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Academic Language Knowledge and Comprehension of Science Text for English Language Learners and Fluent English-Speaking Students

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Academic Language Knowledge and Comprehension of Science Text for English Language Learners and Fluent English-Speaking Students

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Education

By

Sandy Ming-San Chang

2013

ABSTRACT OF THE DISSERTATION

Academic Language Knowledge and Comprehension of Science Text

for English Language Learners and Fluent English-Speaking Students

by

Sandy Ming-San Chang

Doctor of Philosophy in Education

University of California, Los Angeles, 2013

Professor Alison L. Bailey, Chair

As an initial step toward understanding which features of academic language make science-based expository text difficult for students with different English language proficiency (ELP) designations, this study investigated fifth-grade students' thoughts on text difficulty, their knowledge of the features of academic language, and the relationship between academic language and reading comprehension. Forty-five fifth-grade students participated in the study; 18 students were classified as English language learners (ELLs) and 27 students were fluent-English speakers. Participants read two science passages, answered comprehension questions, and engaged in a retrospective interview which probed their knowledge on the academic language features of vocabulary, grammar, and discourse. Qualitative analysis was used to code students' thoughts about the challenges to reading comprehension and to identify the challenges that were related to academic language. Quantitative analyses were conducted to examine whether students' knowledge of academic language features and reading comprehension differed by students' ELP designations, as well as to investigate the relationship between students' knowledge of academic language features and reading comprehension. Results for the qualitative analysis revealed that students found difficult vocabulary, reading abilities, and prior knowledge as the greatest challenges to comprehending the science passages. Results from the quantitative analyses indicated that ELL students' knowledge of academic vocabulary, grammar, discourse knowledge, and reading comprehension (as measured by multiple-choice questions) were significantly lower than the fluent-English speaking students. The results also indicated that vocabulary, not grammar or discourse features, was significantly related to students' comprehension scores. The results have implications for understanding the features of academic language that influence students' comprehension of expository texts in science.

The dissertation of Sandy Ming-San Chang is approved.

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2013

Dedication

To Mom, Dad, and Andy

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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-Proverb

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CHAPTER I
Introduction

Reading proficiency is a foundational skill for both academic achievement and vocational success that would otherwise be unavailable to individuals who cannot comprehend written texts (August & Shanahan, 2006; Kamil, 2003). The need for literacy skills is more important than ever, given the changes in the structure of the U.S. economy: today, service-oriented jobs have replaced manual labor jobs, which dictate the importance of schooling and proficiency in literacy for children's future economic well-being (Perlmann & Waldinger, 1997; Suarez-Orozco & Suarez-Orozco, 2002). Additionally, poor reading skills have long-term implications, including emotional difficulties, low self-esteem and other negative behavioral outcomes, increased chances of school failure and dropout, higher poverty rates, and lower life expectancy (Baker, Wolf, Feinglass, Thompson, Gazmararian, & Huang, 2007; Cicchetti & Nurcombe, 1993; Hernandez, 2012).

As a consequence, reading reform efforts have been a top national priority, and all publicly funded K-12 schools are held accountable for students' reading proficiency. The renewed focus on reading comprehension is reflected in the Common Core State Standards (CCSS) in English language arts that define cross-disciplinary literacy expectations to prepare students for college and career readiness (Common Core State Standards Initiative, 2010). In reading, the CCSS highlight the comprehension of informational text, such as analyzing the structure of texts and attending to text complexity. The CCSS also place special emphasis on the reading of texts in the content areas so that students can build background and foundational knowledge in disciplines such as science and history. Content-specific texts, such as those used in science, are widely used in educational settings but present unique challenges to students' comprehension (Snow, 2010; van den Broek, 2010). Furthermore, in the content area of science, the Next Generation Science Standards (NGSS) have acknowledged the importance of communicating science knowledge and the particular content-area literacy challenges students need to meet by linking each of the Disciplinary Core Ideas with CCSS literacy standards (Achieve, 2013).

Educators and researchers working to increase students' academic success in the area of literacy face some troubling statistics and trends regarding the reading achievement of students in grades 4-12. According to *The Nation's Report Card*, reading proficiency scores of students on the National Assessment of Educational Progress (NAEP) has stagnated in recent years, a development that is more pronounced as students advance in grades (Lee, Grigg, & Donahue, 2007; Snow & Biancarosa, 2003). On the 2011 NAEP reading test, 34% of fourth-graders scored at or above proficient (8% scored at advanced), and 34% of eighth-graders scored at or above proficient (3% scored at advanced) (National Center for Education Statistics [NCES], 2011a). Scores for fourth-graders remained relatively unchanged since 2005, and scores for eighth-graders remained unchanged since 2009.

