the teacher and students discussed the textbook question, How might this change affect other organisms? Paula took up the focus vocabulary in science
language and responded to this question, “We might just destroy their habitats or just destroy the habitats on their plain?” (turn 7). The teacher acknowledged Paula’s answer by emphasizing, “It definitely can destroy the habitats” and further elaborated on Paula’s answer with the visual context provided by the textbook picture: “Look at that whole section of woods that has been cut away” (turn 8). Because the teacher embedded the meaning of the focus vocabulary using the visual context (i.e., the textbook picture), the focus vocabulary was once more presented in the science language: “So it could destroy habitats” (end of turn 8).

The classroom discourse related to the focus vocabulary from this example of substituting vocabulary (i.e., the underlined and boldfaced vocabulary words in turns 2, 3, 4, 7 and 8 from Extract 4.3) has been transcribed using two columns as shown in Table 4.3. This table, with the two columns of science vocabulary and everyday vocabulary featured by SFL researchers, sheds light on the register-switching between the science vocabulary word habitat and its everyday vocabulary words an animal house, places to live in the observed science classroom discourse on the topic of some ways human activities affect the environment.

Table 4.3 Register-switching between Science and Everyday Vocabulary: Habitat

<table>
<thead>
<tr>
<th>Science Vocabulary</th>
<th>Everyday Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dishita:</td>
<td>like an animal house that they have cut down</td>
</tr>
<tr>
<td>Teacher: Habitat</td>
<td>They wouldn’t have places to live.</td>
</tr>
<tr>
<td>Dishita: Yeah, habitat</td>
<td></td>
</tr>
<tr>
<td>Paula: We might just destroy their habitats or just destroy the habitats on their plain?</td>
<td></td>
</tr>
<tr>
<td>Teacher: It definitely can destroy the habitats.</td>
<td>Look at that whole section of woods that has been cut away.</td>
</tr>
<tr>
<td></td>
<td>So it could destroy habitats.</td>
</tr>
</tbody>
</table>
Ciechanowski (2009) has pointed out that students are often most comfortable understanding what is explained to them in their familiar language and discussing ideas with their more familiar everyday language, not with science language. Therefore, most students at first will not readily take up science language in the same way that teachers or science written texts (science textbook passages) use it. This appears to be especially true for ELLs who need extended time and instructional support, compared to their native English-speaking peers, to catch up with academic English for school learning (Cummins, 2000). As shown in Table 4.3, these two students, Dishita and Paula, have drawn on very different kinds of language to present the meaning of the focus vocabulary. Dishita, one Level 5 ELL from India, initiated the use of the focus vocabulary in the more familiar everyday language and further elaborated on her ideas with the everyday vocabulary words: “like an animal house that they have cut down” and “They wouldn’t have places to live.” (This is documented in the right column of Everyday Vocabulary of Table 4.3.) Paula, a native English-speaking student, took up the science vocabulary habitat to answer the textbook question: “We might just destroy their habitat or just destroy the habitats on their plain.” (This is documented in the left column of Science Vocabulary of Table 4.3.) A comparison of these two students’ language choices shows that Dishita appeared to be more comfortable with using the everyday vocabulary words to present the meaning of the focus vocabulary, whereas her native English-speaking peer took up the science vocabulary word to express her understanding.

In order for all students, including ELLs, to develop academic English expected in school science learning, teachers who belong to a community of people who already speak the language of science have a better position from which to model how to register-
switch back and forth between science and everyday vocabulary (Lemke, 1990). As we can see in Table 4.3, the teacher modeled much register-switching during the whole-class discussion of people and the environment. This modeling supported the development of academic English for all students. Table 4.3 shows that the teacher first substituted the science vocabulary habitat for the ELL student’s initial use of the focus vocabulary in her familiar everyday language “like an animal house that they have cut down.” Later, the teacher asked her students to answer the textbook question accompanying the textbook picture. She acknowledged the native English-speaking student who took up the focus vocabulary in science language “We might just destroy their habitat or just destroy the habitats on their plain.” Along with the textbook picture (people changed the area by building a forest road), the teacher further embedded the meaning of the science vocabulary word into the visual context provided by the textbook picture “Look at that whole section of woods that has been cut away” and once more presented the meaning of focus vocabulary in science language “It definitely can destroy the habitats.” The teacher’s constant register-switching back and forth between science and everyday vocabulary in the various contexts (e.g., whole class discussion, visual context provided by the textbook photo) play a significant part in students’ comprehension of the new science concepts being discussed. It can also provide more opportunities for students to hear and talk about the focus vocabulary in both scientific ways of using language and everyday ways of using language.

To summarize this section, these three examples of register-switching between science and everyday vocabulary are considered as the first major kind of support the teacher provided to students in the observed science classroom discourse. These three
examples detail how the teacher supported students learning the field-specific vocabulary, including the nominalizations and technical terms, in her moment-to-moment teaching. A pervasive feature of science textbooks, field-specific vocabulary words express specialized meaning in science and construct dense explanations in earth science textbook passages. These words and explanations are not part of students’ everyday knowledge and far removed from students’ familiar everyday language. As Mrs. Dixon emphasized in the interview, learning the field-specific vocabulary was considered the most challenging literacy task encountered by her students learning this earth science unit. In order for her students to learn the field-specific vocabulary, the teacher unpacked nominalizations and substituted vocabulary, which enabled the teacher and students to go back and forth between their more familiar everyday vocabulary words and science vocabulary words.

An increasing body of research has considered what I term in this chapter “register-switching” between science and everyday language in relation to science teaching and learning. Brown & Ryoo (2008), in their study implementing software into the science curriculum, highlighted the importance of students’ learning of scientific terminology and concepts in everyday terms prior to being taught science language. However, beyond this linear perspective of teaching and learning scientific terminology and concepts from everyday language to science language, the teacher I observed in the fourth grade science classroom setting built the bridging science classroom discourse by register-switching back and forth between science and everyday vocabulary words to cover the difficulties students encountered for their learning of the field-specific vocabulary. Such constant register-switching back and forth between science and
everyday vocabulary, through instances of unpacking nominalization and substituting vocabulary, provided students multiple points of access to the scientific content and language featured in the science textbook. Especially for the Level 4-5 ELLs in the upper elementary mainstream classroom such as Mrs. Dixon’s science classroom, they did have fluency in everyday English (they were fluent in conversational English) but what they needed most was their development of academic English by gaining multiple access to link what they were familiar with (everyday English, commonsense concepts) to what they were learning about (scientific English, scientific concepts). Mrs. Dixon modeled bridging discourse, register-switching between science and everyday vocabulary in whole-class discussions of the science concepts and terminology highlighted in the textbook passages. Students could thus learn to bridge from their more familiar everyday knowledge and language to their unfamiliar science knowledge and language and thereby enhance the intertextual connections.

4.2.2 Using Metaphor and Analogy Directly Related to Everyday Experiences

The second major kind of support was the incorporation of metaphor and analogy into the science curriculum. Mrs. Dixon presented some metaphors and analogies to engage students in the discussion of the scientific terminology and concepts highlighted in the textbook passages. The use of metaphors and analogies allowed the teacher to put the new and/or abstract scientific terminology and concepts into familiar terms more easily understood by the students. Aubusson, Harrison, and Ritchie (2006) noted that metaphors and analogies are used in science education to compare one thing that is less familiar (i.e., target scientific concept) to another thing that is more familiar (i.e., familiar concept in everyday life). Metaphors and analogies are especially useful in
helping students build connections from familiar, everyday concepts to unfamiliar scientific concepts. Consider the following two examples from the observed science classroom discourse. These reveal how the teacher drew on metaphors and analogies to explain the scientific terminology and concepts the students were learning about.

**Example 4.** When introducing the earth science unit, Mrs. Dixon stressed the interrelationship between social studies and science—the glacier formation and movement across Indiana. In the following, Mrs. Dixon was teaching the process of glacier formation both from and with the textbook passage, including the textbook picture about

*From Snow to Ice:*

> Snow is made of fluffy flakes that trap air in the new snow layer. As new snow melts in the day and refreezes at night, it gets more compact. This mature snow is called neve. It soon packs into hard ice.

Mrs. Dixon directed the students to look at the tube in the textbook picture where it specified names for layers of snow. Mrs. Dixon then summarized the content of this textbook passage to elaborate on how glaciers are formed from freshly fallen snow. As more and more snow piles up over time, the weight of the snow on top starts to pack the snow at the bottom. Such packing can turn snow into hard ice. As shown in Extract 4.4, in order for her students to understand how the packing can turn snow into ice, the teacher presented a snowball-making metaphor and analogy (metaphorical words and phrases are underlined and boldfaced in Extract 4.4):

**Extract 4.4 (Example 4)**

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Topic on Glacier Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td><em>...so if you ever make like a really good snowball before. You</em></td>
</tr>
</tbody>
</table>
At the beginning of this example, the teacher explained further how glaciers are formed from freshly fallen snow. She asked if her students had ever made snowballs, bringing up their familiar topic of snowball making in turn 1. The teacher continued providing a recounting of a generalized event about the habitual experience of making a hard snowball by taking a handful fluffy snow and packing it. As she recounted, she also made a dramatic gesture of packing (i.e., Recounting Events Intertextuality; Intertextuality III). The recounting events intertextuality was used to explain how every glacier is formed from freshly fallen snow (see turn 1). The teacher compared the target scientific concept of glacier formation to the generalized event of making a hard snowball. The teacher emphasized the similarity of the scientific concept and the generalized event-
- the pack can turn snow into ice. Along with her repeated gesture of packing, she thereby constructed the snowball-making metaphor and analogy. The teacher, through comparison and contrast made explicit connections between what the learners already knew (the habitual experience of making a hard snowball) and the new concept of glacier formation.

It was in the context of this metaphor and analogy that Mrs. Dixon’s students were supported in making sense of the glacier formation through their more familiar habitual experience of making a hard snowball by packing the snow. Extract 4.4 shows the teacher’s use of the snowball-making metaphor and analogy together with her engaging questions. *They are painful, aren’t they? Those of you experience that?* prompted her students to share their recounts of personal specific events about snowball making and fighting (i.e., Intertextuality to Recounting Events; Intertextuality III) in turns 6, 8, and 12. In these students’ recounts of specific events, they shared their similar experiences of making hard snowballs and/or being hit by hard snowballs. Namely, these students’ shared their personal events of snowball-making. This sharing indicates that Mrs. Dixon’s use of the snowball-making metaphor and analogy, directly related to students’ everyday experiences, grabbed her students’ attention and engaged them in more discussion on their familiar experiences. This example reinforces the importance for students to link what they already know to new concepts.

Aside from the students’ intertextuality to personal specific events prompted by the teacher’s use of metaphor and analogy, other ideas were offered. Ying (a Level 4 ELL student) in turn 4, suggested they should have an experiment on glacier formation (i.e., Intertextuality to Experiment; Intertextuality II). Dishita (a Level 5 ELL student) in turn
10, offered one intertextual connection to the target scientific concept (i.e., glacier formation) asking the teacher how ice is formed. The teacher, therefore, had a chance to incorporate the thematic content highlighted by the textbook passage (i.e., new snow melts and refreezes to turn into ice) in the classroom discussion and to build an intertextual connection to the textbook content (Intertextuality to Written Texts; Intertextuality I). An examination of the various intertextual connections built by the teacher and students in the observed science classroom discourse shows that the class was highly interactive, partly because Mrs. Dixon’s use of the snowball-making metaphor and analogy was directly related to students’ everyday experiences. The metaphor and analogy, along with the intertextual connection to the habitual experience of making a hard snowball, piqued the students’ interest and engaged them in this classroom discussion of glacier formation.

What was seen in Mrs. Dixon’s classroom has been observed in previous studies. For example, metaphors and analogies, as emphasized by Lemke (1990), are frequently used by teachers to engage students in class discussion of the new and abstract scientific concepts by tapping into students’ previous knowledge and their familiar everyday experiences. From his observation of secondary science classrooms, Lemke (1990) pointed out that students are more likely to pay attention to the familiar content and language in metaphors and analogies than to unfamiliar content and language of the scientific terminology and concepts highlighted by the science textbook passages. I will validate this observation through a finer grained analysis of the observed classroom discourse in the context of the teacher’s snowball making metaphor and analogy. Along with the macro-level analysis of Extract 4.4 (the different kinds of intertextuality), the
micro-level intertextual analysis is also used to highlight the different kinds of content and language encountered and produced by the teacher and students, as I will show in the following transitivity analysis based on SFL.

Transitivity Analysis of Teacher’s Use of Snowball Making Metaphor and Analogy. Systemic functional linguistics (SFL) offers a way to characterize content and language of a text. A functional linguistic construct--valuable to understand how the content of a text is linguistically presented--is the system of transitivity. Under the system of transitivity, the Processes, Participants, and Circumstances are three resources constructing the content of a text. Especially noteworthy are the patterns of Participants and Processes, which show how the content of a text is presented through language (e.g., Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2001). Participants, who or what the sentence is about, are linguistically expressed through nouns. Processes, what Participants are doing or how they are described, are linguistically expressed through verbs. The various types of Processes are further divided by Martin & Rose (2003) and Fang & Schleppegrell (2008) into four major categories: doing, being, sensing, and saying (see Section 3.5.3 for more detail on the four types of Processes and the system of transitivity), which will be used to identify the patterns of Processes in the focus texts (see Table 4.4).

Transitivity analysis based on SFL is used to analyze the patterns of nouns, nouns in the position of Subjects (i.e., Subjects) and verbs of the four texts used in the context of the teacher’s use of the snowball-making metaphor and analogy. Table 4.4 outlines these four texts--the textbook passage From Snow to Ice (Text 1), the teacher’s recounting events intertextuality (Text 2), the teacher’s link between everyday and
scientific concepts (Text 3), and the students’ recounting events intertextuality (Text 4)---and further presents a transitivity analysis. Nouns are marked in boldface, nouns in the position of Subjects (Subjects) are marked in boldface as well as underlined, and verbs are marked in italics.
### Table 4.4  Transitivity Analysis of Teacher’s Use of Snowball-making Metaphor and Analogy

<table>
<thead>
<tr>
<th>Text Examples</th>
<th>Language Features</th>
</tr>
</thead>
</table>
| **Text 1: Textbook Passage**  
**Snow** is made of fluffy flakes that trap air in the new snow layer.  
As **new snow** melts in the day and refreezes at night, **it** gets more compact.  
**This mature snow** is called névé.  
**It** soon **packs** into **hard ice.** | Field-specific  
lexical and complex nouns; lexical Subjects (nouns); being Processes in passive voice and doing Processes |
| **Text 2: Teacher’s Intertextuality to Recounting Events**  
so if **you** ever make like a really good snowball before.  
**You** pack,  
**you** pack,  
and **you** pack it.  
**It** ends up turning really hard.  
**They** are painful, aren’t **they?**  
**Those of you** experience that?  
**It’s** really hard  
and **it** becomes really icy. | Everyday vocabulary,  
generic nouns; pronominal Subjects (pronouns); doing Processes, being Processes (attributive), and sensing Processes |
| **Text 3: Teacher’s Link between Everyday and Scientific Concepts**  
… **every glacier** just starts with the fresh snow.  
**Snow** pack on,  
**air** squeezes out,  
**pack, pack, pack,** hard, hard, hard.  
And then **it** turns to the **ice.**  
And **it** becomes the **ice,**  
and then **what** happens?  
**Snow** some more, start packing, becoming ice.  
And then eventually **you** got this huge amount of **ice.** | A mix of field-specific and everyday vocabulary; a mix of lexical and pronominal Subjects; doing Processes and being Processes |
| **Text 4: Students’ Intertextuality to Recounting Events**  
Um, last winter, my… **we had snowball fight** (Sandy)  
and **we made snowballs,**  
(**we**) hid behind.  
And **my brother, Daniel,** he **made one,**  
so **it** got really solid…  
that when **we** tried to break,  
**it** did not break.  
Well, **it’s** kind of like **her.** (Tufan)  
**We** kind of had snowball fight.  
**It** hit so hard on **me.**  
**My cousin** packed the **snowball** so hard, so heavy. (Sara)  
And **my nose** started bleeding. | Everyday vocabulary,  
generic nouns; pronominal Subjects (pronouns); doing Processes in past tense; verbal hedge (“kind of”) |
A transitivity analysis of these four texts reveals the very different vocabulary choices made by the textbook author, the teacher, and the students when constructing the content of each text. Vocabulary is said to be an obvious feature of the different kinds of language because it is the lexical choices that express the content of each text (Biber, 2012; Lemke, 1989; Schleppegrell, 2001). As we can see in Table 4.4, the nouns boldfaced in Text 1 (the textbook passage From Snow to Ice) appear to be technical, long, and complex. These technical nouns which introduce the field-specific vocabulary—new snow, mature snow, névé—and the long and complex noun, made so through modifiers—fluffy flakes that trap air in the new snow layer—describe the different layers of snow and how the ice is formed from snow and convey, not part of everyday knowledge, but specialized knowledge in science. With the use of the technical, long, and complex nouns, the content of Text 1 appears far removed from the lived experiences of the students’ everyday world.

Also with the nouns in the position of subject, Text 1 includes numerous lexical Subjects snow, new snow, this mature snow which accompany the being Processes in the passive voice is made of, is called to define particular science phenomenon snow, névé. These lexical Subjects also accompany the doing Processes melts, refreezes, packs to construct how ice is formed from snow. More specifically, Text 1 has numerous lexical Subjects and two pronominal Subjects it and these nonhuman Subjects enable a focus on “things” (i.e., the science phenomenon-layers of snow). It gives Text 1 seeming objectivity by enabling the absence of reference to any human actor who observes and/or names each particular layer of snow. Together, the recognized patterns of nouns, Subjects, and verbs in Text 1—technical, long, and complex nouns, use of lexical and nonhuman
Subjects accompanying the being Processes in passive voice and doing Processes--can be described to be the technical, information-packaged, and objective language typical of school science textbooks (de Oliveira, 2010; Fang, 2008; Schleppegrell, 2004).

This kind of technical, information-packaged, and objective language in Text 1 might present unique comprehension challenges for Mrs. Dixon’s students as novice readers. When students face this passage (Text 1), they need to deal with the multiple demands of understanding technical information attached to the field-specific vocabulary and processing the dense information packaged into the long and complex nouns, while at the same time constructing how ice is formed from snow by understanding the verbs. Although they had mastered basic reading skills, according to the teacher, students nevertheless found reading the textbook passage difficult because of their unfamiliarity with the range of science language features (e.g., technical, long, and complex nouns; use of lexical and nonhuman Subjects).

In support of her students comprehending the textbook passage, Mrs. Dixon guided her students to look at the textbook picture, which displays several layers of snow, and she elaborated on how glaciers (the bottom layer) are formed from freshly fallen snow (the top layer). As we can see in Text 2, the teacher made recounting events intertextuality about the habitual experience of making a hard snowball, thereby presenting the snowball-making metaphor and analogy in support of her students’ comprehension of the textbook content. A comparison between Text 2 and Text 1 highlights that the teacher used the ordinary, frequent occurring vocabulary out of everyday life experiences, or so-called everyday vocabulary, to recount the generalized event of making a hard snowball that might have been habitually experienced. The
teacher’s lexical choices in Text 2 are more generic a really good snowball than those of the field-specific vocabulary words névé, glacier ice in Text 1 that convey specialized meaning in science. In Text 2, the teacher used numerous pronouns in the position of Subjects, including human pronouns you, they, those of you and nonhuman pronouns it. This reflects that the teacher and students had face-to-face contact in the same place at the same time and therefore could share the ongoing context for interpreting these pronominal Subjects, different from the lexical Subjects in Text 1. An examination of the choices of nouns and Subjects in Text 1 and Text 2 illuminates the point that Text 2, with the use of everyday vocabulary, generic nouns, and pronominal subject, sounds more familiar. That results because its vocabulary choices closely approximate the type of vocabulary words that student normally have in their everyday lives. In contrast, Text 1 sounds distant from students’ everyday life in part because of the field-specific vocabulary word choices.

Regarding the choice of Processes, linguistically expressed by verbs, in Text 2, the teacher included the use of doing Processes make, pack to construct the habitual action of making a hard snowball. Additionally, she used the being process (attributive) in the engaging question They are painful, aren’t they to evaluate the habitual experience of being hit by the hard snowballs. These language features--use of everyday vocabulary, pronominal Subjects, and doing Processes--typical of everyday language in interactional spoken discourses, were drawn on by the teacher to construct the recounting events intertextuality (Intertextuality III). This recounting events intertextuality used everyday language for the snowball-making metaphor and analogy, directly relating to the lived experiences of the students’ everyday world.
Extending from the textbook passage (Text 1) and the teacher’s intertextuality to recounting events (Text 2), the teacher further compared the target scientific concept of glacier formation to the event about making a hard snowball with emphasis on their similarity (that is, the pack can turn snow into ice). Thereby she linked everyday concepts (i.e., making a hard snowball by packing snow into ice) and scientific concepts (i.e., forming glaciers by packing snow into ice) in Text 3. An examination of these three texts (Text 1, Text 2, Text 3) highlights that the teacher brought together the science language of the textbook passage, the everyday language of the teacher’s recounting events intertextuality, and the mixed language of the teacher’s link between everyday and scientific concepts. She thus produced hybrid language to build a bridge from what students already knew to new learning. Such hybrid language in the classroom discourse has been characterized in teaching science (Lemke, 1989, 1990). Examining the patterns of nouns and Subjects in these three texts can show the different types of language encountered by students and how the hybrid language can support students to connect everyday concepts with scientific concepts. Table 4.5 outlines all the nouns from these three texts, including the nouns in the position of Subjects, with nouns are marked in boldface and Subjects are marked in boldface as well as underlined:
Table 4.5  *Nouns in the Three Texts in Teacher’s Snowball-making Metaphor and Analogy*

<table>
<thead>
<tr>
<th>Science Language</th>
<th>Everyday Language</th>
<th>Mixed Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text 1</td>
<td>Text 2</td>
<td>Text 3</td>
</tr>
<tr>
<td>snow</td>
<td>You</td>
<td>every glacier</td>
</tr>
<tr>
<td>fluffy flakes that trap</td>
<td>a really good snowball</td>
<td>the fresh snow</td>
</tr>
<tr>
<td>air in the new snow layer</td>
<td>you</td>
<td>snow</td>
</tr>
<tr>
<td>new snow</td>
<td>you</td>
<td>air</td>
</tr>
<tr>
<td>it</td>
<td>you</td>
<td>it</td>
</tr>
<tr>
<td><em>this mature snow</em></td>
<td>it</td>
<td>the ice</td>
</tr>
<tr>
<td>névé</td>
<td>it</td>
<td>it</td>
</tr>
<tr>
<td>it</td>
<td>they</td>
<td>the ice</td>
</tr>
<tr>
<td>hard ice</td>
<td>those of you</td>
<td>snow</td>
</tr>
<tr>
<td></td>
<td>that</td>
<td>you</td>
</tr>
<tr>
<td></td>
<td>it</td>
<td>this huge amount of ice</td>
</tr>
</tbody>
</table>

As shown in Table 4.5, Text 1 involves the technical, long, and complex nouns (i.e., the field-specific vocabulary) and numerous lexical Subjects, fully characteristic of science language. In contrast, Text 2 is filled with everyday vocabulary and numerous pronominal Subjects *you, those of you, it, they,* and its language closely approximates the type of language that students normally use in their everyday lives (i.e., everyday language). In Text 3, the teacher has a mix of the field-specific vocabulary and everyday vocabulary as well as a mix of lexical Subjects *every glacier, snow, air, ice* and pronominal Subjects *it, you,* thereby mixing both science and everyday language. It is in these three texts that the teacher brings together science, everyday, and mixed language to contribute to the hybridity of the science classroom discourse for teaching science (i.e., how glaciers can be formed from the packing snow into ice).

Such hybridity in science classroom discourse is significant in my observed earth science classes for it allows for the teacher to connect everyday knowledge and everyday
language to science knowledge and science language, thereby making the targeted scientific concepts easier for her students to understand and to make some intertextual connections. For example, as we can see in Text 4 of Table 4.4, encouraged by the teacher’s recounting events intertextuality and her use of the snowball-making metaphor and analogy, some students shared their personal specific events about making hard snowballs and/or being hit by hard snowballs. Thus, they drew on their familiar everyday language to participate in the classroom discussion. Referring to the students’ choices of Participants or nouns, Text 4 contains everyday vocabulary (*snowball fight, snowballs, my nose*) and human pronouns and Participants (e.g., their siblings and relatives) in the position of Subjects. Along with the human pronouns and Participants, students also used a lot of doing Processes in the past tense *had, hid, made* to recount their personal events of snowball making and fighting. The students’ intertextual connections to personal specific events (Intertextuality III) were linguistically achieved through their choices of nouns and verbs--everyday vocabulary, pronominal Subjects, and doing Processes in past tense--typical of everyday language, to recount the particular persons, objects, and places related to their experiences of snowball making. Text 4 also contains students’ verbal hedging (e.g., *kind of*) to make their statement less assertive. Additionally, students used a range of spontaneity phenomena such as hesitations, repetitions, and interruptions, which are commonly seen in everyday language (Eggins, 2004).