The overall trend reveals that the majority of students above third-grade struggle with reading achievement, but students who are English language learners (ELLs) are at a particular risk. ELL students are students whose primary language is not English and are still becoming proficient in English language skills to fully engage in English classrooms (Flores, Batalova, & Fix, 2012). Results on the 2011 NAEP in reading for ELL students showed that 69% of fourth-graders and 71% of eighth-graders scored below basic (NCES, 2011a). Compared to non-ELL students in which 28% of fourth-graders and 22% of eighth-graders scored below basic, ELL students' reading performance are far behind those of their fluent-English speaking peers. Furthermore, as science text is examined in this study, the results of the 2011 NAEP in science is informative: 83% of eighth-grade ELL students scored below basic, where as 32% of non-ELL students scored below basic on the science (NCES, 2011b). For ELL students, science performance could be stymied by their lack of English language knowledge and reading abilities, which affect their access to the content of the material (Cervetti, Bravo, Duong, Hernandez, & Tilson, 2008; Lee, 2005; Quinn, Lee, & Valdes, 2012).

One reason to explain students' troubling reading scores is the increasing demands of academic tasks, which usually involve complex texts. The texts that are used in grades 4 and up are lengthy and written about topics that are detailed, abstract, new, and challenging. Additionally, these academic texts contain specialized, technical vocabulary and are written in sophisticated grammar with varying discourse structures. These demanding features of academic text are the products of the language, or register, used in schools, which is commonly referred to as academic language (Bailey, 2007; Chamot & O'Malley, 1994; Schleppegrell, 2001). Academic language is broadly defined as the forms and functions of language – which includes distinct lexical, syntactic, discourse, and functional features – associated with academic disciplines (Scarcella, 2003; Schleppegrell, 2004; Snow & Uccelli, 2009).

A growing body of research shows that there is a link between academic language knowledge and school achievement (Francis, Rivera, Lesaux, Kieffer, & Rivera, 2006; Hakuta, Bulter, & Witt, 2000; Short & Fitzsimmons, 2007). Student knowledge of academic language is useful in accessing the content of academic texts and academic talk (Guerrero, 2004; Bailey, 2007) and in learning to think in a specific discipline (i.e., thinking as a scientist, historian, mathematician, writer, etc.) (Shanahan & Shanahan, 2008). However, the research on academic language in the context of student learning, and in particular with reading comprehension, is still in its infancy (Anstrom, DiCerbo, Butler, Katz, Millet, & Rivera, 2010). Moreover, the research on academic language and reading comprehension that is currently available tends to focus on only one domain of academic language at a time, such as studies that examine only academic vocabulary (Snow, Lawrence, & White, 2009) or grammar (Schleppegrell, Achugar, & Oteiza, 2004). To date, the collective role of features at different levels of academic language (e.g., word, sentence, and discourse) with respect to students' reading comprehension has not been systematically researched.

The need for research in the area of academic language and all its features for struggling readers has become necessary in recent years as more emphasis has been placed on the academic success and accountability of students. Students with low literacy achievement include students – regardless of English proficiency – who live in high poverty areas (Chall & Jacobs, 2003; Fry, 2008; Snow, Burns, & Griffin, 1998). Also, students who are classified as ELL students have struggled with reading and academic achievement due to their lack of English language proficiency. For these students who struggle with reading, knowledge of academic language features may be especially important for students in the comprehension of academic texts. For ELL students in particular, academic language can be a bridge that connects English development with academic achievement.

The present study aimed to examine the role of academic language features in the comprehension of informational text in science with fifth-grade students, who are in a grade that marks a transition from elementary to middle school. The purpose of the dissertation is to shed light on which features of academic language in science text are most challenging to students and to examine if any differences exist between English language learners and fluent-English speakers' academic language knowledge. Investigating these questions with two populations of students allows for an analysis of how patterns of comprehension and knowledge of academic language features vary for different students when reading expository texts in science.

CHAPTER II
Literature Review

This chapter reviews the research literature that informed the study. First, the chapter explains the nature and complexity of reading comprehension, focusing on reader variability (in particular, on ELL students) and text complexity (especially on the comprehension of expository text). Next, academic language is defined, and the literature on academic language knowledge and academic achievement is reviewed. Finally, the content-area knowledge and discipline-specific reading is discussed.

Reading Comprehension

Overview of reading comprehension. Comprehension from reading text involves more than the reader simply decoding and understanding vocabulary words or passively absorbing information presented in the text. Instead, the comprehension of written text is an active and constant interplay between the reader, the text, and the activity (Alderson, 2000; Dole, Duffy, Roehler, & Pearson, 1991; Purcell-Gates, Jacobson, & Degener, 2004; Snow & Sweet, 2003). Reading comprehension, as defined by the RAND Reading Study Group, is the "process of simultaneously extracting and constructing meaning through interaction and involvement with written language" (Snow, 2002, p. 11). The RAND Reading Study Group's model of reading comprehension involves the following three components: (1) the reader who is doing the comprehending, (2) the text that is being read, and (3) the activity or purpose for reading. These three components occur within a larger sociocultural context. The reader has various levels of cognitive abilities, motivation, knowledge, and background experiences which, in combination, allow for the reader to make meaning from the text. The types of texts that the reader encounters, such as narrative and expository genres, vary in their organizational structure and features, which impact comprehension. The activity, purpose, context, and consequences of reading influence the ways in which the reader approaches and processes texts. For example, a reader uses different comprehension strategies when reading for pleasure or when studying for an exam (Schellings, Hout-Walters, & Vermunt, 1996). Lastly, the sociocultural context is the setting in which the three components interact, and it influences how students acquire literacy knowledge and skills (Tharp & Gallimore, 1988; Vygotsky, 1978). The components of reader variability and text complexity are especially pertinent to this study, and they are described in more detail below.