Taken together, the transitivity analysis of all four texts (see Table 4.4) allows us to focus on the different patterns of nouns, Subjects, and verbs to construct the content of each text in terms of language. It is not surprising, then, that the language constructs of school science knowledge (i.e., the textbook passages--Text 1) differs in significant ways
from the type of language students typically use in students’ responses (i.e., Text 4).

Given the relative novelty of the school science textbook language to most students, providing substantial support for students to understand the content of the textbook passages is necessary. It is in the context of the three texts (Text 1, Text 2, Text 3) that the teacher brought together the science language characteristic of the textbook passage, the everyday language of the teacher’s intertextuality to recounting events, and the mixed language of both science and everyday language to elaborate on the snowball-making metaphor and analogy, resulting in hybridity in the science classroom discourse. Such hybridity through snowball-making metaphor and analogy allowed students to draw on their more familiar content and language in metaphors and analogies and thereby to understand the target science concepts highlighted in the textbook passage more easily, also noted by Lemke’s (1990) observation. Additionally, research emphasizes that in order for teaching and learning science to occur, a critical element in the construction of links between what students already know and target science concepts is the supporting role of teachers in bridging between everyday and science language (Gibbons, 2006; Lemke, 1990). As students saw and heard how the teacher shifted back and forth between the science, everyday, and mixed language to talk science, students linked the textbook content to their more familiar concepts of making a hard snowball. They were also encouraged to draw on their familiar everyday language for sharing their personal specific events to co-construct science understanding in the science classroom discourse.

Example 5. In another example of the teacher’s use of metaphor and analogy directly related to students’ everyday experiences, the teacher explained written instructions for an experiment that her students would later carry out in groups. The
experiment was designed to compare which soil—either sandy or clay could hold more water. Each group of students was to measure the mass of different types of damp soils to compare how much water each held, following the procedures listed in the textbook passage (Buckley et al., 2012, p. 174), as shown in the following:

1. Put each soil in a filter cup. Measure the mass of each filter cup with soil. Make sure they have the same mass. Record your data.
2. Use a spoon to gently pack down the soil.
3. Place each filter cup of soil inside a clear plastic cup. Slowly pour 50 ml of water on each soil sample. Wait 20 minutes. Record the mass of each soil sample.

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Mass of dry soil (g)</th>
<th>Mass of wet soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay soil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Along with the listed experiment procedures, the textbook displayed the experiment materials with the photographs as well as provided all the required experiment materials except for filter cups (i.e., the experiment kits come with the textbook at the beginning of semester). In order for students to make two filter cups for each group, the teacher first asked each group to check if there were ten holes poked into the bottom of each foam cup labeled with sandy and clay soil respectively. Then each group was guided to make the filter papers out of paper towels, which would later be put inside each foam cup poked with ten holes. Thus, the foam cup with the handmade filter was to function as the filter cup. Instead of a lengthy explanation of how students could use the paper towels as filter papers, the teacher presented a “coffee filter paper” metaphor and analogy to explain how a paper towel can act as filter paper (metaphoric words and phrases are boldfaced and underlined in Extract 4.5):
Extract 4.5 (Example 5)

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Explanation of How Paper Towel Can Act as Filter Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td>Okay, if you ever made coffee before or see your parents ever making coffee, they have to put the coffee in the cup. If you just put coffee in the cup though, you would probably get some of the coffee grounds in your drink. So to prevent that, does anyone see what their parents do? What do they put inside the cup, above the holes, above the filter? Above this, they put what in there?</td>
</tr>
<tr>
<td>2</td>
<td>Gina</td>
<td>Well, it's kind of like cupcake paper except that's much bigger. It's like coffee filter…</td>
</tr>
<tr>
<td>3</td>
<td>Teacher</td>
<td>Yeah, just like that, too. But I like your description. It looks almost like the cupcake paper. And if you put it in there, and pour the water go through itself, yes except the holes are even tinier than these. So it makes so...none of the coffee [grounds] would go through. So we are actually making something to work like coffee filter. Because these holes, we would really want to prevent the soils from going through.</td>
</tr>
</tbody>
</table>

To reiterate, in Example 5, following the textbook’s instruction, the students were to compare which soils would hold more water. For the first step, each group needed two filter cups. Consequently, presenting the “coffee filter paper” metaphor and analogy, the teacher explained how to make filter papers from paper towels. The teacher in turn 1 provided a recounting of a generalized event about the habitual experience of parents preventing coffee grounds from getting into their coffee beverage (Intertextuality to Recounting Events; Intertextual III). In the context of this link, the teacher asked if her students had ever made coffee or seen their parents making coffee. Next the teacher asked what their parents might need to put inside the cup to prevent the coffee grounds from getting into their coffee drink. Though the student Gina did not know the exact term, she related to her habitual experience involving cupcake papers and constructed a different metaphor and analogy for it, Well, it’s kind of like cupcake paper except that’s much bigger...it’s like coffee filter to express her understanding of the concept highlighted by the teacher (turn 2). The teacher accepted Gina’s cupcake paper metaphor
and analogy and her intertextuality to recounting events (Intertextual III) in turn 3. The teacher also appreciated the similarity between cupcake paper and coffee filter paper (look alike) noticed by the student. This noticing was important for enriching the other students’ understanding of the target concept--coffee filter paper. Cupcake paper is a more familiar concept, habitually experienced more by more students in their daily lives (the fourth grade students tend to know and experience more with cupcakes not coffee in their daily life). Continuing turn 3, the teacher further elaborated on how the coffee filter paper works to stop the grounds from getting into the coffee drink. Thus, by means of the “coffee filter paper” metaphor and analogy, the teacher linked the everyday concepts (i.e., the coffee filter paper) and scientific concepts (i.e., the filter cup in the soil experiment) to explain how the paper towel can function as a filter paper to prevent soil from going through the holes.

Transitivity Analysis of Teacher’s Use of Coffee Filter Paper Metaphor and Analogy. To take a close look at the language encountered and produced by the students in the teacher’s use of the coffee filter paper metaphor and analogy, a transitivity analysis based on SFL is used to analyze the written instructions of the textbook experiment (Text 1), the teacher’s intertextuality to recounting events (Text 2), the student’s intertextuality to recounting events (Text 3), and the teacher’s link between everyday and scientific concepts (Text 4). Table 4.6 outlines these four texts and some language patterns that distinguish the different kinds of language encountered and used by the students in the science classroom discourse, with nouns are marked in boldface, nouns in the position of Subjects (Subjects) are marked in boldface as well as underlined, and verbs are marked in italics.
### Table 4.6 Transitivity Analysis of Teacher’s Use of Coffee Paper Metaphor and Analogy

<table>
<thead>
<tr>
<th>Text Examples</th>
<th>Language Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Text 1: Textbook Passage</strong></td>
<td>Field-specific vocabulary, long and complex nouns; the absence of human Participants, the understood subject (you); use of doing Processes</td>
</tr>
<tr>
<td>1. <em>Put each soil in a filter cup. Measure the mass of each filter cup with soil. Make sure they have the same mass.</em> Record your data.</td>
<td></td>
</tr>
<tr>
<td>2. <em>Use a spoon to gently pack down the soil.</em></td>
<td></td>
</tr>
<tr>
<td>3. <em>Place each filter cup of soil inside a clear plastic cup.</em> Slowly pour 50 mL of water on each soil sample. Wait 20 minutes. Record the mass of each soil sample.*</td>
<td></td>
</tr>
<tr>
<td><strong>Text 2: Teacher’s Recounting Events Intertextuality</strong></td>
<td>Everyday vocabulary, generic noun; pronominal Subjects (you, they); doing Processes</td>
</tr>
<tr>
<td>Okay, if <em>you</em> ever made coffee before or see your parents ever making coffee, <em>they</em> have to put the coffee in the cup. If you just put coffee in the cup though, <em>you</em> would probably get some of the coffee grounds in your drink. So to prevent that, does anyone see what their parents do? <em>What</em> do <em>they</em> put inside the cup, above the holes, above the filter? Above this, <em>they</em> put what in there?</td>
<td></td>
</tr>
<tr>
<td><strong>Text 3: Student’s Recounting Events Intertextuality</strong></td>
<td>Everyday vocabulary; pronominal Subjects; being Processes (attributive); verbal hedge (kind of)</td>
</tr>
<tr>
<td>Well, <em>it’s</em> kind of like <em>cupcake paper</em> except <em>that’s</em> much bigger <em>it’s</em> like <em>coffee filter</em></td>
<td></td>
</tr>
<tr>
<td><strong>Text 4: Teacher’s Link between Everyday and Scientific Concepts</strong></td>
<td>A mix of field-specific and everyday vocabulary; a mix of lexical and pronominal Subjects; being Processes and doing Processes</td>
</tr>
<tr>
<td>Yeah, just like that, too. But <em>I</em> like <em>your description.</em> <em>It looks</em> almost like <em>the cupcake paper.</em> And if <em>you</em> put it in there, and pour the water go through itself, yes except <em>the holes</em> are even tinier than <em>these.</em> So <em>it</em> makes so <em>none of the coffee</em> [grounds] <em>would</em> go through. <em>So we</em> are actually making something to work like <em>coffee filter.</em> Because these holes, <em>we</em> would really want to prevent <em>the soils</em> from going through.</td>
<td></td>
</tr>
</tbody>
</table>
As Table 4.6 indicates, a transitivity analysis of Text 1 allows us to identify the patterns of nouns, Subjects, and verbs in constructing the procedural instructions Mrs. Dixon’s students were expected to follow in the science experiment. While guiding students to do this experiment, the teacher had them put their science textbooks on their desks and turn to the procedural instructions of the textbook experiment (Buckley et al., 2012, p. 174). This textbook passage (Text 1) contains a list of procedural instructions, specific kinds and amounts of experiment materials, and the data table to record their later results. In order to comprehend Text 1--procedural instructions commonly seen in the science textbook experiments--the students needed to understand what constituted this type of written text. Regarding the use of Participants or nouns, the nouns boldfaced in Text 1 appear to be technical, long, and complex. The technical nouns, including the field-specific vocabulary *each soil, the same mass, your data* and the long and complex nouns through modifiers *the mass of each filter cup, 50 mL of water, the mass of each soil sample,* convey specialized meanings in science, naming specific kinds and amounts of materials required in the soil experiment. Another feature of Text 1 is the absence of human Participants and the understood subject *you* in each clause. Namely, the subject in each clause is the human pronoun “you,” but because it is not written in the clause, it is the understood subject “you.” As for the patterns of Processes or verbs, commonly seen in procedural instructions, Text 1 foregrounds the doing Processes *put, measure, make sure, record, place* in the beginning of each clause. Taken together, the recognized patterns on nouns, subject, and verbs in Text 1 through the transitivity analysis—the technical, long, and complex nouns, the understood subject “you” and the absence of human Participants, the doing Processes in the beginning of each clause—is less like the
everyday language that students normally use with their family members and friends in their everyday lives. The language used to construct the procedural instructions (Text 1), characteristic of school science language, can be a challenge to most students if teachers do not further instruct, demonstrate, and support.

To conduct the soil experiment, the first step in the procedural instructions (Text 1) required the teacher and students to make two filter cups for each group. Using the “coffee filter paper” metaphor and analogy (i.e., Text 2), the teacher focused predominantly on explaining how paper towels can be used as filter papers for filter cups. The transitivity analysis of Text 2 (see Table 4.6) highlights how the teacher’s choices of everyday vocabulary *coffee, your parents, the cup, your drink* the generic noun *coffee* human pronouns *you, they* in the position of Subjects, and the doing Processes *make, put, get* construct a recounting of a generalized event about the habitual experience of what happens when their parents want to prevent the coffee grounds from getting into their coffee drink (Intertextual III). In the context of this recounting events intertextuality the teacher asked her students about their parents’ coffee-making procedure. The recognized patterns of nouns, subject, and verbs in Text 2 show that the background knowledge needed for Text 2 is part of everyday knowledge—the generalized and habitual event of making coffee with coffee filter paper; it is developed largely through everyday social interaction with family members, friends, and others with shared everyday experiences. This contrasts with the specialized knowledge of science required for Text 1.

Encouraged by the teacher’s intertextuality to recounting events (parents making coffee) and the “coffee filter paper” metaphor and analogy in Text 2, although Gina did not know the exact name for the concept highlighted by the teacher, she drew on
her everyday language to construct a cupcake paper metaphor and analogy. A transitivity analysis of Text 3 (see Table 4.6) shows the student’s choices of everyday vocabulary *cupcake paper*, pronominal Subjects *it, that*, being Processes, and the verbal hedge *kind of* are typical of the everyday language that most students use in their everyday social interaction with family members, friends, and others with shared everyday experiences. The cupcake paper metaphor and analogy presented in everyday language was important to enrich the other students’ understanding of the coffee filter paper. Fourth grade students (9-10-years-old) might know and have experienced more with cupcake papers than with coffee filter papers.

Extending from the procedural instructions for the experiment (Text 1), the teacher’s intertextuality to recounting events (Text 2), and the student’s intertextuality to recounting events (Text 3), in Text 4, the teacher further linked everyday concepts (i.e., generalized and habitual events--use of coffee filter paper) with scientific concepts (i.e., the filter paper to prevent soil from going through). A transitivity analysis of Text 4 can give insight to the recognized patterns of nouns and Subjects. With the teacher’s mixed use of everyday vocabulary and field-specific vocabulary, and lexical and pronominal Subjects, Text 4 is presented in the mixed language of both everyday and science language to elaborate on the target concept (i.e., how the filter paper functions).

It is important to note that it is in these four texts (Text 1 to Text 4 in Table 4.6) that the teacher brings together the science language, the everyday language, and the mixed language to construct the teacher’s explanation of how to use paper towels to act as filter papers. An examination of the patterns of nouns and Subjects in these four texts in the context of the teacher’s metaphor and analogy illuminates the hybridity in the
science classroom discourse. Table 4.7 outlines all the nouns, including the nouns in the position of Subjects (underlined), from these four texts.

Table 4.7 *Nouns in Teacher’s Coffee Filter Paper Metaphor and Analogy*

<table>
<thead>
<tr>
<th>Science Language</th>
<th>Everyday Language</th>
<th>Mixed Language</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Text 1</strong></td>
<td><strong>Text 2 &amp; Text 3</strong></td>
<td><strong>Text 4</strong></td>
</tr>
<tr>
<td>the mass of each soil sample</td>
<td>some of the coffee grounds</td>
<td>the cupcake paper</td>
</tr>
<tr>
<td>the mass of each filter cup</td>
<td>what their parents do</td>
<td>your description</td>
</tr>
<tr>
<td>each filter cup of soil</td>
<td>cupcake paper</td>
<td>coffee filter</td>
</tr>
<tr>
<td>a clear plastic cup</td>
<td>coffee filter</td>
<td>something</td>
</tr>
<tr>
<td>each soil sample</td>
<td>the coffee</td>
<td>the water</td>
</tr>
<tr>
<td>the same mass</td>
<td>your drink</td>
<td>the soils</td>
</tr>
<tr>
<td>a filter cup</td>
<td>the filter</td>
<td>these</td>
</tr>
<tr>
<td>your data</td>
<td>the hole</td>
<td></td>
</tr>
<tr>
<td>each soil soil</td>
<td>the cup</td>
<td></td>
</tr>
<tr>
<td><strong>Understood Subject:</strong></td>
<td><strong>Pronominal Subject:</strong></td>
<td><strong>Mix of Lexical and Pronominal Subjects:</strong></td>
</tr>
<tr>
<td>(you)</td>
<td>anyone</td>
<td>none of the coffee</td>
</tr>
<tr>
<td></td>
<td>they</td>
<td>[grounds]</td>
</tr>
<tr>
<td></td>
<td>that</td>
<td>the holes</td>
</tr>
<tr>
<td></td>
<td>you</td>
<td>you</td>
</tr>
<tr>
<td></td>
<td>it</td>
<td>we</td>
</tr>
<tr>
<td></td>
<td></td>
<td>it</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
</tbody>
</table>

Some important differences among the different types of language in the above four texts are captured by the nouns. Text 1 has numerous technical, long, and complex nouns, conveying more specialized meaning in science and not likely to be picked up from students’ everyday social interactions. In addition, Text 1 has the absence of human Participants, using the understood subject *you* at the beginning of each clause. The technical, long, and complex nouns together with the understood subject “you” construct
the procedure instructions of Text 1, commonly seen in school-based science textbook experiments.

In contrast to Text 1, nouns in Text 2 and Text 3 include everyday vocabulary and generic terms coffee, cupcake paper, what their parents do to construct the teacher’s and students’ recounting events intertextuality which is more familiar to students based on their everyday knowledge and language. In both Text 2 and Text 3, the nouns in the subject position are pronominal Subjects, including human and nonhuman pronouns you, it, they, which are more familiar to students. Text 4 with a mixed use of field-specific and everyday vocabulary these, the soils, coffee filter is used by the teacher to link everyday and science concepts. The Subjects in Text 4 also include a mix of lexical Subjects none of the coffee grounds, the holes and pronominal Subjects you, we, it, I. Taken together, the recognized patterns on nouns and Subjects in these four texts (Table 4.7) highlight that the science, everyday, and mixed language were used together by the teacher to discuss the science topic. In these four texts, the science language of procedural instructions, the everyday and familiar language of students, and the mixed language of both science and everyday language come together to contribute to hybridity in science classroom discourse, which is important for students to understand, visualize, and remember the target concepts highlighted by the teacher and the textbook passage.

From both examples of the teacher’s use of metaphor and analogy, we note that because of the unique challenges of school science textbook passages, simply reading the passages together did not guarantee that most of Mrs. Dixon’s students would understand or make intertextual connections to the textbook content. Rather, the teacher’s recounting events intertextuality with the use of metaphor and analogy has significant roles in
support of students’ comprehension of the textbook content. A transitivity analysis of the focus texts in the teacher’s use of metaphor and analogy (Table 4.4, Table 4.6) illuminates that the teacher brought together the science, everyday, and mixed language, thereby connecting what her students already knew to what they were learning in science. Students had opportunities to see and hear the teacher moving between the different types of language to draw on metaphor and analogy related to everyday experiences and to make intertextual connections to the highlighted science concepts. While the teacher modeled how to make intertextual connections, her students’ emergent science understanding was being developed. Thus, students were encouraged to draw on their familiar everyday language and knowledge to contribute their own discourses to the process of co-constructing the science classroom discourse.

4.3 Summary of the Nature of Science Classroom Discourse

This chapter has described in detail how Mrs. Dixon and her fourth grade students taught and learned about the earth’s changing surface in the earth science unit. Additionally, the chapter focused on how science knowledge was constructed through teacher and student intertextual connections to science terminology and concepts highlighted in the science texts and observed science classroom discourse. The chapter began with an overall description of Mrs. Dixon’s earth science unit, consisting of this teacher’s perspectives on this unit, teaching and learning activities, and thematic patterns (see Section 4.1). Evidence from Section 4.1 demonstrated that much of the teacher’s science teaching was guided by and based on the science textbook. Most textbook passages were loaded with field-specific vocabulary (e.g., nominalization, technical vocabulary words, long and complex nouns), and students might have encountered
challenges in making sense of these technical and dense passages, which differ considerably from the expected patterns of everyday language. Because of the unique challenges the science textbook passages presented, simply presenting the materials to be learned by reading aloud from the textbook did not guarantee that students would understand the textbook content. Mrs. Dixon had noted that the language used to construct the specialized science knowledge in the textbook passages sounded unfamiliar to her students as novice readers of this kind of discipline-specific language. In the earth science classes I observed, the instruction typically involved having students read aloud the textbook passages, presenting and explaining the textbook content and language, and then questioning students about the textbook content (i.e., text-dependent questions). In order for her students to better comprehend the science textbook and to make intertextual connections to the science terminology and concepts highlighted in the science textbook, the teacher incorporated instructional support into the observed science classroom discourse, particularly by presenting and explaining the textbook content and language.

The second half of the chapter (Section 4.2) aimed to document and analyze the teacher support incorporated into the observed science classroom discourse. I selected the examples to illuminate the two major kinds of support Mrs. Dixon provided to students for their comprehension of the textbook content and language: register-switching between science and everyday vocabulary and using metaphor and analogy directly related to everyday experiences. One salient result from the presented examples of teacher support was that the teacher connected the textbook passages with a recounting of generalized events about the habitual experiences and/or actions from everyday life experiences (e.g., *depositing grandma’s birthday money into a bank, making a hard snowball, seeing*...
parents making coffee with filter paper). With these instances of the teacher’s Intertextuality to Recounting Events (Intertextuality III), the teacher built on the everyday knowledge students had constructed, connected the students’ everyday knowledge with the school-based science textbook knowledge, and moved students toward a new and more scientific understanding highlighted in the textbook. This type of intertextual connection dominated the examples of teacher support for her students to comprehend the textbook content and language. Table 4.8, as summarized from the presented examples of teacher support in the observed science classroom discourse, displays the instances of the teacher’s Intertextuality to Recounting Events (Intertextuality III).

Table 4.8  Examples of Teacher’s Intertextuality to Recounting Events

<table>
<thead>
<tr>
<th>Teacher Support</th>
<th>Example</th>
<th>School Science Knowledge</th>
<th>Everyday Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register-switching between science and everyday vocabulary</td>
<td>Example 1 Deposition $\rightarrow$ deposit</td>
<td>A natural process of deposition: drop materials somewhere else (deposit)</td>
<td>• Habitual experience of depositing birthday money into a bank</td>
</tr>
<tr>
<td>Using metaphor and analogy directly related to everyday experiences</td>
<td>Example 4 Snowball making metaphor $&amp;$ analogy</td>
<td>Glacier formation: how the pack can turn snow into ice</td>
<td>• Habitual experience of making a hard snowball (pack, pack, pack, hard, hard, hard)</td>
</tr>
<tr>
<td></td>
<td>Example 5 Coffee filter paper metaphor $&amp;$ analogy</td>
<td>Filter paper for experiment on how much water can soil hold</td>
<td>• Habitual action of making coffee with filter paper</td>
</tr>
</tbody>
</table>

As shown in Table 4.8, these instances of the teacher’s intertextuality to recounting events have established that the teacher support has its own discursive expectations (i.e., the teacher connected school science knowledge with everyday knowledge) and its own language features (i.e., the teacher brought together the science,
everyday, and mixed language). The language features identified in these instances of teacher support, as evidenced in the transitivity analysis (see Table 4.6 and Table 4.7), help us see how hybridity in the observed science classroom discourse allowed students to connect school science and everyday knowledge to support their understanding of the textbook content and language. On the basis of these instances of the teacher’s recounting events intertextuality and the transitivity analysis, Table 4.9 summarizes the linguistic features used by the teacher to support her students’ comprehension of the textbook passages and their learning of science in the observed classroom discourse:

Table 4.9 Hybrid Science Classroom Discourse

<table>
<thead>
<tr>
<th>Science Language</th>
<th>Everyday Language</th>
<th>Mixed Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field-specific vocabulary words</td>
<td>Everyday vocabulary words, part of everyday knowledge</td>
<td>• Register-switching between science and everyday vocabulary words</td>
</tr>
<tr>
<td>Technical, long, and complex nouns</td>
<td>Generic nouns</td>
<td>• A mix of field-specific and everyday vocabulary</td>
</tr>
<tr>
<td>Lexical and nonhuman Subjects</td>
<td>Pronominal Subjects</td>
<td>• A mix of lexical and pronominal subjects</td>
</tr>
<tr>
<td>Being Processes in passive voices</td>
<td>Doing Processes</td>
<td>• Being and doing Processes</td>
</tr>
</tbody>
</table>

As Table 4.9 indicates, the teacher introduced the textbook passage first (i.e., science language) and then recounted the generalized events about the habitual experiences and/or actions (i.e., everyday language) in building intertextuality to recounting events. The teacher then mixed the science language and everyday language, linking what students already knew with the target scientific concepts to be learned. As represented in the right column of Table 4.9 (i.e., mixed language), the teacher mixed the field-specific vocabulary and everyday vocabulary as well as a mixed lexical Subjects and pronominal Subjects. Continually moving between science and everyday language,
the teacher built intertextual connections and hybrid science classroom discourse to support students as they encountered difficulties in learning disciplinary knowledge and science language. Thus, hybridity in science classroom discourse is significant for it allows the teacher to connect everyday knowledge and language to school science knowledge and language in order to make targeted scientific concepts easier for students to understand.

Following her support in presenting and explaining textbook passages, Mrs. Dixon used text-dependent questions to query students about the passages. These questions posed particular challenges to the mainstreamed ELLs in Mrs. Dixon’s science classes. The next chapter (Chapter 5) will present evidence about the challenges for ELLs’ identified in the teacher-led question-and-answer sessions for the review and reinforcement of textbook passages. It is important to recognize that even though in answering text-dependent questions in the teacher-led question-and-answer sessions the task was the same, the way students responded to it differed. Not all responses to text-dependent questions were equally accepted and valued by the teacher and classmates. Some student responses with intertextuality to written texts (i.e., textbook), a closer match to the content and language of the textbook, were more readily taken up by the teacher and classmates. However, certain responses from mainstreamed ELLs with their personal assumptions or personal opinions arising out of intuition or feelings were most likely to be viewed as unexpected ideas. Exploring their unexpected ideas highlights the particular challenges for mainstreamed ELLs identified in the observed science classroom discourse. These challenges will be described in the next chapter.
CHAPTER 5. CHALLENGES FOR ELLS IN THE SCIENCE CLASSROOM
DISCOURSE OF THE EARTH CHANGING SURFACE UNIT

This chapter focuses on the challenges of science classroom discourse in Mrs. Dixon’s earth changing surface unit with emphasis on the teacher-led question-and-answer sessions for the review and reinforcement of the textbook content presented and explained earlier. Challenges for mainstreamed ELLs are highlighted in the observed science classroom discourse of Mrs. Dixon’s earth changing surface unit and the support the teacher did or did not provide in response to the identified challenges. This chapter addresses my second research question: “What challenges for ELLs can be identified in science classroom discourse? What support does the teacher provide (or not) in response to the identified challenges?

The evidence will demonstrate that most observed science classes included teacher-led question-and-answer sessions in which the teacher asked text-dependent questions for the review and reinforcement of the textbook content presented and explained earlier. At times, the teacher told students to delve into the textbook passages and to locate relevant information from the passages to answer text-dependent questions. For most students, text-dependent questions prompted them to refer back to the textbook
passages and to provide evidence from the passages (i.e., Intertextuality I), not information from outside sources (e.g., background information extraneous to the textbook passage). But a few students and especially the mainstreamed ELLs, drawing on their everyday knowledge and language (i.e., Intertextuality III), offered unexpected ideas. By “unexpected ideas” I mean their responses to text-dependent questions were not fit with the textbook framework and their responses were often not what the teacher and classmates expected in this classroom context. In particular, I draw attention to the unexpected ideas offered by a Chinese girl, Ying. I followed this girl because the teacher found her unexpected ideas to text-dependent questions puzzling and was concerned about this ELL’s constant interruptions which interfered with the flow of their classroom discourse. Ying was considered a constant interrupter to the classroom instruction and discussion, and therefore was judged by the teacher as disorganized for behavior problems, as evidenced by the teacher’s comments (shown in Section 5.1) during the end of the Unit 5 interview when she commented on students’ overall performance throughout the earth science unit.

The evidence also indicates the teacher expected certain responses from students to text-dependent questions; most students learned which kinds of connections and language (i.e., ones tightly fit the textbook content and language) were more likely to get their responses acknowledged and accepted by the teacher and their classmates. However, even when the teacher at times asked students to refer back to the textbook passages to answer text-dependent questions, the linguistic resources to achieve this task often remained implicit and/or implied. Ying’s responses to text-dependent questions did
not fit with the textbook framework and were often not what her teacher or classmates expected. Ying’s unexpected ideas, together with the particular challenges identified in the observed science classroom discourse, highlight the complex issue of Ying’s behavior problems which concerned the teacher. However, the issue was not a behavior problem but rather a linguistic difference in how the teacher, students, and Ying expected the task of answering text-dependent questions to be accomplished through language. The following sections will discuss and provide evidence for these aforementioned assertions.

The four sections discuss how the teacher took up students’ responses to text-dependent questions in particular ways. Together, they also reveal the challenges for the mainstreamed ELL identified in the observed science classroom discourse and the support the teacher did or did not provide in response to the identified challenges. Evidence demonstrates how Ying, (1) was judged by the teacher as disorganized and distracted, thus leading to behavior problems (Section 5.1); (2) encountered challenges in comprehending and answering text-dependent questions, thereby interrupting the flow of classroom discourse with her persistent questions about text-dependent questions (Section 5.2); and (3) offered unexpected ideas and/or presented ideas in unexpected language patterns, which puzzled her teacher and classmates (Section 5.3). A final section (Section 5.4) summarizes the challenges for the mainstreamed ELL identified in the observed science classroom discourse and the support the teacher did or did not provide in response to the identified challenges.
5.1 Constant Questions and Interruption: Being Judged Disorganized for Behavior Problems

Ying is nine years old and in the fourth grade. She is a pretty, fair-skinned, little girl who, until only a few months previously, had been adapting to her new life in Texas. She grew up in China, moved to Texas with her parents two years ago, went to a new school, and played with her new friends in Texas. Suddenly, at the beginning of last summer, her life changed. Her parents moved to Indiana from Texas driving a U-Haul moving van. Ying, during my classroom observations, appeared withdrawn during the school days and had infrequent face-to-face interactions with her classmates.

Being assessed at a certain level of English proficiency (Level 4 in a 1-5 scale), Ying was classified as a potentially fluent English speaker and newly integrated into mainstream classes (i.e., Mrs. Dixon’s classroom). According to Mrs. Dixon, Ying spoke Mandarin Chinese with her family at home, and due to her mother’s limited English skills, her mother relied on Ying as the translator for the parent-teacher conferences. Mrs. Dixon and other teachers were puzzled by Ying, who seemed to have high oral English proficiency but did poorly engaging in classroom instruction and discussion as well as classroom tasks. Ying was said to constantly interrupt the flow of classroom discourse by persistently asking questions about content presented and explained earlier. Mrs. Dixon, during the interview at the end of this earth’s science unit, commented on the overall student performance and pointed out that:

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1 This information was extracted from Ying’s self-introduction. As a class assignment, all Mrs. Dixon’s students were asked to submit a written self-introduction at the beginning of semester.
And other teachers would come to me. Like one teacher, she said to me a couple of weeks ago. She was teaching and she had just gone over something. And she feels like she (Ying) always raises her hands. That she feels like she (Ying) is understanding more than. We go over the information with her. But I don’t know. It’s hard to tell (the reason why Ying is persistently raising hands and asking questions). (End of Unit Five interview with teacher, 11/23/2011)

Puzzled by her constant questions and interruptions, Mrs. Dixon considered Ying a constant interrupter in classroom discussions. Therefore, Mrs. Dixon judged Ying disorganized and distracted for behavior problems. As Mrs. Dixon put it in the interview at the end of this earth science unit:

She (Ying) interrupts constantly. It would be a topic we just discussed; we just went over the definitions like thoroughly. And she would ask a question that we just went over exactly the same answer…I don’t know. It can be the behavior problems. Because the kids would just look at her and said ‘Ying, we just went over this.’ And she would have the smile. (End of Unit Five interview with teacher, 11/23/2011)

I will present this teacher’s puzzlement about Ying’s disruptive classroom behavior problems in the context of the linguistic analysis of the observed science classroom discourse. Close investigation and analysis of the contrasting language choices made by this puzzling student will help us see the particular challenges faced by the mainstreamed ELL in the observed science classroom discourse. In addition, the evidence will demonstrate that puzzling ELLs like Ying can present us with moments when, at first glance, the student seems to be missing the point and to be confused or constantly
interrupting the classroom discourse with persistent questions. Yet upon further reflection and analysis of Ying’s responses to text-dependent questions will reward us with a better sense of the complexity beneath the task of participating in classroom discourse and answering text-dependent questions for minority students (i.e., mainstreamed ELLs) that otherwise we take for granted. It is important to recognize that even though the task of answering text-dependent questions was the same for all students, how the students responded differed, and their use of language varied. I turn now to examples of the challenges encountered by Ying in participating in Mrs. Dixon’s classroom discourse. These are described in the upcoming sections.

5.2 Challenges in Comprehending and Answering Text-Dependent Questions

In Mrs. Dixon’s classroom, as noted previously in Section 4.1, the teacher’s instructional goals typically involved covering the textbook content and sharing student responses to text-dependent questions for reviewing and reinforcing the textbook content presented and explained earlier. The teacher paced the classroom discourse and kept it tightly focused on the task (i.e., usually reading certain pages of textbook and/or sharing student responses to text-dependent questions). In this particular context of teaching and learning and in order to participate, Ying at times was challenged to comprehend and answer text-dependent questions. The following three examples in this section, along with Ying’s questions and comments, indicated her particular challenges in comprehending and answering text-dependent questions.

Example 1. Example 1 illustrates one instance of Ying’s persistent questions about the text-dependent question for class discussion and therefore interrupted the flow of classroom discourse. During one lesson, the teacher had her students read aloud
textbook passages on *tsunamis*, watched a short video clip on *tsunamis*, and then asked her students to write their responses to one question at the end of a textbook passage on *tsunamis*. While her English-speaking peers were writing down their responses and engaged in sharing their responses to the text-dependent question, Ying persistently raised her hand with questions about the text-dependent question itself. The following extract illustrates how Ying persistently asked the teacher to explain the text-dependent question, thereby interrupting the flow of classroom discourse. Ying’s questioning the text-dependent question is underlined and boldfaced; the teacher’s focusing and refocusing on the task of answering the text-dependent question is boldfaced; and the text-dependent question extracted from the textbook passage is under quotation marks in Extract 5.1:

**Extract 5.1 (Example 1)**

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Topic on Tsunamis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td><strong>We do have a question. It says “Study the photo on this page. How do you think the boat might have ended up where it did?” I want you guys to write down your own ideas.</strong></td>
</tr>
<tr>
<td>2</td>
<td>Ying</td>
<td><strong>Mrs. Dixon, I have a question. What does that mean?</strong></td>
</tr>
<tr>
<td>3</td>
<td>Teacher</td>
<td>What?</td>
</tr>
<tr>
<td>4</td>
<td>Ying</td>
<td><strong>What the question means?</strong></td>
</tr>
<tr>
<td>5</td>
<td>Teacher</td>
<td>So you look at the bottom picture, that boat. Did you see the boat in the picture?</td>
</tr>
<tr>
<td>6</td>
<td>Ying</td>
<td>[Nodding her head]</td>
</tr>
<tr>
<td>7</td>
<td>Teacher</td>
<td>So you have to, now make an inference and think of how did that boat end up where it did. So use the knowledge that you have and you are coming up with the conclusion. <strong>Write down your answer right now and we would share a couple.</strong></td>
</tr>
<tr>
<td>8</td>
<td>…</td>
<td>[Teacher gives students time to write]</td>
</tr>
<tr>
<td>9</td>
<td>Teacher</td>
<td><strong>If you have comments, raise your hand. Bill?</strong></td>
</tr>
<tr>
<td>10</td>
<td>Bill</td>
<td>It could be the water from the tsunamis happening…so like…</td>
</tr>
<tr>
<td>11</td>
<td>Teacher</td>
<td>Yeah, it could be the water and then move it with water. Good. Tufan.</td>
</tr>
<tr>
<td>12</td>
<td>Tufan</td>
<td>I said it might be carried by water from the tsunamis, which moved it to inland.</td>
</tr>
<tr>
<td>13</td>
<td>Teacher</td>
<td>Yeah, Amy?</td>
</tr>
<tr>
<td>14</td>
<td>Amy</td>
<td>The tsunamis when they go around, when the tsunamis may get</td>
</tr>
</tbody>
</table>
In this example, after reading aloud the textbook question, the teacher led students to write down their responses to the textbook question. Ying immediately raised her hand with questions about the textbook question (turn 2). To help Ying understand the text-dependent question, the teacher asked Ying: (1) to take a look at the textbook picture, and (2) to think of how that boat ended up where it landed (turns 5 and 7). The teacher then asked Ying to write down her response to this text-dependent question right away because they were going to share student responses. The teacher, in order to focus students on the task, had explicitly told them to write down their responses to the text-dependent question repeatedly (e.g., turns 1, 7, and 9 boldfaced in Extract 5.1). Most students (like the nominated students) learned to stay on the task of writing down their responses to the text-dependent question and sharing their responses (turns 9-18); their responses to the text-dependent question are shown below:

*It could be the water from the tsunamis happening...so like...*

*I said it might be carried by water from the tsunamis, which moved it to inland*

*The tsunamis when they go around, when tsunamis may get started*

Especially noteworthy of these nominated students’ responses to the text-dependent questions is their reference to the previously read textbook passages on tsunamis. The textbook described the effects of tsunamis “A tsunami may crash into a coast like a wall of water. It may appear like a series of high, fast-moving tides which..."
flood the coast. The water can reach several kilometers inland” (Buckley, Miller, Padilla, Thornton, Wiggins, & Wysession, 2012, p. 186). The nominated students, by connecting to the previously read textbook passage on tsunamis, indicated that water from tsunamis can carry a boat inland. With their intertextuality to the textbook (Intertextuality I), these students followed the content and language of the textbook passages to answer the text-dependent question. The teacher, in turns 11, 13, and 15, took up these students’ responses and acknowledged their contributions when students responded in ways that were closely aligned with the textbook content and language.

However, in contrast to the responses of the other students, in the middle of this lesson, Ying again brought up her question about the text-dependent question (turn 16). Ying’s persistent questions about the textbook question (turns 2, 4, and 16) show her particular challenges in referring back to what they had read and in making sense of the textbook picture (the boat moved from coast to inland) and the textbook question. Perhaps Ying was not aware that these types of questions (text-dependent questions) require students to revisit textbook passages on the related topics and to locate information from these passages to comprehend and answer the questions. Although the teacher in turn 17 briefly took up Ying’s question and explained again what the textbook question meant for Ying, the teacher still did not explicitly point out the need to refer back to the earlier read textbook passages in order to comprehend and answer the text-dependent question. Instead, the teacher immediately nominated other students to continue sharing responses to this question. At that point, Ying chose to not raise her hand with questions, perhaps because the teacher had nominated other volunteering students to share their responses. Perhaps Ying understood that her questions about the
text-dependent question would not be appreciated because the teacher was trying to focus students on the task and to accomplish the task of answering the text-dependent question.

Example 2. In addition to Ying’s persistent questions about text-dependent questions, Ying at times appeared not to stay focused on their task and thereby interrupted the classroom instruction and discussion with questions about the work she was doing on her own. In Example 2, the teacher reviewed Lesson 2, *What are the properties of soil*, by having her students watch a short video on *soil* and later work on the Lesson 2 worksheet (i.e., a set of text-dependent questions prepared by the textbook publisher for Lesson 2 review). Before showing the video, the teacher passed around the Lesson 2 worksheet to each student. In the video, most key concepts highlighted in Lesson 2 were reviewed. While the class focused on the task of watching and discussing the video, Ying, however, decided to raise her hand with questions about the Lesson 2 worksheet. The following extract from the observed science classroom discourse demonstrates the interaction among Ying, the teacher, and the classmates. The teacher’s focusing on the task is boldfaced, Ying’s questioning about the Lesson 2 worksheet is underlined and boldfaced, and the question extracted from Lesson 2 worksheet is under quotation marks in Extract 5.2:
Extract 5.2 (Example 2)

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Topic on Soil, Weathering, Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td>Okay, guys. That video went over how much information we have been talking about. <strong>And what are some of those words you recognize when you are listening? Ankor?</strong></td>
</tr>
<tr>
<td>2</td>
<td>Ankor</td>
<td>Clay and humus.</td>
</tr>
<tr>
<td>3</td>
<td>Teacher</td>
<td>They talk about clay and humus.</td>
</tr>
<tr>
<td>4</td>
<td>Student</td>
<td>Topsoil</td>
</tr>
<tr>
<td>5</td>
<td>Teacher</td>
<td>Topsoil and we also talked about that in the social studies, didn’t we? And subsoil. Lucas?</td>
</tr>
<tr>
<td>6</td>
<td>Lucas</td>
<td>Erosion but they didn’t talk about deposition in that (video).</td>
</tr>
<tr>
<td>7</td>
<td>Teacher</td>
<td>No, we wouldn’t be getting in that. But you can see how they are related but it was not mentioned. This was just really focusing on soil.</td>
</tr>
<tr>
<td>8</td>
<td>Ying</td>
<td>Mrs. Dixon. For the number four, they didn’t say soil, they plant the different crops, so they can get soil healthy.</td>
</tr>
<tr>
<td>9</td>
<td>Teacher</td>
<td>“Farmers should plant the different crops to keep their soil healthy.”</td>
</tr>
<tr>
<td>10</td>
<td>Ying</td>
<td>Is that true?</td>
</tr>
<tr>
<td>11</td>
<td>Teacher</td>
<td>You have to decide and you can look back we just read that. When I say healthy, that means full of nutrients. <strong>Sandy?</strong></td>
</tr>
<tr>
<td>12</td>
<td>Sandy</td>
<td>They talk about the soil.</td>
</tr>
<tr>
<td>13</td>
<td>Teacher</td>
<td>Yeah, the different parts of soil.</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>(Teacher continues discussing the video with the students)</td>
</tr>
</tbody>
</table>

In Extract 5.2, after showing the video, the teacher asked her students, “And what are some of those words you recognize when you are listening?” For most students the question prompted them to recall key words from the video such as erosion, deposition, topsoil, clay and humus. The teacher accepted and acknowledged these students’ responses by repeating or restating their responses when the responses matched her instructional goals of discussing the content of the video. But Ying, in turns 8 and 10, brought up her questions about the Lesson 2 worksheet, which was supposed to be the class’s next task. The teacher briefly took up Ying’s questions instead of asking her to stay on their task (i.e., discussing the video). In turns 9 and 11, the teacher told Ying to refer back to the textbook passages on soils to help Ying justify whether the statement on the worksheet was true or false. In order to refocus students on the current task of
discussing the video, in turn 11, the teacher proceeded to nominate another volunteering student. This student’s response tightly fit to the teacher’s instructional goals of discussing the video and was accepted and acknowledged by the teacher. This example (i.e., Extract 5.2) highlights how appropriate responses to the teacher’s text-dependent questions were more likely to be accepted and acknowledged by the teacher when they closely matched the teacher’s instructional goals. In contrast, Ying’s questions about the work she was doing on her own were probably not so appreciated by the teacher because they did not fit the teacher’s instructional goals or their task.

*Example 3.* Example 3 demonstrates another instance of Ying not staying focused on the task but asking questions about her own work. The teacher at times guided students to navigate within the textbook passages in order for them to locate information from the passages to answer text-dependent questions. In the following example, the teacher was leading a review for Lesson 5, *What are natural resources*, by having the students refer back to the textbook passages to answer Question 6 of the Lesson 5 worksheet. In Extract 5.3, the teacher’s focusing students on the task is boldfaced; Ying’s questioning is underlined and boldfaced, and Question 6 extracted from Lesson 5 worksheet is under quotation marks:

Extract 5.3 (Example 3)

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Discussion of Question 6 on Lesson 5 Worksheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td>Hey, guys. In a moment, <strong>I am going to ask you to look at the last one with me. Okay, the question says</strong> “Melissa is convincing Henry to buy a bicycle instead of a car. She tells him that using fossil fuels causes many problems and we need to conserve fossil fuels. Write two problems that using fossil fuels caused and two reasons why conservation is important.”</td>
</tr>
<tr>
<td>2</td>
<td>Student</td>
<td>What’s conservation?</td>
</tr>
<tr>
<td>3</td>
<td>Teacher</td>
<td>So I am not saying what conservation is. You need to go back because first of all we just talked about that. Second of all, you can look up in...</td>
</tr>
</tbody>
</table>
In Extract 5.3, the teacher explicitly told students how to navigate within and locate information from the textbook for answering the text-dependent question. First, the teacher read aloud Question 6 of the worksheet and directed her students’ attention to this text-dependent question. In turns 3-11, the teacher referred students back to the textbook passages on the topic of *fossil fuels* and further asked them about the uses of fossil fuels. Thus, the teacher highlighted the textbook content, “They (fossil fuels) are burned to
provide energy” (Buckley et al., 2012, p. 200). With intertextual connection to the highlighted textbook content (Intertextuality I), the teacher asked students, “Okay, burning fossil fuels can cause pollution. And what kind of pollution did we talk about?” For most students, to answer Question 6 of the worksheet, the teacher’s connection to the textbook content and question prompted them to discuss which pollution might be caused by burning fossil fuels (e.g., air pollution). In the middle of this task, however, Ying raised her hand with questions about Question 5 of the Lesson 5 worksheet, “On Question 5, if it’s true, what do we write?” (turn 16). The teacher took up Ying’s question and in turn 17 told her how to justify for the true statement. Nevertheless, the teacher immediately refocused the classroom discourse back onto which pollution might be caused by burning fossil fuels and, therefore, kept carrying on their task (i.e., answering Question 6 of the Lesson 5 worksheet). Ying’s questions and comments in turns 16 and 18 demonstrated that Ying appeared not to stay focused on the task, but, instead, she worked on the question on her own. Without participating in the task, Ying missed the learning opportunity of navigating within the textbook to locate information for answering text-dependent questions. In addition, Ying’s questions about her own work might have contributed to the teacher’s impression of Ying’s disruptive behavior problems--not participating in their current classroom task but interrupting the flow of their classroom discourse with the questions of her own work.

As the three examples above depicted, Ying’s questions and comments seemed to indicate her lack of awareness and knowledge about referring back to the related textbook passages and locating the information from the textbook for comprehending and answering text-dependent questions. However, this classroom context of limited
instructional time and multiple pressures to cover the textbook content and to share student responses to questions made it hard for the teacher to take more time to consider the particular challenges encountered by Ying in comprehending and answering text-dependent questions. To focus students on the task, the teacher spent time telling students to write down their responses to text-dependent questions, nominating students to share their responses, and acknowledging student responses when they tightly matched the instructional goals. Ying at times appeared not to stay focused on the task by persistently questioning the text-dependent questions or asking questions about her own work, thereby interrupting the flow of the classroom discourse.

Although the teacher briefly took up Ying’s questions and explained for Ying what the text-dependent questions meant, the teacher immediately proceeded to refocus students on the task by nominating other volunteering students to answer the questions they were discussing. In doing so, the teacher perhaps missed opportunities to better support Ying in understanding the need to connect to the textbook passages to comprehend and answer text-dependent questions. The teachers also neglected to explicitly tell Ying about the importance of attending to the task in order to participate in the classroom discourse. Instead, Ying’s persistent questions about text-dependent questions or questions about her own work (i.e., both were not matching the instructional goals) were not generally viewed as appropriate. Rather, they were seen as interruptions to the classroom discourse. Even when Ying attempted to participate in the classroom discourse and respond to the text-dependent questions, she at times offered unexpected ideas and/or presented ideas in unexpected language patterns which puzzled her teacher and classmates. This situation is described in the next section.
5.3 Challenges in Answering Text-Dependent Questions: Unexpected Ideas

In Mrs. Dixon’s classroom, the textbook provided the discursive framework from which the teacher enacted her instruction and from which she held expectations about how students should talk science in class. In this context of teaching and learning, the teacher had to balance every student’s right and desire to participate and respond to text-dependent questions with the teacher’s concerns to keep the classroom discourse in line with the textbook and to complete the curriculum within the allotted time. When students shared responses which were a closer match to the textbook and moved the lesson forward, their responses were more likely to be accepted and acknowledged by the teacher and classmates. But Ying, due to her constant questions about text-dependent questions, was often slower than her classmates to respond to the questions. Consequently, she did not get to contribute to classroom discourse as often as others (see Section 5.2 of Ying’s Challenges in Comprehending and Answering Text-dependent Questions for more detail). Furthermore, the evidence will indicate that when Ying did attempt to respond to text-dependent questions, her line of thinking was sometimes hard for the teacher and classmates to follow. The primary contributor to their puzzlement was the fact that Ying’s responses did not fit into the discursive framework of the textbook. Rather, Ying often intuitively recounted events about the habitual experiences in her everyday life or drew on everyday knowledge and language to answer the teacher’s text-dependent questions.

In this section, I provide evidence to exemplify Ying’s unexpected ideas in response to text-dependent questions. This evidence comes from her oral responses to the questions and then from her written responses. As shown below, the first two examples
(Example 4 and Example 5) illustrate her unexpected ideas in response to text-dependent questions orally and the last example (Example 6) illustrates her unexpected ideas from her written responses to one essay questions of the Unit 5 test.

**Example 4.** As Example 4 shows, during one lesson, the teacher first nominated one student to read aloud the textbook passage on the topic of *People and the Environment*. This textbook passage highlights some positive and negative ways in which humans impact the environment and thereby upset the balance of the environment. To draw students’ attention to the textbook content, the teacher questioned students about the content. The teacher’s question and student responses are shown in the following extract.

In Extract 5.4, the students’ responses are boldfaced, Ying’s response is boldfaced and underlined, and the extracted textbook passage is under quotation marks:

**Extract 5.4 (Example 4)**

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td>Yeah. “When we change the environment, however, we sometimes upset the balance in the environment.” This is not the first time we talk about this. Does this sound familiar from social studies?</td>
</tr>
<tr>
<td>2</td>
<td>Students</td>
<td>Yeah.</td>
</tr>
<tr>
<td>3</td>
<td>Teacher</td>
<td>Yeah. Think about the land in Indiana. What did it once look? How did it once look? It did not always look like this. But how did people change that? Paula.</td>
</tr>
<tr>
<td>4</td>
<td>Paula</td>
<td><strong>There used to be that people cut down the forests and drained the swamps.</strong></td>
</tr>
<tr>
<td>5</td>
<td>Teacher</td>
<td>Right, draining the swamps, cutting the forests. There are all these things we have done when we interact with the environment and we change it. And think about all the creatures that were living there before we made those changes. So we definitely affect the environment those ways. Good connections. What else, Sara?</td>
</tr>
<tr>
<td>6</td>
<td>Sara</td>
<td><strong>People hunt animals and we need animals.</strong></td>
</tr>
<tr>
<td>7</td>
<td>Teacher</td>
<td>Right, there is a lot of hunting that goes on.</td>
</tr>
<tr>
<td>8</td>
<td>Amy</td>
<td><strong>We are getting fewer and fewer animals.</strong></td>
</tr>
<tr>
<td>9</td>
<td>Teacher</td>
<td>Yeah, Ying?</td>
</tr>
<tr>
<td>10</td>
<td>Ying</td>
<td><strong>Sometimes animals hit the car.</strong></td>
</tr>
<tr>
<td>11</td>
<td>Teacher</td>
<td>Yeah, like me.</td>
</tr>
<tr>
<td>12</td>
<td>Students</td>
<td>Unless you did that twice. [Students challenge Ying’s answer]</td>
</tr>
</tbody>
</table>
After the student read aloud the textbook passage on the topic of *People and the Environment*, the teacher repeated the concluding sentence of this textbook passage:

“When we change the environment, however, we sometimes upset the balance in the environment” (Buckley et al., 2012, p. 189). The teacher noted that they had covered the same topic/content in the social studies curriculum. By referring to social studies, the teacher initiated an intertextual connection to the social studies textbook passages (Intertextuality I) (turn 1). The teacher then asked students to reflect on the social studies textbook passages learned earlier and think about how people changed the land in Indiana (turn 3). The teacher’s link (Intertextuality I) and question prompted Paula to connect to the social studies passages, and she answered: “There used to be that people cut down the forests, and drained the swamps” (turn 4). Paula’s response was constructed by drawing from the social studies textbook passage (Intertextuality I). The connected passage described how the people in Indiana changed the environment: “People moving into the area (tiptop till plain) discovered how rich and fertile the soil was and decided to use the land for farming. They drained the swamps and cleared the forests to build farms” (Scott Foresman: Indiana Grade 4 Social Studies, 2003, P. 53). Both Paula’s response and connected social studies textbook passage highlight that the people cut down the forests, drained the swamps, and changed the land of Indiana. These associated the topic of how people can change the environment and upset the balance in the
environment. Paula’s response, tightly fit to the textbook content and language (Intertextuality to Written Texts; Intertextuality I), was accepted and acknowledged by the teacher (turn 5). Also, the teacher elaborated on Paula’s response by guiding students to think of the changes occurring to those creatures living on the changed land.

As for other volunteering students, Sara and Amy in turns 6 and 8 brought up two generalized events (people hunt animals and people get fewer animals) to answer the teacher’s question, and both students accurately associated with the topic of humans and the environment. Their responses were also accepted and acknowledged by the teacher in turns 7 and 9. Especially salient in these student responses is that no particular people are involved, and there is no reference to specific times. This contributes to the generalized events or intertextuality to implicit generalized events (Intertextuality IV). To further clarify, according to Pappas & Varelas (2004), intertextuality to implicit generalized events (Intertextuality IV) is regarded as an important linguistic tool. With this tool, students do not use narrative autobiographic accounts but rather share impersonal accounts of science phenomenon.

Ying, when asked for her contribution, suggested, “Sometimes animals hit the car” (turn 10). The teacher accepted her answer but immediately added “Yeah, like me” (turn 11). The teacher may have intended to elaborate further on Ying’s response by sharing the teacher’s similar personal experience and thereby building an intertextual connection to a specific event in which Ying was not involved but the teacher herself was (Intertextuality III). (As recorded in my classroom fieldnotes, Mrs. Dixon, a few weeks previously, had recounted and talked with her students (and the researcher) about a specific event—a deer hit her car when she was driving to school.) Perhaps Ying
connected to this specific event in which she was not personally involved but her teacher was and she thus responded, “Sometimes animals hit the car.” Although Ying’s response was accepted and elaborated on by the teacher, her response was challenged by her classmates (turn 12): “Unless you did that twice.” (I will further elaborate below on this response.) Most students had noted that in order to answer the teacher’s question about how people change the environment and upset the balance in the environment, they needed to highlight humans as actors who cause change to the environment and animals. The students’ knowledge of how to respond is illustrated by the student responses accepted and acknowledged by the teacher and classmates. The responses are shown below (Participants in the position of Subjects are boldfaced and the doing Processes are underlined):

[There used to be that] **people** cut down the forests, and **(people)** drained the swamps.

**People** hunt animals and **we (people)** need animals.

**We (people)** are getting fewer and fewer animals.

<table>
<thead>
<tr>
<th>Participant: Actor</th>
<th>Doing Process</th>
<th>Participant</th>
</tr>
</thead>
</table>

A transitivity analysis of these student responses highlights that each of these clauses describes that the concrete actions *cut down, drained, hunt, get* expressed by the doing Processes are performed by human actors *people, we* with these actors occupying the position of subject in each clause. The Participants in the position of Subjects (*people, we*) are human actors who do the deed or perform the action. The transitivity analysis of these student responses, along with their choices of human actors, shows these students’ awareness of the active roles taken by humans in causing changes to the environment and
animals when students associate the topic of people and the environment. However, different from these students’ choices of human actors, Ying had “animals,” not humans people, we, in the position of subject to perform the action of hitting the car, “Sometimes animals hit the car.” Note that not only did her classmates respond to the question based on their association of people with the environment but also they challenged Ying’s response and contribution. They pointed out “Unless you did that twice” (turn 12) to emphasize that unless you as the human driver acted to hit animals the second time (animals hit the car the first time).

In response to the students’ challenge of Ying’s contribution, in turn 13 the teacher further explained that it was still a human decision to live there and to drive the car; consequently, animals would be hit by the car. In the context of this explanation, another volunteering student, Carol, connected to the science textbook picture and pointed out, “Um…like the guy in the picture; he is about to hit the bear” (turn 14). (The textbook picture shows a bear a few steps away from a car driving on the forest road.) Carol’s response highlighted the human driver the guy in the picture, he taking the active role of driving the car on the forest road and the bear, a forest dweller, a few steps away from the car. Carol’s response connecting to the textbook picture (Intertextuality I) was taken up by the teacher immediately because it matched the textbook content. Additionally, the response moved the lesson forward because Carol’s response linked to the textbook question Mrs. Dixon was going to ask students to answer and discuss: “Study the photo. How have humans changed this environment to meet their needs?” (Buckley et al., 2012, p. 189).
A comparison of the different kinds of connection drawn by students and the teacher feedback to their responses in this example can further highlight how appropriate uses of connection (i.e., those that fit into the textbook content and the teacher’s instructional goals) in student responses to text-dependent questions were more likely to be accepted by the teacher and classmates in the class. The macro-level intertextual analysis of student responses to the teacher’s text-dependent question associating the topic of people with the environment and the teacher feedback is summarized below:

Table 5.1 Kinds of Intertextuality in Student Response to Text-dependent Questions

<table>
<thead>
<tr>
<th>Student</th>
<th>Student Response and Teacher Feedback</th>
<th>Macro-Level Intertextuality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paula</td>
<td>There used to be that people cut down the forests and drained the swamps.</td>
<td>Intertextuality to Written Texts, Intertextuality I</td>
</tr>
<tr>
<td>Teacher</td>
<td>Right, draining the swamps, cutting the forests...</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Sara</td>
<td>People hunt animals and we need animals.</td>
<td>Intertextuality to Implicit Generalized Events, Intertextuality IV</td>
</tr>
<tr>
<td>Teacher</td>
<td>Right, there is a lot of hunting that goes on...</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Amy</td>
<td>We are getting fewer and fewer animals.</td>
<td>Intertextuality to Implicit Generalized Events, Intertextuality IV</td>
</tr>
<tr>
<td>Teacher</td>
<td>Yeah...</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Ying</td>
<td>Sometimes animals hit the car.</td>
<td>Intertextuality to Recounting Events, Intertextuality III</td>
</tr>
<tr>
<td>Teacher</td>
<td>Yeah, like me.</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Student</td>
<td>Unless you did that twice.</td>
<td>Students Challenge Ying’s Response</td>
</tr>
<tr>
<td>Carol</td>
<td>Um…like the guy in the picture, he is about to hit the bear.</td>
<td>Intertextuality to Written Texts, Intertextuality I</td>
</tr>
<tr>
<td>Teacher</td>
<td>Right. Yes. Looking at this picture. This is a good example.</td>
<td>Teacher Acknowledgement</td>
</tr>
</tbody>
</table>

Paula’s and Carol’s responses, with their intertextuality to the textbook, were immediately accepted and acknowledged by the teacher because they fit neatly within the
discursive framework of the textbook and the teacher’s instructional goals. Sara and Amy’s responses, with their intertextual connection to implicit generalized events, were also acknowledged by the teacher because they closely fit into the teacher’s lesson topic of the environment and people. However, in contrast to her peers’ responses closely matching the textbook and the instruction, Ying’s response with the recounting events intertextuality about the specific event in which Ying was not personally involved (Intertextuality III), appeared to be less of a fit to the textbook and instruction and was even challenged by Ying’s classmates.

In some cases, Ying intuitively drew on everyday knowledge and language to answer the teacher’s text-dependent questions. Although Ying’s responses did not closely fit the teacher’s lesson topic or the textbook content, her responses were sometimes accepted by the teacher. Due to the teacher’s multiple tasks that included coordinating the activities of 25 fourth graders and organizing lessons to cover the mandated science curriculum, the teacher sometimes overlooked some approximations and inaccuracies that Ying (and other students) made as they tried to understand content and answer the text-dependent questions. The teacher seemed to accept these approximations in Ying’s responses but immediately proceeded to elaborate further on Ying’s responses and to connect her responses with the textbook content and language. Because the teacher needed to cover a set of amount of materials in each science class, she was careful to keep classroom discourse focused on textbook passages and the objectives of the lesson. When the teacher quickly focused or refocused the class onto the textbook, most students had learned the teacher’s expectations and connected to the textbook for answering text-dependent questions. This is described in the next example.
**Example 5.** In the following example, the teacher was leading a review for the Unit 5 test. In Extract 5.5, Ying’s response is boldfaced and underlined; the teacher’s elaboration of Ying’s response is boldfaced; the student responses are boldfaced; the question extracted from the review for Unit 5 test is under quotation marks:

Extract 5.5 (Example 5)

<table>
<thead>
<tr>
<th>Turn</th>
<th>Speaker</th>
<th>Topic on Preserving the Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teacher</td>
<td>Okay. Question Six. “List one way in which the national park service benefits”…That means it’s good for…“humans and one way it benefits other organisms.” So another way that it’s good, it’s helpful to other organisms. What does the National Park Service do that is good for humans and for organisms? Hector?</td>
</tr>
<tr>
<td>2</td>
<td>Hector</td>
<td>Well, they help plant trees.</td>
</tr>
<tr>
<td>3</td>
<td>Teacher</td>
<td>Why do we enjoy a National Park? Would a National Park be the place we want to visit?</td>
</tr>
<tr>
<td>4</td>
<td>Students</td>
<td>Yeah.</td>
</tr>
<tr>
<td>5</td>
<td>Teacher</td>
<td>Why? Ying?</td>
</tr>
<tr>
<td>6</td>
<td>Ying</td>
<td>Because everything is kind of beautiful and everything is kind of good.</td>
</tr>
<tr>
<td>7</td>
<td>Teacher</td>
<td>Right. We go to the National Park because it’s so beautiful. Because the National Park has been preserved. Because you can see this natural environment. So the National Park benefits us because it preserves the site. But how does National Park Service benefit the organisms at the same time? Tufan?</td>
</tr>
<tr>
<td>8</td>
<td>Tufan</td>
<td>I wrote “The National Park Service benefits human by preserving natural sites. It protects plants and animals.”</td>
</tr>
<tr>
<td>9</td>
<td>Teacher</td>
<td>Yeah, it protects the habitats.</td>
</tr>
<tr>
<td>10</td>
<td>Tufan</td>
<td>Yeah.</td>
</tr>
<tr>
<td>11</td>
<td>Teacher</td>
<td>Habitats of these plants and animals. It preserves these so. They preserve and we benefit because we can go and enjoy that nature settings.</td>
</tr>
</tbody>
</table>

As the teacher read aloud Question 6 of the Unit 5 review (Buckley et al., 2012, p. 211), she also explained vocabulary of this text-dependent question using a synonymous definition. To support her students’ comprehension of this question, the teacher explained that the word “benefit” has the same meaning as “it’s good or helpful for” (turn 1). After this explanation, the teacher asked students, “What does the National Park Service do that is good for humans and for organisms?” Hector immediately
responded, “Well, they help plant trees” (turn 2), but his response did not specify how the National Park Service would benefit humans and other organisms respectively. In that moment, Hector’s answer was overlooked by the teacher. In her rush to keep the class focused on the task of answering the text-dependent question, the teacher proceeded by narrowing down to the first part of the question—the benefit of the National Park Service to humans. The teacher asked students, “Why do we enjoy a National Park? Would a National Park be the place we want to visit?”

Ying, when asked for her response, suggested, “Because everything is kind of beautiful and everything is kind of good” (turn 6). This response was drawn from Ying’s commonsense knowledge of everyday lives to describe the characteristics of the National Park. However, this might not have been the answer for which the teacher had been looking (i.e., the one closely fitting within the textbook content and specifying the benefit of the National Park Service to humans). Consequently, even though Ying’s response was taken up by the teacher, the teacher proceeded to merge Ying’s everyday discourse with the scientific way of thinking and talking featured in the textbook in order to make Ying’s description of the National Park characteristics connect back to the textbook content. The textbook passage thus described the National Park Service: “The United States has established the national park service to preserve nature’s beauty, historic sites, and the environments of many plants and animals” (Buckley et al., 2012, p. 194). With intertextuality to the textbook passage (Intertextuality I), the teacher elaborated on Ying’s response—the characteristics of the National Park (being process of attribution, Because everything is kind of beautiful)—to highlight the benefit of the National Park Service to humans (turn 7): “Right. We go to the National Park because
it’s so beautiful. Because the National Park has been preserved. Because you can see this natural environment. So the National Park benefits us because it preserves the site.” Here, the teacher’s elaboration on Ying’s response refocused the class onto the lesson topic, highlighted by the textbook, of preserving the environment. Thus, the teacher supported students to think and talk about “What does the National Park Service do that is good for humans,” a way of thinking and talking more closely fitting within the textbook and beyond Ying’s use of everyday knowledge and language in her description of National Park characteristics.

Then, in turn 7, the teacher directed students’ attention to the second part of the text-dependent question, “how does the National Park Service benefit other organisms”. Tufan raised his hand to share his written response (turn 8): “The National Park Service benefits humans by preserving natural sites. It protects plants and animals.” Tufan’s response fit within the textbook content: “The united states has established the national park service to preserve…the environment of many plants and animals” (Buckley et al., 2012, p. 194). Thus, his response was immediately accepted and acknowledged by the teacher who emphasized that the National Park Service protects the natural environment of many plants and animals. Example 5 (i.e., Extract 5.5, Table 5.1) highlights the different connections drawn and language used by the teacher and students in the task of answering the text-dependent questions. Some of these different connections and language uses were subtle and only evident upon further linguistic analysis (i.e., micro-level intertextual analysis or transitivity analysis based on SFL). In the following paragraphs, I will examine the extent to which the teacher and students responded to the
text-dependent questions reflected in their use of different connections and language, with focus on the unexpected ideas offered by Ying.

Transitivity Analysis of Ying’s Unexpected Ideas When Answering Text-Dependent Questions. To take a close look at the different connections and language produced and encountered by the students in answering the text-dependent question (Extract 5.5), a transitivity analysis based on SFL is used to analyze Ying’s response (Text 1), the teacher’s elaboration of Ying’s response (Text 2), Tufan’s response (Text 3), and the connected textbook passage of preserving the environment (Text 4). Table 5.2 outlines these four texts and some language patterns, with nouns marked in boldface, nouns in the position of Subjects marked in boldface as well as underlined, and verbs marked in italics.
Table 5.2 *Transitivity Analysis of Ying’s Unexpected Ideas When Answering Questions*

<table>
<thead>
<tr>
<th><strong>Text Examples</strong></th>
<th><strong>Language Features</strong></th>
</tr>
</thead>
</table>
| **Text 1:** Ying’s Response  
Because *everything* is kind of beautiful  
and *everything* is kind of good.  
[Intertextuality to recounting events from everyday experiences] | Everyday vocabulary,  
generic nouns; being  
Processes (attributive);  
verbal hedge (*kind of*) |
| **Text 2:** Teacher’s Elaboration of Ying’s response  
*We go to the National Park*  
because *it’s* so beautiful.  
Because *the National Park* has been preserved.  
Because *you can see this natural environment*.  
So *the National Park benefits* us  
because *it preserves the site.*  
But how does *National Park Service* benefit the organisms at the same time?  
[Intertextuality to Written Texts, i.e., science textbook] | Field-specific  
vocabulary; a mix of  
pronominal Subjects  
(we, it, you) and lexical  
Subject; being Process  
and doing Processes |
| **Text 3:** Tufan’s Response  
*The National Park Service* benefits *human* by preserving  
natural sites.  
*It protects plants and animals.*  
[Intertextuality to Written Texts, i.e., science textbook] | Field-specific  
vocabulary; lexical and  
pronominal Subjects;  
doing Processes |
| **Text 4:** Textbook of “Preserving the Environment”  
*The United States has established* *the National Park*  
*Service to preserve* nature’s beauty, historic sites,  
and *the environments of many plants and animals.* | Field-specific  
vocabulary; lexical  
Subject; doing  
Processes |

As Table 5.2 indicates, transitivity analysis of these four texts allows us to identify the patterns of nouns, Subjects, and verbs in constructing the teacher and students’ responses to the text-dependent question. Regarding the use of Participants or nouns, Ying’s choice of Participant in her response *everything* tended to be generic and everyday vocabulary used in daily conversations. In the teacher’s elaboration of Ying’s response, the teacher drew on the field-specific nouns regarding the topic of national
parks preserving the environment *the National Park, the natural environment, the organisms* and a mix of the pronominal Subjects *we, it, you* and the lexical Subjects *the National Park, National Park Service* to connect Ying’s description of National Park characteristics with the textbook content. At that point, the teacher brought in the textbook content and language to refocus students on the textbook content of The National Parks preserving the environment. In so doing, the teacher supported students to respond to the text-dependent question with reference to the textbook content beyond Ying’s use of everyday knowledge and language and her description of National Park characteristics. Different from Ying’s choice of everyday vocabulary and generic noun *everything* in answering the teacher’s text-dependent question, Tufan used the field-specific vocabulary *the national park service, humans, natural sites, plants and animals* and lexical Subject *the national park service* and constructed his response to closely fit to the textbook. Tufan’s use of field-specific vocabulary and lexical Subject highlights the scientific phenomenon (things) rather than people, which flavors his responses with impersonality. Tufan’s response is thus characteristic of science language featured in the textbook passages such as Text 4. Text 4 includes a number of field-specific vocabulary words *the United States, the National Park Service, nature’s beauty, historic sites, the environments of many plants and animals* in order to be clear, precise, and impersonal while explaining science phenomenon such as national parks preserving the natural environment.

In the transitivity analysis of these four texts, two types of Processes or verbs are most commonly used by the teacher and students in their responses to the text-dependent question: being Processes of attribution *is* to describe characteristics of the
National Parks and doing Processes to express actions related to the topic of national parks preserving the environment *preserve, protect, establish*. With regard to her choice of Processes or verbs, Ying drew on the being Processes (attributive) to describe national parks’ characteristics—*Everything is kind of beautiful and everything is kind of good*. Her choice of the being Processes (attributive) conveyed her personal feelings or attitudes towards national parks. Even though Ying’s response, along with her choice of the being Processes, was taken up by the teacher, the teacher proceeded to use the doing process (e.g., *go, has been preserved, benefit, preserve*) to express actions highlighted by the textbook related to the topic of The National Parks preserving the environment. The teacher elaborated on Ying’s response (Text 2) to refocus students onto the pertinent topic beyond Ying’s general description. Science texts are not about personal feelings or attitudes but they aim to be as clear and precise as possible to define and explain some science phenomenon. As we can see in the analysis of Processes/verbs in Text 3 and Text 4, Tufan did not respond based on his personal feelings or attitudes towards the National Parks; rather, he followed the textbook author’s use of the doing Processes to refer precisely and unambiguously to the actions related to how National Park Services can benefit humans and other organisms.

In summary, overall, the transitivity analysis of these four texts (see Table 5.2) highlights the different connections and language drawn on by the teacher and students in responding to the text-dependent question. Ying, along with her choice of everyday vocabulary, generic nouns, and the being Processes of attribution, tended to draw on everyday knowledge and language to construct her general description of the National Parks’ characteristics and her personal feelings or attitudes toward National Parks. Also
salient in Ying’s response was her repeated use of the verbal hedge kind of which made her description less assertive and is characteristic of everyday language normally used in conversations. Although Ying’s use of everyday knowledge and language was taken up by the teacher in her elaboration of Ying’s response, the teacher immediately proceeded to use field-specific vocabulary, lexical Subjects, and the doing Processes, thereby bringing in the textbook content and language to connect Ying’s description of National Parks’ characteristics with the topic of the National Parks preserving the environment. In Mrs. Dixon’s classroom, the textbook provided the discursive framework from which the teacher enacted instruction and held expectations about how students should answer text-dependent questions. As we can see from the transitivity analysis of Tufan’s response, Tufan seems to have been aware of the teacher’s implicit expectation and followed the textbook to use the field-specific vocabulary, lexical Subjects, and doing Processes to refer concisely and unambiguously to the topic of the National Parks preserving the environment.

Most students in Mrs. Dixon’s classroom, like Tufan, were learning the different ways of knowing science valued in school (i.e., science language featured in the textbook) beyond their personal, commonsense world of recounting particular events and into new worlds of science phenomenon such as erosion, weathering, deposition, and national parks preserving the environment highlighted in the textbook. Fourth grade students who are being inducted into a discipline such as science need to become familiar with the specialized language of that discipline (i.e., science language). However, some students and especially ELLs (Ying) at first do not readily take up science language in the same way that the teacher or the science textbook uses it. Instead of being aware of the
teacher’s implicit expectations and following the textbook to answer text-dependent questions, Ying tended to draw on her familiar everyday knowledge and language to respond to questions. It is important to recognize that even though the task of answering text-dependent questions was the same, the ways students responded differed. As the transitivity analysis demonstrates, students varied their language to respond to text-dependent questions. All students—but especially mainstreamed ELLs—need assistance to learn how to construct responses to text-dependent questions structured in ways that are appropriate for the academic task they are performing.

**Example 6.** In Example 6, I present Ying’s unexpected ideas and unexpected language patterns in her written response to one essay question on the Unit 5 test. The transitivity analysis of Ying’s and other ELLs’ written responses will indicate that Ying, unlike the other ELLs in Mrs. Dixon’s classroom, did not follow the textbook content and language to answer text-dependent question but relied on her use of everyday knowledge and everyday language. In such a situation of written language use, Ying’s use of everyday knowledge and language compared to the others’ use of the more closely approximated science language showed her unawareness and unreadiness to use the appropriate science language to define and explain the targeted science phenomenon.

At the end of this earth science unit, the Unit 5 test was administered in Mrs. Dixon’s classroom to assess students’ understanding of this unit’s concepts. The Unit 5 test consisted of ten text-dependent questions, including eight multiple choice questions and two essay questions. In order to take a close look at the different connections and language used by the ELLs, I examined their written responses to one essay question. I conducted the transitivity analysis of the students’ written responses, focusing on the
ways in which three ELLs presented their responses. I selected these three ELLs to reflect a range of English proficiency levels and to see how they drew on the different connections and language to answer the essay question. Ying, Hyun, and Chin (all pseudonyms), were nine years old at the time of my research observation. Ying is from China and speaks Mandarin Chinese with her family at home. Having been assessed at a Level 4 in a 1-5 scale of English proficiency, Ying was newly integrated into mainstream classes (i.e., Mrs. Dixon’s classroom). Hyun is from South Korea and speaks both Korean and English with his family at home; he had been assessed at a Level 5 on a 1-5 scale of English proficiency and thereby was regarded as a fluent English speaker. Hyun had been integrated into mainstream classes for at least two years. Chin is Korean American and speaks primarily English in school and at home with his parents; however, his parents also use Korean. Chin’s parents indicated that they talked with and read to Chin in English. Since Chin’s parents have indicated English is their home language in school documents, Chin has never been required to take any English proficiency test; therefore, Chin is regarded as one of “unofficial ELLs” (i.e., ELLs not recorded in official school documents) by the researcher. These three ELLs took the Unit 5 test in Mrs. Dixon’s classroom. To demonstrate the different connections and language drawn on by these three students, a more in-depth focus on their responses is provided below.

The essay question of Unit 5 test, “Name one landform made by erosion and one landform made by deposition. Explain how each landform forms,” asked students to name one landform made by erosion and deposition and to explain, respectively, how each landform is made. The three ELLs’ written responses are presented in Table 5.3 with the transitivity analysis and some language patterns. Nouns are marked in boldface,
nouns in the position of Subjects are marked in boldface as well as underlined, and verbs are marked in italics:

Table 5.3  Transitivity Analysis of Students’ Written Responses

<table>
<thead>
<tr>
<th>Text Examples</th>
<th>Language Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Text 1: Ying’s Response</strong></td>
<td>Mix of field-specific and everyday vocabulary; mix of lexical and pronominal Subjects; mix of doing Processes and being Process (attributive); verbal hedge “kind of”</td>
</tr>
<tr>
<td><strong>Erosion makes canyons.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Weathering break rocks.</strong></td>
<td></td>
</tr>
<tr>
<td>Will <strong>erosion carries away weathered rock.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>deposition makes something</strong></td>
<td></td>
</tr>
<tr>
<td>that I think starts with an d.</td>
<td></td>
</tr>
<tr>
<td><strong>It’s</strong> kind of close to an waterway.</td>
<td></td>
</tr>
<tr>
<td><strong>Text 2: Hyun’s Response</strong></td>
<td>Field-specific vocabulary and expanded nouns; lexical Subjects; doing Processes</td>
</tr>
<tr>
<td><strong>Erosion makes canyons</strong></td>
<td></td>
</tr>
<tr>
<td>because <strong>water can wear away bits of rock from the earth.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Deposition makes deltas</strong></td>
<td></td>
</tr>
<tr>
<td>because <strong>water from the sea can bring up stuff from the ocean to the shore.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Text 3: Chin’s Response</strong></td>
<td>Field-specific vocabulary and expanded nouns; lexical Subjects; being Processes (identification) and doing Processes (passive voice)</td>
</tr>
<tr>
<td><strong>One landform made by erosion is canyon.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>One landform made by deposition is sand dune.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Canyons are formed</strong></td>
<td></td>
</tr>
<tr>
<td>when <strong>water carves grooves into rocks.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sand dunes are made</strong></td>
<td></td>
</tr>
<tr>
<td>when <strong>wind carries grains of sand</strong></td>
<td></td>
</tr>
<tr>
<td>and <strong>makes a mound.</strong></td>
<td></td>
</tr>
</tbody>
</table>

From the transitivity analysis of these ELLs’ responses as shown in Table 5.3, Hyun and Chin appear to have used the science textbook as a guide for what they perceived was expected of them. Both students wrote in a relatively formal and objective style characteristic of the language used in the science textbook passages. As we can see in the analysis of Participants or nouns in their responses, both students drew on the field-specific vocabulary *erosion, canyons, deposition, deltas, sand dunes* to convey specialized knowledge of science, and they expanded nouns through modifiers *bits of*...
rock from the earth, water from the sea, one landform made by erosion, one landform made by deposition, grains of sand to package in more science information. Hyun and Chin also used a high number of lexical Subjects erosion, weathering, deposition. These lexical Subjects highlight the scientific phenomenon (things) rather than people in the position of Subjects. This flavors the responses with impersonality. Taken together, their use of field-specific vocabulary, expanded nouns, and lexical Subjects enabled Hyun and Chin to present their information formally, objectively, and impersonally. Their responses appear to be characteristic of the language featured in the science textbook, which contrasts sharply with everyday language typically used in interactive situations.

Different from Hyun’s and Chin’s formal, objective, and impersonal writing style, Ying tended to draw on interactive language of everyday life to construct her response to the essay question. Ying struggled with obvious difficulties correctly using the present tense Weathering break rocks; Will erosion carries away weathered rock and capitalizing the first word of a sentence deposition makes something that I think starts with an d. Nevertheless, drawing on the more closely approximated science textbook language, she used the field-specific vocabulary erosion, canyons, weathering and lexical Subjects erosion, weathering to construct a non-commonsense interpretation of the science phenomena of one landform made by erosion. However, her response became incoherent and puzzling as the text moved from naming one landform formed by erosion to making her personal assumption that her audience would share knowledge to name the landform. She wrote that deposition makes something that I think starts with d, while simultaneously expressing her personal opinion about the appearance of this landform. It’s kind of close to an waterway. Ying’s personal assumption and personal opinion,
along with her use of everyday vocabulary *something, and, waterway*, the first person pronoun *I*, pronominal subject *It*, and the verbal hedge *kind of*, make the second part of her written response characteristic of everyday language typically used in interactive situations.

The language used in written texts is often influenced by the audience for whom they are being written. In the classroom context, the teacher placed a high value on the students who could show their understanding of this unit’s concepts. It was expected that student responses to the essay question would be based on logic and the science knowledge students had learned from the textbook passages rather than on their personal assumptions or personal opinions arising out of intuition or feelings. The language of student responses was therefore expected to be in a relatively formal, impersonal, and objective style, characteristic of the science textbook passages they had read. A comparison of these three ELLs’ written responses, along with the transitivity analysis (Table 5.3), highlights that both Hyun and Chin were aware of their audience (i.e., the teacher) putting a high value on expressing their scientific understanding. Consequently, they drew on the more closely approximated science textbook language to express their understanding of erosion and deposition. In contrast, however, to Hyun and Chin, instead of expressing her understanding of deposition for her audience (i.e., the teacher), Ying, with phrases such as …*something that I think starts with and* and *It’s kind of close to*, drew on everyday language and appeared to have interacted with the audience as if the audience were present, which differs significantly from the expected patterns of science language in such a written situation of language use.
To summarize this section, the evidence from these three examples (Examples 4-6) presented above indicated the challenges Ying encountered in answering text-dependent questions. Namely, the evidence from Ying’s oral and written responses to the text-dependent questions demonstrates that her line of thinking was sometimes hard for the teacher and classmates to follow. The primary contributor to their puzzlement lay in the fact that Ying’s responses did not fit into the discursive framework of the textbook. Rather, Ying often intuitively recounted events about the habitual experiences in her everyday life or drew on everyday knowledge and language to answer the teacher’s text-dependent questions.

As shown in Ying’s, the teacher’s, and peers’ responses to text-dependent questions (see Extract 5.4, Extract 5.5, Table 5.3) and in the macro-level intertextual analysis of student responses to the teacher’s text-dependent question (Table 5.1), the teacher was more likely to take up students’ responses when they fit within the discursive framework of the textbook content and language. Mrs. Dixon’s most common purpose for asking text-dependent questions was to reinforce the textbook content presented and explained earlier. So the teacher, by means of the text-dependent questions, was careful to keep class discussions focused on the textbook passages. Most students in Mrs. Dixon’s classroom were aware of the teacher’s implicit expectations and followed the textbook content and language in response to the teacher’s text-dependent questions. However, instead of being aware of the teacher’s implicit expectations and following the textbook to answer text-dependent questions, Ying tended to draw on her familiar everyday knowledge and language to respond to questions. Certain responses from Ying
--her use of everyday knowledge and language and her personal assumptions or opinions arising out of intuition or feelings--were most likely to be viewed as unexpected ideas. How differently Ying’s unexpected ideas and her peers’ responses to text-dependent questions were constructed through language is highlighted in the transitivity analyses shown in Table 5.2 and Table 5.3. Ying’s peers and/or other ELLs, along with their use of field-specific vocabulary, expanded nouns, and lexical Subjects, presented their information formally, objectively, and impersonally. Their responses appear to be more characteristic of the language featured in the science textbook, which contrasts sharply with everyday language used in Ying’s unexpected ideas.

5.4 Summary of Challenges for ELLs in Science Classroom Discourse

A detailed account of the fourth grade mainstream classroom discourse provided a sense of the complexity beneath the task of participating in classroom discourse and answering text-dependent questions for minority students (i.e., mainstreamed ELLs) that we otherwise take for granted. This chapter, in particular, focused on the challenges for ELLs which were identified in the observed science classroom discourse and the support the teacher did or did not provide in response to the identified challenges. I followed the focal ELLs student (Ying) because the teacher found her unexpected ideas to text-dependent questions puzzling and was concerned about this ELL’s constant interruptions which interfered with the flow of their classroom discourse, as evidenced by the teacher’s comments during the end of Unit 5 interview.

In this chapter, I also provided evidence that answering text-dependent questions in Mrs. Dixon’s classroom meant following the content and language of the textbook. The teacher at times told students to delve into the textbook passages and to
locate relevant information from the textbook for answering text-dependent questions. In the middle of this task, the teacher and most students engaged in sharing their responses to text-dependent questions; however, Ying at times appeared not to stay focused on the task by persistently questioning text-dependent questions or asking questions about her own work. Ying’s persistent questions interrupted the flow of the classroom discourse and further revealed that she lacked awareness to refer back to the textbook to comprehend and answer text-dependent questions. Regarding the particular challenges Ying had in comprehending and answering text-dependent questions, the teacher briefly took up Ying’s questions and explained to Ying what the questions meant. Nevertheless, after the teacher briefly took up and explained Ying’s questions, the teacher immediately refocused the classroom discourse back onto their task (e.g., by nominating other students to continue sharing responses to the questions they were discussing). This classroom context of multiple pressures to cover the textbook content and to complete the task of answering text-dependent questions within the allotted time made it hard for the teacher to take more time to consider Ying’s particular challenges in comprehending and answering text-dependent questions or to provide more instructional support beyond briefly taking up Ying’s questions.

It is also noted, moreover, that Ying’s persistent questions about text-dependent questions and/or questions about her own work were not generally viewed as appropriate in this particular classroom context. Rather, they were seen as interruptions to the classroom discourse. Even when Ying attempted to participate in the classroom discourse and respond to text-dependent questions, she at times offered unexpected ideas or presented ideas in unexpected language patterns which puzzled her teacher and
classmates. It is important to recognize that even though in answering text-dependent questions in the teacher-led question-and-answer sessions the task was the same, the way students responded to it differed. As the above intertextual analyses demonstrated (see Table 5.1, Table 5.2 and Table 5.3), students constructed their responses to text-dependent questions with different kinds of connections and language that were more or less likely to get taken up. In other words, not all responses to text-dependent questions were equally accepted and valued by the teacher (and classmates). The teacher acted in particular ways because the science textbook provided the discursive framework from which the teacher enacted the instruction. This discursive framework also led the teacher to hold implicit expectations about how students should answer text-dependent questions.

The transitivity analyses of student responses to text-dependent questions (see Table 5.2 and Table 5.3) reveal that student responses with their intertextuality to the textbook (Intertextuality I)--a closer match to the teacher’s instructional goals of reviewing and reinforcing the content and language of textbook--were more readily taken up by the teacher and classmates. However, Ying’s responses using recounting events intertextuality (Intertextuality III) or everyday knowledge and language were more likely viewed as unexpected ideas to text-dependent questions. As we can see in the findings and analyses presented in this chapter, the teacher implicitly expected certain responses from students to text-dependent questions (i.e., following the textbook content and language). Her implicit expectations for the particular ways students should present their responses and interact with their teacher and peers required students to construct their spoken and written responses in expected ways. Most student in Mrs. Dixon’s classroom learned which kinds of connections and language (i.e., ones tightly fit the textbook
content and language) were more likely to get their responses acknowledged and accepted by the teacher and their classmates. They were learning the different ways of knowing science expected and valued in school (i.e., science language featured in the textbook) beyond their personal, commonsense world of recounting particular events and into new worlds of science phenomenon such as erosion, weathering, and deposition highlighted in the textbook. However, instead of being aware of the teacher’s implicit expectations and following the textbook to answer text-dependent questions, some students and especially ELLs (Ying) tended to draw on the familiar everyday knowledge and language to respond to questions. Analysis of Ying’s responses to the teacher’s text-dependent questions showed she did not readily take up science language in the same way that the teacher or the science textbook used it. In contrast to her peers’ responses closely matching the textbook content and language, Ying’s response with the recounting events intertextuality about the specific event along with her use of everyday knowledge and language appeared to be less of a fit to the textbook and instruction and was even generally viewed as unexpected ideas by Ying’s teacher and classmates.

Exploring Ying’s unexpected ideas highlights the complex issue of Ying’s reputed behavior problems. However, rather than a behavior problem, the issue may have been complicated by linguistic differences in how the teacher, students, and Ying expected the task of responding to text-dependent questions to be accomplished through language. The ability to follow the textbook content and language and especially the ability to adopt the linguistic features of the textbook enable students’ responses to be more readily taken up by the teacher. Yet it is not the linguistic features that were typically in focus for the teacher. The teacher in the present study appeared unable to be
explicit about her expectations for students beyond saying “you can look back we just read that” or “you need to go back in your book.” Nevertheless, students’ responses referring back to the textbook passages but not following the textbook language were not readily accepted and acknowledged by the teacher (and classmates). On the other hand, students who had learned the teacher’s implicit expectations and followed the textbook content and language were appropriately prompted by the teacher to provide their spoken and written responses to text-dependent questions. Consequently, through this process of answering the teacher’s text-dependent questions, these students gained more practice drawing on the textbook content and language to construct responses. Ultimately, how the teacher actually wanted students’ to answer text-dependent questions and why these types of answers were valued often remained implied by the teacher. The findings and analyses presented in this chapter suggest the need to recognize and make the deliberate effort to bring teachers’ unconscious expectations to their conscious awareness, which is critical to support upper elementary students’ and especially minority students’ participating in science classroom discourse and answering text-dependent questions--their learning science from classroom discourse.
CHAPTER 6. DISCUSSION, IMPLICATIONS, AND CONCLUSION

This study examined how Mrs. Dixon and her fourth grade students in *The Earth’s Changing Surface* unit constructed science knowledge in the observed science classroom discourse. The study took a close look at how the observed science classroom discourse supported and challenged the upper elementary students’ and English Language Learners’ (ELLs) development of science understanding and science language, more specifically their intertextual connections to science terminology and concepts highlighted in science texts and science classroom discourse. The research questions guiding this study were:

1. What is the nature of science classroom discourse?

2. What challenges for ELLs can be identified in science classroom discourse? What support does the teacher provide (or not) in response to the identified challenges?

In this chapter, I summarize the key findings and analyses presented in Chapters 4 and 5. These key findings and analyses are then brought together to discuss the connections between the two research questions answered in these two chapters by highlighting how the observed science classroom discourse offers opportunities and poses demands for upper elementary students’ and ELLs’ learning science from classroom
discourse (Section 6.1). The chapter continues by presenting implications for teachers and teacher educators (Section 6.2). This chapter concludes by reflecting on my dissertation study (Section 6.3).

6.1 Summary and Discussion of Key Findings and Analyses

Section 6.1 is divided into the upcoming two sections. Section 6.1.1 summarizes the key findings and analyses of Chapters 4 and 5 as they relate to research questions one and two respectively. Section 6.1.2 discusses the connections between the two research questions by highlighting how the observed science classroom discourse supports and challenges upper elementary students’ and ELLs’ learning science from classroom discourse, particularly their intertextual connections to science terminology and concepts emphasized in science texts and science classroom discourse.

6.1.1 Summary of Key Findings and Analyses

Research question one was answered primarily in Chapter 4. To address the nature of science classroom discourse, Chapter 4 began with an overall description of the earth science unit and examined the kinds of support the teacher provided to teach the textbook content and language in the observed science classroom discourse. The SFL discourse analysis of the observed science classroom discourse highlighted that much of this teacher’s science teaching was guided by the science textbook. The textbook used particular language structures and wording to express the science terminology and concepts that may have been unfamiliar to students. A particular type of intertextuality (i.e., Recounting Events Intertextuality or Intertextuality III) dominated the presented examples of teacher support. By recounting events about habitual experiences or actions, the teacher supported the students, connecting school science knowledge emphasized in
the textbook with everyday knowledge with which students were more familiar. The transitivity analyses of these examples of teacher support highlighted that the teacher, with recounting events intertextuality, incorporated a great deal of modeling of moving between science and everyday language in presenting and explaining the textbook passages.

Research question two was largely answered in Chapter 5. Chapter 5 turned to the challenges for ELLs, challenges identified in the teacher-led question-and-answer sessions for the review and reinforcement of textbook passages. The teacher interview data revealed that the teacher, puzzled by Ying’s constant questions and interruptions, judged Ying disorganized and distracted for behavior problems. I followed Ying because of the teacher’s puzzlement and concern regarding Ying’s disruptive and distracted classroom behavior. Specifically, when responding to the teacher’s text-dependent questions, Ying’s answers were often not what her teacher and/or classmates expected. It is important to recognize that even though, for all students, the task of answering text-dependent questions was the same, how students responded differed and their use of language varied. The intertextual analyses of student responses to text-dependent questions presented in Chapter 5 showed that not all student responses were equally accepted and valued by the teacher and classmates. The teacher’s expectations for the specific ways students answered text-dependent questions often remained implicit and implied. Ying appeared to be unaware of the teacher’s implicit expectations or the linguistic resources by which to accomplish the advanced science literacy task of answering text-dependent questions. Rather, Ying often intuitively drew on everyday knowledge and language to construct her personal assumptions or opinions. In contrast,
most of Ying’s classmates learned which kinds of intertextuality and language (i.e., ones tightly fitting the textbook content and language) were more likely to get their responses accepted and acknowledged by the teacher and peers in the classroom context.

### 6.1.2 Discussion of Key Findings and Analyses

It can be seen through the findings and analyses summarized in the preceding section that the observed science classroom discourse has its own discursive expectations and language features. In the fourth grade science classes observed and documented in this study, the instruction typically involved having students read aloud the science textbook passages, presenting and explaining the textbook content and language, and then questioning students about the textbook content. In these three stages of the textbook instruction, the teacher and students approached the teaching and learning of science in somewhat different ways, including the different intertextuality, different discursive expectations, and different language features. Table 6.1 outlines these differences, and this section discusses them to highlight how the observed science classroom discourse offers opportunities and poses demands for upper elementary students’, including ELLs’, learning science from classroom discourse.
Table 6.1 *Intertextuality, Discursive Expectations, and Language Features of Textbook Instruction*

<table>
<thead>
<tr>
<th>Textbook instruction</th>
<th>Intertextuality</th>
<th>Discursive Expectations</th>
<th>Language Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reading aloud textbook</td>
<td>Learning vocabulary and information from the science textbook</td>
<td>Science textbook language (field-specific vocabulary, technical, long, and complex nouns, nominalizations, lexical and nonhuman Subjects)</td>
<td></td>
</tr>
<tr>
<td>2. Presenting and explaining textbook content and language</td>
<td>Teacher’s Intertextuality to Recounting Events (Intertextuality III)</td>
<td>Connecting school science knowledge with everyday knowledge</td>
<td>Hybrid science classroom discourse (teacher moving between science and everyday language)</td>
</tr>
<tr>
<td></td>
<td>Students’ Intertextuality to Recounting Events (Intertextuality III)</td>
<td>Sharing their personal specific events (e.g., personal experience of making snowballs)</td>
<td>Everyday Language (everyday vocabulary pronominal Subjects, doing Processes in past tense)</td>
</tr>
<tr>
<td>3. Questioning students about the textbook content (text-dependent questions)</td>
<td>Students’ Intertextuality to Written Texts (Intertextuality I)</td>
<td>Following the textbook content and language</td>
<td>To the more closely approximated science textbook language</td>
</tr>
<tr>
<td></td>
<td>Ying’s Intertextuality to Recounting Events (Intertextuality III)</td>
<td>Drawing on everyday knowledge and language to contribute ideas (most of which are unexpected ideas)</td>
<td>Everyday language (everyday vocabulary generic nouns, being Processes-attributive, verbal hedge “kind of”)</td>
</tr>
</tbody>
</table>

**Impact of Science Textbook on Disciplinary-Specific Discourse: Textual**

**Demands.** As we can see from the first stage of textbook instruction (see the top row of Table 6.1), in Mrs. Dixon’s classroom, the content area expectations required students to learn vocabulary and information from the science textbook passages read aloud by the teacher and students. Learning this vocabulary and information was the challenging literacy task the fourth grade students were expected to encounter in the earth science unit. As stated by the teacher in the interview, “It’s mostly the vocabulary and learning the
differences between all of the words. Because there is so much information, it could get really confusing.” As presented in Chapter 4, teaching and learning science in Mrs. Dixon’s classroom was largely text-based. The major teaching and learning activities in the earth science unit involved reading and discussing the textbook; therefore, most students spent the majority of class time reading the science textbook which has its typical discipline-specific language features that may present unique comprehension challenges for students. SFL analyses of the textbook passages read aloud by the teacher and students (e.g., Figure 4.2, Text 1 of Table 4.4, Text 1 of Table 4.6) showed the science textbook authors use particular language features—the field-specific vocabulary, technical, long and complex nouns, nominalizations, and lexical and nonhuman Subjects. These particular language features are not part of students’ everyday knowledge and far removed from students’ familiar everyday language. This gap between the language of the science textbook and students’ everyday language presents obstacles for students’ comprehension. Consequently, the need to learn from the complex science textbook that contains multiple language demands can be a daunting task for these upper elementary students in Mrs. Dixon’s classroom as novice readers of this kind of discipline-specific language.

Similar to the textual demands of the science textbook to students in this study, some studies on challenges for students in science reading have also demonstrated that register differences between the language of science textbooks and students’ everyday language can present obstacles to students’ full comprehension of science textbooks. As SFL literacy researchers make clear in their analyses of science textbooks at the elementary and secondary school levels (e.g., de Oliveira, 2010; Fang, 2006, 2008; Fang,
Lamme, & Pringle, 2010; Fang & Schleppegrell, 2008; Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2004), students can be challenged by the discipline-specific language of science textbooks. Their analyses of science textbooks reveal that science textbook authors use particular language features to express science terminology and concepts that may present potential linguistic challenges for students in reading science textbooks (see Chapter 2 for more detail). Science textbooks use discipline-specific language to organize and condense science information densely, objectively, and impersonally, but this kind of discipline-specific language makes the reading of science textbooks especially challenging to all students, maybe even more so for the fourth graders and ELLs in Mrs. Dixon’s classroom. It is important to recognize that the key language features found in the aforementioned researchers’ analyzed science textbooks are also present in the fourth grade science textbook passages read aloud by the teacher and students in Mrs. Dixon’s classroom.

Thus, because of the unique textual demands and challenges posed by school science textbook passages, simply reading the textbook passages aloud did not guarantee that most students would understand the textbook or learn from the textbook the vocabulary and information expected by the teacher. Consequently, in order to respond to the textual demands posed by the science textbook passages, the teacher presented and explained the textbook content and language, thereby incorporating teacher support into science classroom discourse. With the textbook having such a significant role in teaching and learning science in Mrs. Dixon’s classroom, the students’ abilities to make sense of the textbook and their abilities to negotiate meaning through textbook instruction became central components of their science literacy. When studying science literacy practices and
texts in school, it is crucial to investigate the textual demands that school science textbooks pose to students (Norris & Phillips, 2003; Shymansky, Yore, & Good, 1991). Yet the findings and analyses of this study go beyond investigating the textual demands of science textbooks. The study documents and analyzes the nature of and the challenges for ELLs that science classroom discourse presents. These findings and analyses can provide a richer picture of science literacy by documenting the textual demands and the teacher and students’ responses to them. The teacher support for the students’ responses to the textual demands posed by the science textbook is discussed in more detail in the next section.

**Responding to Textual Demands of Science Textbook: Teacher’s Support.** In the second stage of textbook instruction (see the middle row of Table 6.1), in order for her students to meet the textual demands of the science textbook, the teacher presented and explained the textbook content and language through classroom discourse. One of the greatest challenges the fourth grade students, including ELLs, faced in the earth science classes was reading the science textbook. Not only is the language technical with field-specific vocabulary, but it is typically dense, objective, and impersonal, with few or no relevant illustrations. Given the relative novelty of the school science textbook content and language to most students, providing substantial support for students to understand the language and content of the textbook passages is necessary. Evidence from this study demonstrated examples (see Examples 1-5 in Chapter 4) to illuminate the two major kinds of support Mrs. Dixon provided to students for their comprehension of the textbook: register-switching between science and everyday vocabulary and using metaphor and analogy directly related to everyday experiences. With these examples of teacher support,
the extracts from the observed science classroom discourse which contained instances of teacher’s intertextuality were then analyzed at two levels: macro-level intertextual analysis (to classify and categorize the sources of intertextuality) and micro-level intertextual analysis (to take a closer look at the language used to construct intertextuality). In the upcoming two sections, I summarize results of the macro-level and micro-level intertextual analyses and discuss the issue of responding to textual demands of science textbook with emphasis on teacher support incorporated into the observed science classroom discourse.

*Macro-level Intertextual Analysis: Teacher Support in Connecting School Science knowledge with Everyday Knowledge.* One salient result from the macro-level intertextual analysis was that the teacher’s Intertextuality to Recounting Events (Intertextuality III) dominated the presented examples of teacher support. As summarized in Table 6.2, the teacher, through these instances of Intertextuality to Recounting Events, connected the school science textbook knowledge with the students’ everyday knowledge.

Table 6.2 *Instances of Teacher’s Intertextuality to Recount Events (Intertextuality III)*

<table>
<thead>
<tr>
<th>Example</th>
<th>School Science Knowledge</th>
<th>Everyday Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1: Deposition → deposit</td>
<td>A natural process of deposition: drop materials somewhere else (deposit)</td>
<td>• Habitual experience of depositing grandma’s birthday money into a bank</td>
</tr>
<tr>
<td>Example 4: Snowball-making metaphor &amp; analogy</td>
<td>Glacier formation: how the pack can turn snow into ice</td>
<td>• Habitual experience of making a hard snowball (pack, pack, pack, hard, hard, hard)</td>
</tr>
<tr>
<td>Example 5: Coffee filter paper metaphor &amp; analogy</td>
<td>Filter paper for experiment on how much water can soil hold</td>
<td>• Habitual experience of seeing parents make coffee with filter paper</td>
</tr>
</tbody>
</table>

(Adapted from Table 4.8 in Chapter 4)
Among these instances of the teacher’s Intertextuality to Recounting Events, the teacher frequently drew on metaphor and analogy to explain the ideas of science (see Examples 4 and 5). As we can see in Example 4, it was in the context of the teacher’s snowball-making metaphor and analogy, along with intertextuality to recounting events (i.e., habitual experience of making a hard snowball), that her students were supported in making sense of the glacier formation (how the pack can turn snow into ice) through their more familiar habitual experience of making a hard snowball by packing the snow. The use of the snowball-making metaphor and analogy with the intertextual connection allowed the teacher to put the abstract and difficult science concepts (the glacier formation) in the familiar terms the students more easily understood (making a hard snowball by packing the snow). Some students picked up on the teacher’s metaphor and analogy of glacier formation to making a hard snowball, and the teacher’s intertextuality prompted Sandy, Tufan, and Sara to share their recounts of personal specific events about snowball making (i.e., students’ Intertextuality to Recount Events) as well as to discuss the properties of snowball (ice), including solidness and hardness related to the glacier formation. These students were encouraged to use their familiar everyday knowledge and language to co-construct science understanding in the science classroom discourse. This study found that the teachers’ use of metaphor and analogy, along with Intertextuality to Recounting Events, were particularly useful in contextualizing the science textbook content and language, thereby helping students connect the difficult science concepts with more familiar terms. This finding is also supported by Cameron (2002), Fang, Lamme, & Pringle (2010), and Wellington & Osborne (2001). They acknowledge that metaphor and analogy play an important role in the understanding and learning of
concepts in science. Metaphor and analogy are favorite devices used by teachers, making the abstract and difficult science concepts easier for students to understand, visualize and remember. As suggested by Walqui (2006), in order for students to better comprehend content-area textbooks including school science textbooks, “Teachers may also provide verbal contextualizations by creating analogies based on students’ experiences. Effective teachers continually search for metaphors and analogies that bring complex ideas closer to the students’ world experiences” (p. 173).

Although it may seem obvious that teachers can contextualize the science textbook content and language through metaphor, analogy, and Recounting Events Intertextuality to help students connect school science knowledge with their everyday knowledge, this issue is not completely straightforward, especially in mainstream science classrooms with ELLs. There may be a mismatch between everyday knowledge of ELLs and that of their native English-speaking teachers and peers due to the contrasting differences in their everyday life experiences. As presented in Chapter 4, Mrs. Dixon’s students seemed to have had habitual experiences in making a hard snowball, seeing parents making coffee with filter paper. The students could apply their shared life experiences of everyday knowledge to the teacher’s use of metaphor and analogy which served as effective support for the students, including the ELLs, in Mrs. Dixon’s classroom. However, in a different classroom context, these connections may not work. It is important to recognize that, on the one hand, the ELLs in Mrs. Dixon’s classroom had achieved a certain level of English proficiency (level 4 and/or level 5 on a scale of 1-5), had fluency in everyday, conversational English, and might have lived in the U.S. for an extended time. On the other hand, in a different classroom context, perhaps some
ELLs might be new arrivals to the U.S., and they might be from the tropics, not having any experience of making snowballs, for example. Coffee might not be a regular drink in their homes and communities, simply not part of their everyday life. Such a mismatch of everyday knowledge between the teacher and the ELLs might result in uncomfortable classroom experiences. Unlike many native English-speaking students who arrive at elementary classrooms and find familiar environments and the teacher who speaks their same language (English), many ELLs might feel like they are moving “from one world to another” as they go from home and community to school (Colombo, 2005, p. 1). Their teachers often differ from their families in race, culture, language, and everyday life experiences. Classroom expectations and patterns of communication may also differ from those at home. These issues will be further discussed in the section of the third stage of textbook instruction (i.e., the issue of Challenges for ELLs Identified in the Task of Answering Text-dependent Questions: Intertextual Analyses & Teacher’s Expectation).

Some researchers have also noted that the mismatch between everyday life experiences of ELLs and those of their native English-speaking teachers and peers may become critical in the pedagogical process in school (e.g., Colombo, 2005; Duff, 2001; Hasan, 1996; Macken-Horarik, 1996). Everyday life experiences are defined by Macken-Horarik (1996) as “the world of the home and the community into which children are born and which provides them with their primary formation” (p. 235-236). She goes on to argue “But everyday world is not uniform. In multi-cultural societies…children’s starting points vis a vis schooling are diverse and open-ended” (Macken-Horarik, 1996, p. 236). The mismatch of everyday life experiences (or everyday knowledge) between teachers and the children they teach might not only result in uncomfortable classroom experiences...
for some students and teachers but lead some students to perform poorly at classroom and school contexts. For instance, Hasan (1996) demonstrated that certain differences in using everyday language at home led some children and especially ELLs to perform poorly at school because of the incongruence between what was expected at school and what they brought from home and community. To bridge the mismatch confronting ELLs and teachers of ELLs, some researchers have suggested teachers help ELLs learn the labels for certain everyday words their native English-speaking peers already know based on their life experiences (e.g., August, Carlo, Dressler, & Snow, 2005). Some researchers have urged teachers to attend professional development workshops (e.g., Family Literacy Nights with Latino families) promoting more meaningful interaction with immigrant families and promoting teachers’ greater understanding and empathy of cultural diversity (e.g., Colombo, 2005). These researchers advocate that it is an educator’s responsibility to assist students and especially ELLs in crossing the mismatch and focusing on their learning tasks.

**Micro-level Intertextual Analysis: Teacher Support in Moving between Science and Everyday Language.** In addition to the macro-level intertextual analysis presented in the preceding section, this study also took a closer look at these examples of teacher support at the micro-level of intertextual analysis. The language features identified in these instances of teacher’s Intertextuality to Recounting Events, as evidenced in the transitivity analyses based on SFL (see Table 4.9), helped us see how the teacher brought together the science, everyday, and mixed language, thereby moving between science and everyday language to help students meet the textual demands posed by the science textbook. As shown in Table 6.3, the teacher introduced the textbook passage first (i.e.,
science language) and then recounted the generalized events about the habitual experiences and/or actions (i.e., everyday language) in building Intertextuality to Recounting Events (Intertextuality III). The teacher then mixed the science language and everyday language (i.e., mixed language), linking what students already knew with the target scientific concepts to be learned. In this context, the teacher brought together the science, everyday, and mixed language, resulting in the hybridity in the observed science classroom discourse. Such hybridity allowed the teacher to connect school science knowledge and language with everyday knowledge and language and to make the targeted science terminology and concepts featured in the science textbook easier for students to understand.

Table 6.3  *Micro-level Intertextual Analysis of Teacher’s Intertextuality to Recount Events*

<table>
<thead>
<tr>
<th>Science Language</th>
<th>Everyday Language</th>
<th>Mixed Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field-specific vocabulary words</td>
<td>Everyday vocabulary words, part of everyday knowledge</td>
<td>• Register-switching between science and everyday vocabulary words</td>
</tr>
<tr>
<td>Technical, long, and complex nouns</td>
<td>Generic nouns</td>
<td>• A mix of field-specific and everyday vocabulary words</td>
</tr>
<tr>
<td>Lexical and nonhuman Subjects</td>
<td>Pronominal Subjects</td>
<td>• A mix of lexical and pronominal Subjects</td>
</tr>
<tr>
<td>Being Processes in passive voices</td>
<td>Doing Processes</td>
<td>• Being and doing Processes</td>
</tr>
</tbody>
</table>

(Excerpted from Table 4.9 in Chapter 4)

As with Table 6.3, the micro-level intertextual analysis highlighted that the teacher, continually moving between science and everyday language, built the intertextual connections and hybrid science classroom discourse in support of students’ comprehension of the science textbook content and language. This study also found that the students had opportunities to see and hear the teacher moving between the different
types of language in her presentation and explanation of the textbook; therefore, their emergent science understanding was being developed, they linked the textbook content to their more familiar concepts, and they were also encouraged to draw on their familiar everyday language for sharing their personal specific events to co-construct science understanding in the observed science classroom discourse. This teacher support featured in this study’s micro-level intertextual analysis also supports Lemke’s (1990) argument, restated by Gibbons (1999, 2006), that in order for teaching and learning science to occur, a critical element in the construction of links between what students already know and target science concepts is the supporting role of teachers in moving between everyday and science language.

This supporting role has also been recognized by an increasing body of research. For instance, Lemke’s (1990) work suggests that teachers who belong to a community of people who already speak the language of science have the better position from which to model how to translate back and forth from everyday and science language. The language of science, “is a foreign ‘register’ (specialized subset of a language within English), and it sounds foreign and uncomfortable to most students” (Lemke, 1990, p. 172). Lemke argues “Teachers should express all semantic relations among terms, and all conceptual relationships for each topic, in ordinary colloquial language as well as in scientific language, insofar as possible, and clearly signal when they are using each” (Lemke, 1990, p. 172-173). Moving between everyday and science language is advocated as a way for teachers to support their students’ establishing intertextual connections to scientific terminology and concepts highlighted in science texts (Lemke, 1989, 1990).
Gibbons (1998, 1999, 2003, 2006) used Lemke’s insights in her research, focusing on how hybrid science classroom discourse can support fifth graders from diverse linguistic and cultural backgrounds to move from their personal ways of making meanings toward more technical, subject-specific ways of talking science. Bridging between everyday and science language, Gibbons emphasized, is particularly relevant to ELLs’ successful learning of science language because their learning science and the language of science can occur as teacher and students bring together everyday and science language to talk science, in other words, register shifts. Lemke’s and Gibbons’s research resonates with one finding of this study— the teacher’s support in moving between science and everyday language. The micro-level intertextual analysis revealed that the teacher, along with her intertextuality to recounting events, constantly moved back and forth between science and everyday language when presenting and explaining the textbook. Such constant register shifts between science and everyday language provided the students in Mrs. Dixon’s classroom multiple points of access to the science terminology and concepts highlighted in the science textbook. Level 4-5 ELLs in this classroom, fluent in conversational English, mostly needed development of their academic English by gaining access to connections between what they were familiar with (everyday English, commonsense concepts) to what they were learning about (scientific English, scientific concepts). Because Mrs. Dixon modeled the hybrid science classroom discourse, her students, including ELLs, learned to bridge from more familiar everyday knowledge and language to unfamiliar science knowledge and language and thereby enhance the intertextual connections.
Another issue emerging from the teacher’s support in moving between science and everyday language was that her use of everyday knowledge and language added complexity to the students’ participation. They were encouraged to draw on familiar everyday knowledge and language, along with their Recounting Events Intertextuality, to participate in the observed science classroom discourse. While what the students brought to bear on their talking science from their everyday life experiences is important, it should not be viewed only as beneficial and good. As the evidence in my study demonstrated, at times a few students and especially ELLs like Ying inappropriately applied everyday knowledge and language to face the task of answering text-dependent questions. The inappropriate use of everyday knowledge and language did not help these students to construct effective responses in academic ways that fit the teacher’s expectations and context in their science classes. In other words, the teacher did not take up their responses most likely because they did not fit within the teacher’s instructional goals and academic expectations in this particular classroom context. In contrast, other students followed the textbook content and language and had their responses accepted and taken up because they fit well within the teacher’s instructional goals and academic expectations. In this particular classroom context, the science textbook provided the discursive framework from which the teacher held expectations about how students should answer text-dependent questions (see the intertextual analyses of students’ responses in Chapter 5). Therefore, this demonstrates the need for teachers to be aware of the language expectations of assigned tasks and to consider the challenges for ELLs identified in school-based tasks. I attend to these challenges in the next section where I
present a summary of the results of intertextual analyses of students’ responses to text-dependent questions.

**Challenges for ELLs Identified in the Task of Answering Text-dependent Questions: Intertextual Analyses & Teacher’s Expectation.** In the third stage of textbook instruction (see the bottom row of Table 6.1), the teacher questioned students about the textbook content through text-dependent questions. The teacher relied on text-dependent questions to engage her fourth graders in reviewing and reinforcing the textbook content presented and explained earlier. My findings reported on the dominance of the text-dependent questions in the fourth grade science classroom while other research indicates that this pattern is similar to what is found in secondary school settings (Hinchman, 1992; Slater, 2004). These researchers found that much student work in the secondary schools involved answering the text-dependent questions printed on the worksheets or in the textbook chapters. As suggested by Fisher & Frey (2012a; 2012b), text-dependent questions should make up a higher percentage of questions asked in secondary schools because the focus on student engagement in reading content area textbooks helps develop their understanding of the information presented. It is also important to note that text-dependent question is labeled differently by different researchers. Hinchman (1992) for example calls it “textually-explicit question” and Slater (2004) calls it “question in review sessions.” Following Fisher & Frey (2012a), I call this type of questions which require students to delve into a text to find answers as text-dependent question in my dissertation study.

In the task of answering text-dependent questions, students are expected to delve into a text and to provide textual evidence in their spoken and written responses
beyond simply drawing on their personal experiences and everyday knowledge. However, the evidence from my dissertation study highlighted that not all students came to school equally prepared to face the task of answering text-dependent questions in the expected ways, nor did all share the same understanding that certain ways of responding were expected by the teacher (and peers). For most students, text-dependent questions prompted them to refer back to the textbook passages, to provide textual evidence in their spoken and written responses (i.e., Intertextuality I), and to follow the textbook content and language. But a few students and especially ELLs, drawing on their everyday knowledge and language (Intertextuality III), at times offered ideas unexpected by the teacher and peers.

It is important to recognize that although the task of answering text-dependent questions was the same for all students, how the students responded differed, and their use of language varied. Even when the teacher at times told students to refer back to the textbook passages and to locate relevant information from the passages to answer text-dependent questions, the kinds of intertextuality and language to achieve this task often remained implicit and implied. As seen in the intertextual analyses presented in Chapter 5 (see Table 5.1, Table 5.2, and Table 5.3), some student responses with their intertextuality to the textbook—a closer match to the teacher’s instructional goals of reviewing and reinforcing the content and language of textbook—were more readily taken up by the teacher. Students like Paula, Tufan, and Carol learned which kinds of intertextuality and language (i.e., ones tightly fit the textbook content and language) were more likely to promote acceptance of their responses. The teacher acted in particular ways because the science textbook provided the discursive framework from which the
teacher enacted the instruction. Furthermore, this discursive framework also led the teacher to hold implicit expectations about how students should answer text-dependent questions.

However, instead of being aware of the teacher’s implicit expectations and following the textbook to answer text-dependent questions, some students like Ying tended to draw on their everyday knowledge and language to respond to questions. Intertextual analyses of Ying’s responses to the text-dependent questions presented in Chapter 5 (see Table 5.1, Table 5.2, and Table 5.3) showed she did not readily take up science language in the same way that the teacher or the science textbook used it. In contrast to her peers’ responses closely matching the textbook content and language, Ying’s response with the Recounting Events Intertextuality (Intertextuality III) along with her use of everyday knowledge and language appeared to be less of a fit to the textbook and instruction and was even generally viewed as unexpected ideas by Ying’s teacher and classmates.

These moments contained great potential for the teacher to explicitly instruct students about how to use the particular kind of intertextuality and language to construct appropriate responses expected of the school-based task of answering text-dependent question. The teacher appeared not able to be explicit about her language expectations for students beyond saying “you can look back we just read that” or “you need to go back in your book.” This is not surprising given the fact that the deconstruction of student responses through intertextual analysis (i.e., the particular kind of intertextuality and language) as well as explicit talk about expectations for how student responses should be linguistically presented may not be familiar to the teacher. Teacher educators and
professional development providers, therefore, should consider the need to help teachers build an understanding of how to use intertextual analysis of student responses to text-dependent questions as potential explicit ways of engaging students to talk about the language characteristics of appropriate student responses. Had the teacher, through intertextual analysis, taken up the student responses and designed mini lessons, she might have been able to explicitly talk about her language expectations and to engage students in discussion about the different kinds of intertextuality and language used to construct appropriate (and inappropriate) responses. (See Section 6.2 for further discussion with an example of intertextual analysis of student responses.)

6.2 Implications for Teachers and Teacher Educators

While the vast majority of the content of this study has involved understanding how the teacher and students taught and learned science in the observed science classroom discourse, this study has several implications for teachers and teacher educators, including those in curriculum design. In the following section, these implications will be presented and discussed.

Much of the research in challenges for students in science reading have demonstrated that register differences between the language of science textbooks and students’ everyday language can present obstacles to students’ full comprehension of science textbooks. As SFL literacy researchers make clear in their analyses of science textbooks at the secondary and elementary school levels (e.g., de Oliveira, 2010; Fang, 2006, 2008; Fang & Schleppegrell, 2008; Fang, Schleppegrell, & Cox, 2006; Schleppegrell, 2004), students can be challenged by the textual demands of science textbooks, particularly the discipline-specific language. The findings and analyses from
this study substantiated that many of the textual demands of science textbooks are evident in the fourth grade classes, as well. With the science textbook having a significant role in teaching and learning science, students’ scientific literacy development is highly dependent on reading the science textbook. SFL analyses of the textbook passages read by the teacher and students illuminated that the science textbook uses particular language features, including the field-specific vocabulary, technical, long and complex nouns, nominalizations, and lexical and nonhuman Subjects. These language features are not part of students’ everyday knowledge and are far removed from students’ familiar everyday language. Consequently, in order for students to meet the textual demands of science textbooks, this study affirms the need for teachers to help students understand the content and language of science textbooks at upper elementary grades. In Mrs. Dixon’s classroom, for example, the teacher frequently incorporated teacher support into the observed science classroom discourse for presenting and explaining the science textbook content and language. This study provided examples to illustrate the two major kinds of teacher support for making sense of the science textbook: register-switching between science and everyday vocabulary and using metaphor and analogy directly related to everyday experiences (see Examples 1-5 in Chapter 4).

The macro-level and micro-level intertextual analyses of the presented examples of teacher support underscored the importance of the teacher’s use of Recounting Events Intertextuality (Intertextuality III) in her presentation and explanation of the textbook content and language. These intertextual analyses also suggest that the teacher’s use of Recounting Events Intertextuality plays a key role in connecting between science and everyday knowledge and moving between science and everyday language (see Table 6.2
By recounting events about habitual experiences or actions (i.e., Recounting Events Intertextuality), teachers can connect the science terminology and concepts highlighted in science textbooks with students’ everyday, familiar knowledge. For example, Mrs. Dixon used the snowball-making metaphor and analogy with the habitual experience of making snowballs to help students connect the new, targeted knowledge of the glacier formation (how the pack can turn snow into ice) to their more familiar habitual experience of making a hard snowball by packing the snow. This allowed the teacher to put the abstract and difficult science concepts (the glacier formation) in familiar concepts the students more easily understood. It should be cautioned, however, that the habitual experiences or actions of students need to be considered when using these to help students understand science textbooks. Some researchers have recognized a mismatch between the everyday knowledge of ELLs and that of their native English-speaking teachers and peers due to the contrasting differences in their everyday life experiences (e.g., Colombo, 2005; Hasan, 1996; Macken-Horarik, 1996). Duff (2001) also noted that ELLs are often at a disadvantage in mainstream content-area classrooms when the teacher talk revolves around some habitual experiences/actions that may not be familiar to these students.

This study has also advocated that teachers, through Recounting Events Intertextuality, can bring together science, everyday, and mixed language, thereby moving between science and everyday language in support of students’ comprehension of science textbooks. Such constant register shifts can allow teachers not only to link what students already know with targeted science terminology and language featured in science textbooks but also to provide multiple points of access to targeted science
terminology and language. Recommendations for teachers to use constant register shifts between science and everyday language in science classroom discourse do not stem from this study alone (see, for example, Brown & Spang, 2007; Ciechanowski, 2006, 2009; Gibbons, 1999, 2006; Lemke, 1989, 1990; Varelas, Pappas, & Rife, 2005; Varelas & Pappas, 2006). Lemke suggested, “Teachers should express all semantic relations among terms, and all conceptual relationships for each topic, in ordinary colloquial language as well as in scientific language, insofar as possible, and clearly signal when they are using each” (1990, p. 172-173).

Teachers who belong to a community of people who already speak the language of science have the better position from which to model how to move back and forth between everyday and science language. For example, Mrs. Dixon frequently modeled moving between science and everyday language in support of her students’ comprehension of the textbook content and language. Especially the Level 4-5 ELLs in this classroom, who were fluent in everyday English, most needed development of their academic English by gaining multiple access to link what they were familiar with (everyday English) to what they were learning about (academic English in the science textbook). The teacher, through Recounting Events Intertextuality, moved back and forth between science and everyday language in the whole-class discussions of the science concepts and terminology. Her students, including ELLs, could thus learn to bridge from their more familiar everyday knowledge and language to unfamiliar science knowledge and language and thereby enhance the intertextual connections. As this study has pointed out, it is important for upper elementary teachers to model continually moving between everyday and science language in presenting and explaining science textbooks so that
students and especially ELLs can more easily learn disciplinary knowledge and science language.

This study’s findings and analyses related to the challenges for ELLs corroborate de Oliveira (2011) and Schleppegrell (2012a, 2001), suggesting the need for teachers to explicitly talk about language expectations for school-based tasks. The challenges for ELLs identified in the observed science classroom discourse emphasize the need for teachers to make explicit to students their expectations for how student responses to school-based tasks (e.g., answering text-dependent questions) should be linguistically presented. This recognized need is supported by other research. de Oliveira’s (2011) research, for example, illustrated that the secondary and high school history teachers had expectations that often remained implicit in terms of how historical understanding and information should be presented in their students’ expository writing tasks. Even when teachers asked students to “take a stance” or “present their ideas clearly,” the expected ways to express the expository writing tasks often remained implied. Textual analysis of the students’ written texts revealed that the students at times had correct historical information but presented and organized in ways not expected by the teachers. de Oliveira’s (2011) research draws our attention to the significant gaps that existed between the history teachers’ expectations and the students’ and ELLs’ writing practices. Her research points to the need to better prepare teachers to explicitly talk about their expectations for school literacy tasks. Schleppegrell (2012a) also identified teachers’ challenges in talking explicitly about their language expectations of assigned school-based tasks. As she put it:
…teachers are often not aware of their implicit expectations for the ways children will use language in a particular context…For many teachers, language is so transparent in its meanings that it is challenging to talk about explicitly and make expectations for language use clear to children. (Schleppegrell, 2012a, p. 412)

Teachers’ challenges in making their language expectations explicit to students are not surprising because teachers do not typically receive any kind of professional development in explicit ways to deal with language in their instruction (Lucas & Villegas, 2013). The findings and analyses of this study suggest the need for the teacher to develop a better understanding of the role of language in the three stages of the textbook instruction (see Table 6.1), thereby recognizing the different intertextuality, different discursive expectations, and different language features in the observed science classroom discourse. When teachers strive to teach students, including ELLs, to learn science, they must also take into account how language can be used for students to participate in science classroom discourse. The findings of this study highlighted that not all students came to school equally prepared to face the advanced science literacy task of answering text-dependent questions and participating in science classroom discourse in the expected way, nor did all share the same understanding that certain ways of responding are expected by teachers (and peers). These findings revealed the need for teachers to understand the role of language in science classroom discourse and to become critically aware of the kinds of intertextuality and language in student responses through intertextual analysis so as to explicitly talk about expectations for the assigned school-
based tasks. This will enable teachers to actively encourage and support language use and participation by students and especially ELLs in science classroom discourse.

As seen in Mrs. Dixon’s classroom, for example, few students, particularly the focal ELL (Ying), were often unaware of the teacher’s expectations for the task of responding to text-dependent questions (i.e., following the science textbook content and language). This task required students to delve into the science textbook passages to provide textual evidence in their spoken and written responses beyond simply drawing on their personal experiences and everyday knowledge. Intertextual analyses of Ying’s responses showed that, in contrast to her peers’ responses closely matching the textbook content and language, Ying’s responses with the Recounting Events Intertextuality and her use of everyday knowledge and language appeared to be less of a fit to the textbook and instruction and were generally viewed as unexpected ideas by the teacher and classmates (see Table 5.1, Table 5.2, and Table 5.3 in Chapter 5). Therefore, it is important to raise all students’ awareness of the kinds of intertextuality and language in student responses expected of the task of answering text-dependent questions.

Intertextual analyses can be used as an explicit way to increase students’ and particularly ELLs’ awareness of different kinds of intertextuality and language in student responses available to them and to support them in becoming critically aware of these differences (i.e., intertextuality to written texts vs. intertextuality to recounting events; everyday language vs. science language).

Teachers can use intertextual analysis of student responses to text-dependent questions as potential explicit ways of engaging students to talk about the language characteristics of appropriate student responses and to make language expectations for
the task explicit to students. One example of Ying’s oral responses unexpected by the teacher and peers in this study might have contained a potential moment for the teacher, through intertextual analysis, to engage her students in discussing language expectations for the task of answering text-dependent questions. After the teacher and students read aloud the science textbook passage on *People and the Environment*, the teacher repeated the concluding sentence of the passage: “When we change the environment, however, we sometimes upset the balance in the environment” (Buckley et al., 2012, p. 189). The teacher noted that they had covered the same topic/content in the social studies curriculum. The teacher then asked students to reflect on the social studies textbook passages learned earlier and asked students “Think about the land in Indiana…It did not always look like this. **But how did people change that?**” At the time of my observation, students drew on the different kinds of intertextuality and language and constructed the more and less readily accepted responses to this text-dependent question. The teacher could have dedicated time to instructing students on how to take a close look at the different kinds of intertextuality and language in student responses. She could have told students they were revisiting a lesson learned the day before. The teacher then could have led the students to revisit the various student responses and to discuss the different kinds of intertextuality and language used by students.

For example, with the use of Table 6.4 (through macro-level intertextual analysis of student responses), the teacher could have led students to focus on the different connections students could develop in their responses, including connections to the textbook, connections to implicit generalized events, connections to personal experiences:
Table 6.4  Different Student Responses to Text-dependent Question

<table>
<thead>
<tr>
<th>Student 1</th>
<th>There used to be that people cut down the forests and drained the swamps.</th>
<th>Connection to Textbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>Right, draining the swamps, cutting the forests...</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Student 2</td>
<td>People hunt animals and we need animals.</td>
<td>Connection to Implicit Generalized Events</td>
</tr>
<tr>
<td>Teacher</td>
<td>Right, there is a lot of hunting that goes on...</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Student 3</td>
<td>We are getting fewer and fewer animals.</td>
<td>Connection to Implicit Generalized Events</td>
</tr>
<tr>
<td>Teacher</td>
<td>Yeah...</td>
<td>Teacher Acknowledgement</td>
</tr>
<tr>
<td>Student 4</td>
<td>Sometimes animals hit the car.</td>
<td>Connection to Personal Experiences</td>
</tr>
<tr>
<td>Teacher</td>
<td>Yeah, like me.</td>
<td>Connection to Personal Experiences</td>
</tr>
<tr>
<td>Students</td>
<td>Unless you did that twice.</td>
<td>Peer Questioning</td>
</tr>
<tr>
<td>Student 5</td>
<td>Um...like the guy in the picture, he is about to hit the bear.</td>
<td>Connection to Textbook</td>
</tr>
<tr>
<td>Teacher</td>
<td>Right. Yes. Looking at this picture. This is a good example.</td>
<td>Teacher Acknowledgement</td>
</tr>
</tbody>
</table>

(Adapted from Table 5.1)

A comparison of the different kinds of connections used by students could have helped the teacher explicitly talk about how appropriate uses of connections in student responses were more likely to be accepted by the teacher and peers in the class (i.e., those connections that fit into the textbook content and the teacher’s instructional goals).

Perhaps, along with Table 6.4, the teacher could have engaged students in discussing the teacher (and peer) feedback to the different kinds of connections in student responses, thereby making the teacher’s expectations for this task clear. The teacher could have asked students to reflect on what they had learned from the science textbook passage on People and the Environment and the social studies textbook passage in order to critique the different kinds of connections in the student responses. A few students might have been able to produce a thoughtful critique of the different connections, but the teacher...
could have explicitly taught this kind of critical thinking to the whole class. For instance, the responses of Students 1 and 5, with their connection to the textbook, were immediately accepted and acknowledged by the teacher because they fit neatly within the discursive framework of the textbook and the teacher’s instructional goals of reviewing and reinforcing the textbook content learned earlier. The response of Students 2 and 3, with their connection to implicit generalized events, were also acknowledged by the teacher because they closely fit into the teacher’s lesson topic of the environment and people. In contrast, Student 4’s response with connection to personal experiences, appeared to be less of a fit to the textbook and instruction and was even challenged by other classmates (see Students’ response). In the whole-class discussion, the teacher, by drawing explicit attention to the different connections in these appropriate and inappropriate student responses, could have explicitly talked about the expectations for the task of answering text-dependent questions and she might have expanded all students’ awareness of the different intertextual connections available to them when responding to text-dependent questions.

In addition to the potential discussion about the different kinds of intertextuality in student responses, the teacher could also have led students to attend to the language of the more readily accepted student responses. Had the teacher used transitivity analysis through SFL (i.e., micro-level intertextual analysis) to discuss the language resources used in the more and less readily accepted student responses, she might have been more able to help all students note that in order to answer the text-dependent question about how people change the environment and upset the balance in the environment, students need to highlight humans as actors who cause change to the environment and animals and
need to know, as well, how language can be used to present them. Perhaps, the teacher could have provided students with typed copies of the more accepted student responses. Then the teacher and students, with highlighters in hand, could have identified the specific language features used to express humans as actors who cause change to the environment and animals—language feature including the use of specific types of Processes (verbs) and the use of specific types of Participants (nouns). The teacher could have guided students to underline the concrete actions expressed by the doing Processes (e.g., cut down, drained, hunt, hit) with highlighters and then to highlight the human actors expressed by the Participants that occur as Subject of the sentences (e.g., people, he), as follows:

[There used to be that] **people** cut down the forests, and **(people)** drained the swamps.

**People** hunt animals and we need animals.

[Um…like the guy in the picture.] **he (person)** is about to hit the bear.

<table>
<thead>
<tr>
<th>Participant: Actor</th>
<th>Doing Process</th>
<th>Participant</th>
</tr>
</thead>
</table>

Along with the initial transitivity analysis of these more readily accepted student responses (see the above), the teacher could have asked students to look at how the wording of these responses was presented and asked if they could see any patterns. A few students might be able recognize the boldfaced Subject of these sentences and the verbs, but the teacher could explicitly teach to all the students the language characteristics of these student responses. By drawing explicit attention to the use of specific types of the doing Processes as well as the Participants in these student responses, the teacher could have explicitly talked about how the concrete actions cut down, drained, hunt, hit
expressed by the doing Processes are performed by human actors people, he with these actors occurring as Subject of the sentences. Thus, through their explicit talk about how language can be used to construct student responses, the teacher could hope to support students in becoming critically aware of the active roles taken by humans in causing change to the environment and animals and to make students conscious of the language expectations for the task of answering this text-dependent question. Furthermore, the teacher could have guided students to see why Student 4’s response (Sometimes animals hit the car) was not appropriate to this text-dependent question. Different from other students’ choices of human actors, Student 4 had “animals,” not humans (e.g., people, he) as Subject to perform the action of hitting the car. Student 4’s response was challenged by other classmates, “Unless you did that twice” to emphasize that unless you as the human driver acted to hit animals the second time (animals hit the car the first time). As with the transitivity analysis based on SFL, the teacher could have guided students to take a closer look at how language can be used to construct these appropriate (and inappropriate) responses and to make them conscious of the language expectations for the task of answering text-dependent questions.

Given that the focal ELL (Ying) in Mrs. Dixon’s classroom appeared not to be aware of the teacher’s expectations for the task of answering text-dependent questions and to have such trouble with following the textbook content and language to answering text-dependent questions, the implications from this study suggest that teachers should consider explicitly teaching students the kinds of intertextuality and language expected by the school-based task rather than having these expectations remain implicit and/or implied. Not all students come to school equally prepared to face the school-based task of
answering text-dependent questions in the expected way, nor do all share the same understanding that certain ways of responding are expected by teachers (and peers). The focal ELL in this study, for example, needed this kind of explicit instruction. Exploring Ying’s unexpected ideas reveals the complex issue of Ying’s reputed behavior problems which concerned the teacher. However, rather than a behavior problem, the issue might have been complicated by language differences in how the teacher, students, and Ying expected the task of answering text-dependent questions to be accomplished through language. As suggested by this study, teachers can use intertextual analysis of student responses to text-dependent questions as potential explicit ways of engaging students in discussion about the expectations for that task.

This kind of deconstruction of student responses to text-dependent questions through intertextual analysis may not be familiar to teachers; thus, professional development should build an understanding of how to use intertextual analysis as explicit talk about language expectations for the school-based task of answering text-dependent questions. Teachers need to be made aware through intertextual analysis of the role of language in science classroom discourse and receive professional development to become critically aware of the kinds of intertextuality and language in student responses so as to explicitly talk about expectations for the assigned school-based task of answering text-dependent questions. Ultimately, this will enable teachers to actively encourage and support language use and participation by students and especially ELLs in science classroom discourse. To participate in this kind of professional development, teachers must be supported by teacher educators and/or professional development providers to build on their expertise. These educators and providers need to prepare teachers to
analyze student responses to text-dependent questions using tools like those presented in
the macro-level and micro-level intertextual analyses of student responses in Chapter 5 to
understand how to provide explicit instruction of expectations for how student responses
to school-based tasks should be linguistically presented.

6.3 Conclusion

I had two purposes in mind when I designed this study and walked into Mrs. Dixon’s classroom. These purposes were reflected in the two research questions which
guided my inquiry: to explore the nature of science classroom discourse and to describe
challenges for ELLs identified in science classroom discourse as well as support the
teacher provides (or not) in response to the identified challenges. The findings and
analyses from this study have helped to describe how Mrs. Dixon and her fourth grade
students in the earth science unit constructed science knowledge in the observed science
classroom discourse, particularly the kinds of support the teacher provided to teach the
science textbook content and language. The SFL discourse analysis of the observed
science classroom discourse demonstrates that much of the teacher’s science teaching
was guided by and based on the science textbook. In order for students to meet the textual
demands of the science textbook (e.g., the discipline-specific language), the teacher drew
on Recounting Events Intertextuality to connect between science and everyday
knowledge and to move between science and everyday language in her presentation and
explanation of the textbook content and language.

Furthermore, this study examined through the macro-level and micro-level
intertextual analyses the challenges for ELLs identified in the teacher-led question-and-
answer sessions, with a closer look at the different kinds of intertextuality and language
used by students, including ELLs, in the task of answering text-dependent questions. Not all responses to text-dependent questions were equally accepted and valued by the teacher and classmates. The teacher demonstrated different ways of taking up the students’ responses because the science textbook provided the discursive framework from which the teacher enacted the instruction. This discursive framework also led the teacher to hold implicit expectations about how students should answer text-dependent questions. Most students learned which kinds of connections and language (i.e., ones tightly fit the textbook content and language, Intertextuality to Written Texts) were more likely to get their responses acknowledged and accepted. However, instead of being aware of the teacher’s implicit expectations and following the textbook to answer text-dependent questions, the focal ELL tended to use Recounting Events Intertextuality (or everyday knowledge and language) to respond to questions and offer ideas unexpected by the teacher and classmates.

The evidence in my dissertation reminds us that the task of participating in science classroom discourse and answering text-dependent questions is much more than a simple process that we take for granted, as it requires students to draw from the textual information of the science textbook, it demands students to use the discipline-specific language of the science textbook, and it challenges students to meet the teacher’s implicit and/or implied expectations for how student responses should be linguistically presented all at the same time. Such a school-based task of participating in science classroom discourse and answering text-dependent questions challenges all fourth grade students, but it is particularly challenging for ELLs with their diverse language and culture backgrounds and less contact with academic language in the content areas such as science.
The Level 4 ELL (Ying) in this study, for example, was fluent in conversational English and appropriately used it in daily communications, yet she faced additional demands in learning in her second language the academic English expected by this school-based task. Upper elementary students being inducted into a discipline such as science need to become familiar with the specialized language of that discipline. It is important to recognize that science language (e.g., the discipline-specific language of science textbooks) is really not native but a learned formed of language with teachers’ explicit language instruction. The process of doing this study has highlighted for me that upper elementary students and especially ELLs need instructional support from teachers in learning to develop new ways of participating in science classroom discourse and answering text-dependent questions that correspond to teachers’ expectations. Without such instructional support, students and especially ELLs will remain unaware of the register differences between everyday and science language and continue to use their more familiar everyday knowledge and language to contribute ideas unexpected by teachers, not having opportunities to learn different ways of knowing science valued in school beyond their personal, commonsense world of recounting particular events. This study has reinforced the importance of looking closely at how upper elementary students learn science from classroom discourse and making teachers’ language expectations for how their responses to school-based tasks should be linguistically presented when considering how we can enhance the scientific literacy development of both fourth grade native English-speaking students and ELLs in mainstream science classrooms.
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REFERENCES


Fang, Z. (2008). Going beyond the Fab Five: Helping students cope with the unique linguistic challenges of expository reading in intermediate grades. *Journal of Adolescent and Adult Literacy, 51*(6), 476-487.


Wells, G. (1994). Text, talk and inquiry: Schooling as semiotic apprenticeship. In N. Bird et al. (Eds.), *Language and learning* (pp. 18-51). Hong Kong: Institute of Language in Education and University of Hong Kong Department of Curriculum Studies.


APPENDICES
Appendix A  Initial Interview Questions

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Would you tell me about your experience teaching science in your class?</td>
</tr>
<tr>
<td>2.</td>
<td>Could you tell me about the kinds of teaching strategies and activities you have in your science lessons?</td>
</tr>
<tr>
<td>3.</td>
<td>Could you tell me a little bit about your experience teaching English Language Learners in your class?</td>
</tr>
<tr>
<td>4.</td>
<td>Could you tell me a little bit about your students, including the mainstreamed ELLs?</td>
</tr>
<tr>
<td>5.</td>
<td>During these months of data collection, can I come to visit your science class on daily basis? Or how often do you prefer my visit to your science class weekly?</td>
</tr>
<tr>
<td>6.</td>
<td>Is there anything else you would like to add?</td>
</tr>
</tbody>
</table>
Appendix B  Interview 1 Questions

Interview 1 questions are the interview questions designed for the teacher at the beginning of each science unit.

1. Please talk about your pedagogical plans (some planned activities) for this science unit.

2. Please talk about the challenges your fourth grade students, including the mainstreamed ELLs, might encounter in learning such a particular science unit.

3. Please talk about your planned instructional support for your students’ learning of this particular science unit.

4. Is there anything else you would like to add?
Appendix C  Interview 2 Questions

Interview 2 questions are the interview questions designed for the teacher at the end of each science unit.

<p>| | |</p>
<table>
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<tbody>
<tr>
<td>1</td>
<td>Can you talk about your impression on students’ overall performance on this science unit?</td>
</tr>
<tr>
<td>2</td>
<td>Please talk about your perceptions of how your students are supported and challenged to make connections to the scientific terminology and concepts highlighted in the textbook passages and classroom discussions of this unit.</td>
</tr>
<tr>
<td>3</td>
<td>Please talk about the instructional strategies and materials (e.g., instructional videos, textbook, school library books) you use in this science unit.</td>
</tr>
<tr>
<td>4</td>
<td>What do you think of the mainstreamed ELLs’ performance in participating in science classroom discussions and/or science activities?</td>
</tr>
<tr>
<td>5</td>
<td>Have you met and/or had conferences with your ELLs’ parents? Have they ever mentioned any concern for their children’s performance in the fourth grade (transition year)?</td>
</tr>
<tr>
<td>6</td>
<td>Is there anything else you would like to add?</td>
</tr>
</tbody>
</table>
## Appendix D  Episode Summaries of Mrs. Dixon’s Earth Changing Surface Unit

10/04/2011

<table>
<thead>
<tr>
<th>No.</th>
<th>Instructional Segment</th>
<th>Activity/Dominant Participation and Interaction Structure</th>
<th>Modes (role of written and spoken texts)</th>
<th>Constructed knowledge about science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reviewing</td>
<td>T/Class: Whole-class IRE</td>
<td>Spoken: T reviews what they discussed about glaciers</td>
<td>Glaciers</td>
</tr>
<tr>
<td>2</td>
<td>Reading textbook passage on glaciation</td>
<td>T/Class: Whole-class IRE</td>
<td>Spoken: Nominate one student to read aloud the textbook passage on <em>Glaciation</em> Q/A between T and students about the content of textbook passage Written: Textbook passage on <em>Glaciation</em> Picture: Textbook picture of glacier formation</td>
<td>Learn how glaciers shaped the state of Indiana</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S read aloud textbook passage on <em>Glaciation</em> T highlights the vocabulary (moraine, till, kettles) and definitions of till and kettles</td>
<td>Learn the formation of a glacier-the process of glacier formation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Accompanying the textbook passage and pic <em>From ?</em> T paral process: of glacier formation to snowball making</td>
</tr>
<tr>
<td>3</td>
<td>Watching</td>
<td>T/Class: Whole-class</td>
<td>Spoken</td>
<td></td>
</tr>
<tr>
<td>BrainPOP video on glacier</td>
<td>IRE</td>
<td>Written Animated Picture</td>
<td>How do glaciers move and shape the landscape?</td>
<td></td>
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<td>---------------------------</td>
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<td>---------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Describing movement of glaciers across Indiana</td>
<td>T/Class: Whole class IRE &amp; Discussion</td>
<td>Spoken: T describes the movement of glaciers across Indiana Written &amp; Drawing: T draws the map of Indiana to model the movement of glaciers in the state of Indiana</td>
<td>Learn how the movement of glaciers across Indiana shaped the landscape of Indiana</td>
<td></td>
</tr>
<tr>
<td>5 Creating ice cream model - how glaciers formed the Indiana landscape</td>
<td>T/Whole class: Each student builds up his/her own model</td>
<td>Spoken: T directs students to build individual model of glaciers in Indiana</td>
<td>Learn the content of the till: soil, clay, boulders, gravel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Materials required: Baggies, Plastic foam plates, ice cream, Oreo cookies, Cotton candies, Candies; using ice cream to represent glaciers; using Oreo cookies to represent dark soils; using cotton candies to present clay and boulders; using candies to represent gravel; using hand movement of ice cream to represent the movement of glaciers</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Model the movement of glaciers in the state of Indiana → glaciers move from Michigan to Indiana, moving down to the center of Indiana, moving back (retreating), part of glaciers melting and leaving the lakes and rivers, forming lakes and tills, moving slowly</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Drawing the outline of Indiana on plastic foam plates 2. Getting baggies 3. Putting Oreo cookies into baggies and crushing cookies up (dark soil) 4. Putting cotton candies into baggies (boulders, clay) 5. Putting candies into baggies (gravel) 6. Shaking baggies 7. Putting the mixture from baggies into</td>
<td></td>
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</tbody>
</table>
the very top of plates
8. Turning baggies inside out and using them as gloves to take out ice cream (glaciers)
9. Moving along ice cream, stopping, and then moving back

10/10/2011

<table>
<thead>
<tr>
<th>No.</th>
<th>Instructional Segment</th>
<th>Activity/Dominant Participation and Interaction Structure</th>
<th>Modes (role of written and spoken texts)</th>
<th>Constructed knowledge about science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Reading textbook passage on weathering</strong></td>
<td>T/Whole Class: IRE</td>
<td>Spoken: Nominate students to read aloud the textbook passages on <em>Weathering</em>. Q/A between T and students about the content of textbook passage. Written: Textbook passage on <em>Weathering</em> Textbook questions</td>
<td>Definition of weathering Two types of weathering: Chemical weathering Physical weathering</td>
</tr>
<tr>
<td>2</td>
<td><strong>Watching BrainPOP on</strong></td>
<td>T/Whole Class: IRE</td>
<td>Spoken: T reviews and discusses the video Written &amp; Pictures:</td>
<td>Learn how rocks break down into soil and how slow and Mechanical weathering is synonym for</td>
</tr>
<tr>
<td>No.</td>
<td>Instructional Segment</td>
<td>Activity/Dominant Participation and Interaction Structure</td>
<td>Modes (role of written and spoken texts)</td>
<td>Constructed knowledge about science</td>
</tr>
<tr>
<td>-----</td>
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<td>-----------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Introducing topics of soils, weathering, &amp; erosion</td>
<td>T/Whole Class</td>
<td>Spoken: T informs students how they should behave Guest speaker briefly introduces himself</td>
<td>Be good listeners, listen for directions, and ask questions</td>
</tr>
<tr>
<td>2.a</td>
<td>Experiment</td>
<td>Guest Speaker/Whole</td>
<td>Spoken:</td>
<td>Observations of what</td>
</tr>
</tbody>
</table>

- **Weathering**: Caption of the content of the video clip and animated pictures. Natural forces can actually change the shape of Earth’s surface. The difference between mechanical and chemical weathering.

- **Reading supplement article from BrainPOP**: T/Whole Class: IRE. Spoken: T discusses the article (thermal expansion-Liberty Bell). Written & Picture: Accompanying the picture of Liberty Bell, T projected the written text on board. Learn another example of physical weathering – thermal expansion.
<table>
<thead>
<tr>
<th>Class: IRE &amp; Discussion</th>
<th>Guest speaker has students answer “what soil is made of”? and then he directs students to observe the soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual group work</td>
<td>Written: Guest speaker asks two students to write students’ ideas on board</td>
</tr>
<tr>
<td></td>
<td>Materials required: A bucket of soils, one scoop of soils, soil trays</td>
</tr>
</tbody>
</table>

**soil is made of:**
1. Divide students into 8 groups
2. Get the materials to observe the soils—a bucket of soils, one scoop of soils, soil trays
3. Observe the soils and make a list of everything students can find in the soils

**2b. Demonstrating how to use the tool, soil sieve, in experiment**

<table>
<thead>
<tr>
<th>Guest Speaker/Whole Class: IRE &amp; Demonstration</th>
<th>Spoken: Guest speaker explains, demonstrates and directs how to use the soil sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials required: Soil sieve, other materials mentioned above (a bucket of soils, one scoop of soils, soil trays)</td>
<td></td>
</tr>
</tbody>
</table>

Learn how to use the soil sieve within individual group:
1. Get soil sieve
2. Pour the soil from the tray into the top of sieve
3. Shake the sieve back and forth
4. Pour the separated soils from the sieve into the different piles on the tray

**3. Reviewing and discussing**

<table>
<thead>
<tr>
<th>Guest Speaker/Whole Class: IRE &amp; Discussion</th>
<th>Spoken: Guest speaker asks questions about soil.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions asked by the guest speaker:</td>
<td></td>
</tr>
<tr>
<td>• Does anyone know the difference between dirt and soil?</td>
<td></td>
</tr>
</tbody>
</table>
Written & Drawing:
Guest speaker directs students attention on their answers on board and makes some drawings to review some concepts students just learned from Mrs. Dixon’s prior class about soil

• Can you tell me something about the difference among the different piles [of soils]?
• So here is my question: the rock he has, and the other rocks we would find in other soils, would they ever change size?
• What’s happening to this mountain [drawn on the board]?
• But what is it when it is breaking down or tearing apart? What’s the word we want there?
• So we have water for rain, what about other things that can tear that apart?
• Breaking it up is weathering. But when particles start moving or they get moved away, what was that called?
• Who really cares [about soils]? Why would somebody care about soils?
<table>
<thead>
<tr>
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<th>Modes (role of written and spoken texts)</th>
<th>Constructed knowledge about science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reviewing and introducing</td>
<td>T/Whole Class</td>
<td>Spoken: T reviews what the guest speaker highlighted in yesterday class and introduces the new key word (i.e., erosion)</td>
<td>Learn the key concepts of soils: erosion</td>
</tr>
<tr>
<td>2</td>
<td>Reading textbook passage on erosion</td>
<td>T/Whole Class: IRE &amp; discussion</td>
<td>Spoken: T asks students to prepare their highlighters and then explicitly elaborates on what students are expected to do during the reading aloud T asks questions about the content of textbook passage and students answers Written: Textbook passage Textbook questions and teacher-prepared questions Textbook pictures Materials required: Highlighter</td>
<td>Highlight and learn the topic of each paragraph: 1. textbook definition of “erosion” 2. description of how the water causes erosion 3. description of how the glacier causes erosion Students are expected to take out their highlighters, listen, read, and think about the textbook passage read aloud by one volunteering student</td>
</tr>
</tbody>
</table>
| 3 | **Reading textbook passage on deposition** | **T/Whole Class: IRE & discussion** | **Spoken:** T nominates students to read aloud the textbook passage and then asks questions about the content of textbook passage  
**Written:** Textbook passage  
Textbook questions  
Textbook pictures of canyon | **Learn the textbook definition of “deposition”** | **Deconstruct the nominalized, scientific vocabulary:** deposition → deposit (i.e., connect the nominalized, scientific vocabulary “deposition” to students’ everyday knowledge and language—*deposit money in bank*) |
| 4 | **Watching BrainPOP video on erosion** | **T/Whole Class: IRE & discussion** | **Spoken:** T reviews some key concepts of the video clip  
**Written & Pictures:** Caption of the content of the video clip and animated pictures | **Learn definition of erosion** | **Learn the difference between weathering and erosion** |
<table>
<thead>
<tr>
<th>No.</th>
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<th>Modes (role of written and spoken texts)</th>
<th>Constructed knowledge about science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reviewing and introducing</td>
<td>T/Whole Class: IRE</td>
<td>Spoken: T reviews the prior guest speaker’s class and introduces today’s experiment on how much water can soils hold.</td>
<td>Learn about soils and the properties of soils</td>
</tr>
<tr>
<td>2</td>
<td>Experimenting on how much water can soils hold</td>
<td>T/Whole Class: IRE &amp; Small Groups</td>
<td>Spoken: T calls on students to pass out the experiment materials and explains the experiment purpose. Written: Textbook as the step-by-step guide for their experiments and the place to record their results. Materials required for experiments: two cups of soils-one is sandy soil and another is labeled clay soil; two cups with their bottoms poked ten holes; preparing filter cups by giving each group paper towels, tracing the bottom of cup with pencils two times, cutting out the circles.</td>
<td>In this experiment, students will learn about the properties of soil→ students will measure the mass of different types of damp soils to compare how much water each holes. T explains the paper towels act as filter to prevent soil from going through (clogging the holes) by using the coffee filter example.</td>
</tr>
</tbody>
</table>
| 3 | **Following textbook experiment procedures** | T/Small Groups | Spoken: T directs each group to follow the step-by-step experiment procedures listed in the textbook  
Written: Textbook | Students follow textbook experiment procedures to measure the mass of damp soils to compare how much water each holds |
|---|---|---|---|---|
| 4 | **Sharing extra-credit student work**  
during the 20 minutes of waiting for experiment results | T/Whole Class & Individual student | Spoken: T nominates some students to orally share their work with class | Students share their written work, poster, and pictures with the class |
| 5 | **Discussing experiment results** | T/Whole Class: IRE & Discussion | Spoken: T discusses with students  
Written: Students write down their experiment results to answer textbook question | Students learn to measure the mass of different types of damp soils to compare how much water each holds → based on their experiment results, students would conclude that clay soil holds more water than sandy soil  
Students are expected to write down experiment results, compare and communicate their experiment results; they are also expected to answer the textbook question “Based on your measurements, which type of soil holds more water? Explain.” |
<table>
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<tr>
<th>No.</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reviewing</td>
<td>T/Whole Class: IRE</td>
<td>Spoken: T reviews what they had read about soil yesterday</td>
<td></td>
</tr>
</tbody>
</table>
| 2   | Reading textbook passage on crop growth | T/Whole Class: IRE & Discussion | Spoken: T nominates one student to read aloud the textbook passage; T discusses textbook questions with students  
Written: Textbook passage  
Textbook questions | Learn about how farmers can replace nutrients in the soil- farmers can rotate crops and plow their crops back into the soil | To focus students on the task of reading textbook, T said, “This is the one we need to read along and to listen very carefully “ |
| 3   | Setting up new tasks | T/Whole Class: IRE & Discussion | Spoken: T explains what students are expected to do; one task is to write up their Lesson 2 worksheet after watching videos and another is to watch videos  
Written: Lesson 2 Worksheets | Explicit expectation of their writing Lesson 2 worksheet: T encourages students to use textbook as reference (to look back)  
...because I expect complete sentences, complete ideas |
4  **Watching and discussing the videos**  | T/Whole Class: IRE & Discussion  | Video  | The videos review most of key concepts in Lesson 2 such as parent-rock, weathering, soil, erosion, topsoil, subsoil, bedrock, humus, earthworms, people protect soil by rotating crops, adding nutrients, plowing

5  **Writing Lesson 2 worksheet**  | Individual work  | Written: Worksheet Textbook  | Review the key concepts of Lesson 2: particles, humus, crops, crop growth, the properties of soil

10/24/2011

<table>
<thead>
<tr>
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<th>Activity/Dominant Participation and Interaction Structure</th>
<th>Modes (role of written and spoken texts)</th>
<th>Constructed knowledge about science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Reviewing</strong></td>
<td>T/Whole Class: IRE</td>
<td>Spoken: T reviews they had talked about earthquakes and volcanoes</td>
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</tbody>
</table>
| 2 | **Reading textbook passage on Tsunamis** | **T/Whole Class: IRE & Discussion** | **Spoken:** the teacher herself reads aloud the textbook passage and then nominates students to read aloud; **T** discusses textbook questions with students | **Written:** Textbook passage 
**Learn about the definition of tsunami, how does a tsunami start, and what happens when a tsunami get closer to shore** 
**Contextualized the 520 meters Tsunamis by using one meter wood stick ruler [Line 28-34]** |
| 3 | **Watching and discussing BrainPOP video on tsunamis** | **T/Whole Class: IRE & discussion** | **Spoken:** T reviews the key concepts of the video clip 
Written & Pictures: Caption of the content of the video clip and animated pictures | **Learn definition of tsunami and the cause of tsunami** |
| 4 | **Answering and discussing textbook question** | **T/Whole Class: IRE & discussion** | **Spoken:** T reads aloud textbook question and discusses with students 
Written: Textbook question 
Textbook passages | **Ying encounters specific challenges understanding the textbook question** |
| 5 | **Reading textbook passage on Landslides** | **T/Whole Class: IRE & discussion** | **Spoken:** T nominates students to read aloud; T discusses textbook questions with students 
Written: Textbook question 
Textbook passage | **Focus students’ attention on the textbook passage and picture of “landslide” [** |
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
</table>
| 6    | **Answering and discussing textbook question** | T/Whole Class: IRE & discussion  
Spoken: T reads aloud textbook question and discusses with students  
Written: Textbook question  
Textbook passage  
Highlight the difference between focus and epicenter |
| 7    | **Writing Lesson 3 worksheet and listing important facts about earthquakes, volcanoes, tsunamis, and landslides after their group discussion** | Individual writing of Lesson 3 worksheet and Fact List  
Spoken: Group discussion to share their individual writing of important facts  
Written: Lesson 3 worksheet  
Fact list  
Pictorial: Students are allowed to draw pictures of the natural phenomenon  
Discussion with their group members over the important facts of earthquakes, volcanoes, tsunamis, and landslides |
<table>
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<th>Constructed knowledge about science</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Reviewing</td>
<td>T/Whole Class: IRE</td>
<td>Spoken: T reviews they had experimented on “How can pollution affect water” yesterday and discusses with students about what they learned from the experiment.</td>
<td>Review that students observe how light travels easily through clear water, and how less light travels through cloudy water</td>
</tr>
<tr>
<td>2</td>
<td>Reading textbook passage on People and the Environment</td>
<td>T/Whole Class: IRE &amp; Discussion</td>
<td>Based on their review of the air pollution, T highlights that they are going to learn the different kinds of pollution. T nominates students to read aloud and connects to the social studies textbook passage explained earlier; T discusses textbook questions with students accompanying the textbook picture</td>
<td>Learn to describe some positive and negative ways in which human activities affect the environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Written: Textbook passage Textbook questions Pictorial: Textbook picture</td>
<td></td>
<td>Encourage students to connect to the social studies textbook passage to discuss how human activities affected Indiana environment; T said “Yeah, we upset the balance in the environment. This is not the first time we talk about this. Does this sound familiar from social studies…Yes, think about the land in Indiana…”</td>
</tr>
<tr>
<td>3</td>
<td><strong>Reading textbook passage on pollution and air pollution</strong></td>
<td>T/Whole Class: IRE &amp; Discussion</td>
<td>Spoken: T nominates students to read aloud the textbook passages on pollution and air pollution; T discusses with students about some facts about air pollution</td>
<td>Learns Air Pollution</td>
</tr>
</tbody>
</table>
| 4 | **Watching BrainPOP on air pollution and listing facts about air pollution** | T/Whole Class: IRE & Discussion  
Individual Work: Each student’s list about air pollution | Written: Each student is directed to list facts about air pollution from the textbook passages and the video  
Visual & Animation: BrainPOP on Air pollution | Learns Air Pollution | Discuss the facts about air pollution from the textbook passages and video |
| 5 | **Reading textbook passage on water pollution** | T/Whole Class: IRE & Discussion | Spoken: T nominates students to read aloud the textbook passages on water pollution; T discusses with students about some facts about water pollution | Learn Water Pollution | Discuss some facts about water pollution from the textbook passages |

Dishita: ...like an animal house that they have cut down  
T: Habitat…  
Dishita: yeah, Habitat, they wouldn’t have places to live…
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Review</td>
<td>T/Whole Class: IRE &amp; Discussion</td>
<td>Spoken: T reviews they had learned from Lesson 4</td>
<td>Reviews the ways to preserve our environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Discuss the word meaning of preserve students: protect T: protect + save National Parks to preserve our environment</td>
</tr>
</tbody>
</table>

| 6   | Watch BrainPOP on water pollution and listing facts about water pollution | T/Whole Class: IRE & Discussion Individual Work: Each student’s list about water pollution | Written: Each student is directed to list facts about water pollution from the textbook passages and the video Visual & Animation: BrainPOP on water pollution | Learns Water Pollution Discuss the facts about water pollution from the textbook passages and video |

11/9/2011
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<tr>
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</tr>
</thead>
</table>
| 1   | Reading textbook passages on Ores | T/Whole Class: IRE & Discussion | Spoken: T nominates students to read aloud and asks students to share their responses to the textbook questions  
Written: Textbook passage  
Textbook question | Learn nonrenewable resources: fossil fuels & ores (e.g., how do fossil fuels form)  
Definition of nonrenewable resources |
| 2   | Reading textbook passages on How Resources can Last | T/Whole Class: IRE & Discussion | Spoken: T nominates students (to read aloud and asks students to share their responses to the textbook question  
Written: Textbook passage | Learn the ways that people can conserve resources |

Looking back at their textbook passages specified by the teacher

T/Whole Class: IRE & Discussion

Spoken: T nominates some students to share their ideas on the ways to preserve our environment  
Written: Textbook passages specified by the T (p. 192-p. 195)

Discuss the ways to preserve our environment  
T ask students to elaborate on some key words: reclamation, nonrenewable

11/11/2011
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<tr>
<th>Longer</th>
<th>Textbook question</th>
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<tr>
<td>3</td>
<td><strong>Watching BrainPOP on fossil fuels</strong></td>
</tr>
<tr>
<td></td>
<td>T/Whole Class: IRE &amp; Discussion</td>
</tr>
<tr>
<td></td>
<td>Spoken:</td>
</tr>
<tr>
<td></td>
<td>T summarizes the content of the video</td>
</tr>
<tr>
<td></td>
<td>Written &amp; Pictures:</td>
</tr>
<tr>
<td></td>
<td>Caption of the content of the video clip and animated pictures</td>
</tr>
<tr>
<td></td>
<td>Learn fossil fuels (how do fossil fuels form?)</td>
</tr>
<tr>
<td>4</td>
<td><strong>Writing Unit 5 Review Questions</strong></td>
</tr>
<tr>
<td></td>
<td>T/Whole Class: IRE &amp; Discussion</td>
</tr>
<tr>
<td></td>
<td>Spoken:</td>
</tr>
<tr>
<td></td>
<td>T nominates students to share their written responses to the unit review questions</td>
</tr>
<tr>
<td></td>
<td>Written:</td>
</tr>
<tr>
<td></td>
<td>Unit 5 Review Questions</td>
</tr>
<tr>
<td></td>
<td>Review Unit 5 key concepts such as weathering, erosion, deposition</td>
</tr>
<tr>
<td>5</td>
<td><strong>Watching Video on Weathering, Erosion, Deposition</strong></td>
</tr>
<tr>
<td></td>
<td>T/Whole Class: IRE</td>
</tr>
<tr>
<td></td>
<td>Written &amp; Pictures:</td>
</tr>
<tr>
<td></td>
<td>Caption of the content of the video clip and animated pictures</td>
</tr>
<tr>
<td>No.</td>
<td>Instructional Segment</td>
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</tbody>
</table>
| 1   | **Review Lesson 5**  | T/Whole Class: IRE & Discussion                         | Spoken: T asks the review questions and discusses with students  
|     | *what are natural resources* | Written:  
|     |                       | Textbook passage on Renewable Resources (p. 198)       |                                        | Review renewable and nonrenewable resources  
|     |                       |                                                        | Review Questions:  
|     |                       |                                                        | What’s a renewable resource?  
|     |                       |                                                        | Why do we need to be careful with renewable resources?  
|     |                       |                                                        | Is solar and wind energy renewable or nonrenewable?  
|     |                       |                                                        | What makes them renewable?  
|     |                       |                                                        | What are fossil fuels?  
|     |                       |                                                        | Conservation means what? |
| 2   | **Writing Lesson 5** | T/Whole Class: IRE & Discussion                         | Spoken: T reminds students of answering Lesson 5 worksheet with reference to the textbook passages they read earlier and discusses the last question of Lesson 5 Worksheet with the class  
|     | *worksheet*             | Written:                                                |                                        | Review Lesson 5  
|     |                       |                                                        | Ying asks questions of her own work and does not participate in their task of discussing the last questions of Lesson 5 Worksheet |
11/15/2011

<table>
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</table>
| 1   | Unit 5 Review         | T/Whole Class: IRE & Discussion                        | Spoken: T reads aloud unit 5 review questions from the textbook, nominates students to share their written responses and discusses with students  
Written: Unit 5 Review Questions from the textbook | Review Unit 5 key concepts  
T encourages students to look back to the textbook passages to answer these review questions |
| 2   | CPS Review            | T/Whole Class: IRE                                     | Spoken: Using Classroom Performance System (CPS), T reads aloud the review questions or nominates students to read aloud the review questions projected on board  
Written: Review questions projected on board | Review Unit 5 the key concepts |
VITA
VITA

EDUCATION

Doctor of Philosophy, Education
Purdue University, West Lafayette, IN, U.S.A. Dec. 2013
- Emphasis: Literacy and Language Education
- Additional Specialization: English Language Learning
Dissertation: Science Classroom Discourse for Fourth Grade English Language Learners’ Scientific Literacy Development
Chair: Dr. Luciana C. de Oliveira

Master of Arts, Department of Applied Foreign Languages, TESOL Option
National Yunlin University of Science and Technology, Yunlin, Taiwan Dec. 2005
Thesis: A Descriptive Study of English Teachers’ Beliefs and Course Planning in Technological Institutes
Chair: Dr. Chuan-Hsiu Hung

Bachelor of Arts, Department of Foreign Languages and Literature
National Chi Nan University (NCNU), Nantou, Taiwan May 2002

CREDENTIALS

Teaching Credential, Secondary English June 2006
Teacher Certificate No.: Secondary 9502409
Registered as a qualified teacher of English for Secondary Education by the Ministry of Education (MOE), Taiwan

RESEARCH EXPERIENCE

Purdue University, West Lafayette, IN Aug. 2011 – June 2012
Graduate Student Researcher, Purdue Research Foundation Project
Project on Science Classroom Discourse for Fourth Grade English Language Learners’ Scientific Literacy Development
Supervisor: Dr. Luciana C. de Oliveira
- Collected the interview data, textual data, and classroom discourse data from one fourth grade science classroom with English Language Learners (ELLs). Analyzed the various types of classroom observation data to describe how the observed science classroom discourse supports and challenges ELLs’ learning science from classroom
discourse. Collaborated with the fourth grade teacher to develop lessons and activities for her students, including ELLs.

**Happy Hollow Elementary School, West Lafayette, IN**  Aug. 2008 – June 2009  
**Graduate Student Researcher,** College of Education, Purdue University  
Project on Science and Language Learning: Lessons for and from Students  
Supervisor: Dr. Luciana C. de Oliveira

- Assisted the elementary teacher in the design and implementation of science lessons that focused on the development of academic language and literacy. Observed science classes and analyzed data on supporting the elementary teacher of ELLs. Prepared data summaries and contributed to data analysis. Co-authored book chapters and journal articles.

**Community Schools of Frankfort, Frankfort, IN**  Aug. 2008 – June 2009  
**Graduate Student Researcher,** Community Schools of Frankfort through the Indiana Department of Education and Title 1 of No Child Left Behind (NCLB)  
Project on Teaching Language Arts, Mathematics, Science, and Social Studies to ELLs  
Supervisor: Dr. Luciana C. de Oliveira

- Assisted in working with elementary, middle, and high school teachers of English Language Learners (ELLs) and providing professional development for teachers in areas related to the teaching of ELLs and other culturally and linguistically diverse students.

**Community Schools of Frankfort, Frankfort, IN**  Jan. 2008 – June 2008  
**Graduate Student Researcher,** Community Schools of Frankfort through the Indiana Department of Education and Title 1 of No Child Left Behind (NCLB)  
Project on Determining a Knowledge Base for Teaching ELLs in Elementary School  
Supervisor: Dr. Luciana C. de Oliveira

- Coded and analyzed data on developing a knowledge base for preparing in-service teachers to work with English Language Learners (ELLs). Prepared data summaries and co-presented at conferences.

**National Hui-Wei University of Science and Technology**  June 2004 – June 2005  
**Graduate Student Researcher,** National Science Council (NSC), Taiwan  
Project on Teachers’ Interactive Decision Making in Reading Instruction: A Comparison between Expert Teachers and Novice Teachers  
Supervisor: Li-Chin Chiang

- Coded and analyzed data on the expert and novice teachers’ interactive decision-making in reading instruction. Prepared data summaries.

**National Yunlin University of Science and Technology**  June 2003 – June 2004  
**Graduate Student Researcher,** Department of Applied Foreign Language  
Supervisor: Dr. Chuan-Hsiu Hung

- Assisted in the development of the lessons and activities for students in business communication and negotiation through English.
TEACHING AND RELATED EXPERIENCE

Higher Education Experience

Purdue University  
Instructor, College of Education

- Undergraduate Course: Teaching English as a New Language
- Taught and prepared undergraduate elementary education students to work with English Language Learners (ELLs). Supervised students during their Theory into Practice (TIP) experiences in elementary schools. Observed lessons, provided feedback and guidance, and designed curriculum based on students’ experiences. The practical component is designed to provide elementary education students with experience working with ELLs.

National Yunlin University of Science and Technology  
June 2002 – June 2003
Instructor, Department of Applied Foreign Language

- Undergraduate Remedial English Courses
- Taught reading and writing courses to non-English major student challenged by reading and writing in English. Developed curriculum and materials.

K-12 Experience

TanShow Junior High School, Tanzh, Taiwan  
Dec. 2006 – April 2007
Middle School English Teacher

- Taught and developed materials for middle school students. Developed and implemented lessons and activities that focused on reading, writing, grammar, and listening.

National Feng-Yuan Commercial High School, Fengyuan, Taiwan  
High School English Teacher

- Taught English classes that focused on reading, writing, and grammar to high school students. Assisted in school administration.

Gram Language Center, Douliou, Yunlin, Taiwan  
June 2003 – June 2005
English Teacher

- Taught basic and intermediate English as a Foreign Language to elementary and middle school students. Developed and implemented lessons and activities that focused on listening, speaking, reading, and grammar.

MPM Language Center, Puli, Nantou, Taiwan  
June 1999 – June 2001
English Teacher

- Taught basic English as a Foreign Language to children. Developed lessons and activities that focused on motivating students to learn English.
Workshop for Teachers
Northwest Allen County Schools, Fort Wayne, IN  Mar. 2013
Assistant

- Workshop with 30 secondary teachers on English Language Learners (ELLs) in Secondary Content Area Classrooms: a program of professional development for secondary teachers focused on addressing instruction for ELLs in mainstream classrooms. Full-day consultation in 2 middle schools and a high school.
- Assisted Dr. Luciana de Oliveira in workshop on instructional strategies to work with ELLs in mainstream classrooms and her consultation with the secondary and high school teachers of ELLs.

PUBLICATIONS

Journal Articles (Referred)


Book Chapters (Referred)


*[100 abstract proposals were submitted for this book and 12 accepted]
**Audiovisual Media**

**Conference Proceedings (Referred)**


* [The Best Paper Award for the Fourteenth ETA Conference]

**Manuscripts in Preparation:**
Lan, S-W., & de Oliveira, L. C. Science classroom discourse for fourth grade English Language Learners’ scientific literacy development.

**PRESENTATIONS**

**Conference Presentations (Referred)**


**Annual meeting of the Indiana Teachers of English to Speakers of Other Languages (INTESOL) Conference**, Indianapolis, IN Lan, S-W., & de Oliveira, L. C. *Layers of complexity: Nouns in fourth-grade science textbooks.*


**Annual meeting of the TESOL International Association**, Boston, MA Mar. 2010 de Oliveira, L. C., Burke, A., & Lan, S-W. *Perspectives on the knowledge base for teaching English language learners.*

Annual meeting of the Indiana Teachers of English to Speakers of Other Languages (INTESOL) Conference, Indianapolis, IN Nov. 2009
Lan, S-W. Register analysis of international graduates’ academic writing through Systemic Functional Linguistics (Poster presentation).

Sixth International Conference on Language Teacher Education, May 2009
Washington, D. C.

de Oliveira, L. C., Burke, A., Kuo, N-H., & Lan, S-W. Mainstream elementary teachers' perspectives on the knowledge base for teaching English language learners.

1st Purdue University Graduate Student Symposium on ESL Studies, Apr. 2009
West Lafayette, IN
Lan, S-W., & Cheng, D. A linguistic knowledge base for mainstream teachers of English language learners.

Annual meeting of the Indiana Teachers of English to Speakers of Other Languages (INTESOL) Conference, Indianapolis, IN Nov. 2008
Lan, S-W. Language in K-12 Science textbooks for English language learners (Poster presentation).

Invited Plenary and Invited Talk
Academic Writing for Educators (EDCI 591), Department of Curriculum and Instruction, Purdue University July 2013
Iddings, J., & Lan, S-W. Writing a dissertation proposal: Genre expectations.

Panel discussion, Center for Instructional Excellence, Purdue University Mar. 2013

Research Seminar Series, Department of Curriculum and Instruction, Sept. 2011
Purdue University

Teacher Research Seminar (taught by Janet Alsup), Purdue University Sept. 2010
de Oliveira, L. C., Dodds, K. N., & Lan, S-W. Working and researching with teachers.

Research seminar series, Department of Curriculum and Instruction, Oct. 2009
Purdue University
de Oliveira, L. C., Burke, A., & Lan, S-W. Perspectives of elementary teachers on the knowledge base for teaching English language learners.
SERVICES
Sixth International Conference on Language Teacher Education, Washington, D. C. May 2009
Volunteer
• Assisted the presenters in setting up their presentations and materials.

Annual meeting of the Indiana Teachers of English to Speakers of Other Languages (INTESOL) conference, Indianapolis, IN Nov. 2007; Nov. 2008
Volunteer Moderator
• Moderated the presentations and assisted the presenters in setting up their presentations.

TRAVEL GRANTS AND AWARDS
Travel Grant, College of Education, Purdue University Mar. 2010
Dean’s Graduate Student Travel Grant, $200.

The Best Paper Award for the Fourteenth ETA Conference, Nov. 2005
Chien-Tan, Taiwan
Among all the 217 submitted papers, this paper is one of the seven papers named as the best paper.