Reader variability. Readers bring to the reading task a multitude of varying capabilities (e.g. cognitive, motivational, linguistic), skills (e.g., oral language proficiency, fluency in word recognition), and knowledge base (e.g., content, discourse practices) in order to make sense of texts. Much of what is known in how readers comprehend text comes from decades of research on what skilled readers do as they read. Skilled readers are good comprehenders. They are accurate and fluent in word recognition, connect their world knowledge to comprehend text, construct meaning using a wide variety of strategies (e.g., activating prior knowledge, questioning, monitoring their comprehension), and draw valid inferences from text (Duke & Pearson, 2002; Kintsch, 1988; Pressley & Afflerbach, 1995; Snow, Burns, & Griffin, 1998).

The reasons for students who struggle with reading are not associated with a single source, but rather with a combination of sources. Research demonstrates that older struggling readers (e.g., grades 4 and above) have difficulty mainly with comprehension and not with decoding or word identification (Biancarosa & Snow, 2006; Duke, Pressley, & Hilden, 2004; Kamil, 2003; Torgesen et al., 2007; Valencia & Buly, 2004). Difficulty in comprehension (that is not related to decoding) means that poor readers lack strong vocabulary knowledge (Anderson & Freebody, 1981; Nagy & Scott, 2000) and have inadequate knowledge about genres and text structures (Perfetti, 1994). Additional reasons that explain student difficulties in reading comprehension include the use of fewer metacognitive reading strategies and less skill in applying these processes strategically when reading text (Cain & Oakhill, 2004; Oakhill & Cain, 2007; Pressley & Hilden, 2006).

ELL students comprise a large percentage of the struggling reader population (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Lee & Burkham, 2002; National Center for Education Statistics, 2007). ELL students are not a homogenous group of students; instead, they have diverse linguistic and socioeconomic backgrounds (Walqui & Heritage, 2012). Although ELL students are typically children who are born and raised in the United States (Capps, Fix, Murray, Ost, Passel, & Herwantoro, 2005), children who come from homes where a language other than English is predominantly spoken may have a more difficult time adjusting to school contexts than children who are raised in English-speaking homes. Gee (1989, 2004) refers to the term *discourse* as the language learned and used by people in various contexts, and the language first spoken by children – their primary discourse – is learned from their homes. Discourse communities can differ with respect to the uses of language and literacy valued and practiced. Schools in the United States tend to reflect a European-American and middle-class view of what counts as literacy (Cazden, 1988; Hernandez, 1989). Thus, if a student's primary discourse is similar to the discourse found in schools, the student might have an easier time adopting and adapting to its language and literacy practices; however, if a student's primary discourse is different, the student may have difficulty in learning and succeeding in school contexts (Heath, 1981; Solomon & Rhodes, 1995).

The research in second language acquisition suggests that ELL students may have fewer opportunities to engage in listening, speaking, reading, and writing in English, and these reduced opportunities limit their exposure with English literacy, which affect later reading development (Geva, 2006; Snow, Burns, & Griffin, 1998). Findings from studies conducted on reading comprehension and ELL students show that vocabulary knowledge is critical in comprehending text (Garcia, 1991; Proctor, Carlo, August, & Snow, 2005; Schoonen, Hulstijn, & Bossers, 1998). Particularly concerning is that ELL students know fewer English vocabulary words compared to their monolingual peers (August, Carlo, Dressler, & Snow, 2005; Nation, 2001) and do not have the depth of word knowledge, even for frequently occurring words, compared to native-language speakers (Verhallen & Schoonen, 1993).

The findings from the studies above help explain why many ELL students fall behind their native-English speaking peers in measures of reading achievement. However, there is nothing inherent in the language-minority status of students that prevents ELL students from learning to read English and to read it well (Goldenberg, Rueda, & August, 2006; Lesaux & Geva, 2006). That is to say, there is a strong argument to be made that ELL students' reading difficulties may be more a function of individual differences than of language background. Lesaux and Kieffer (2010) examined the word-level components of reading comprehension among sixth-grade ELL- and native-English students. The findings in the study demonstrated that there were no differences with respect to the factors that caused reading difficulties between the two groups, and language status was not a source of reading difficulties. Poor readers in both groups were characterized by low vocabulary knowledge. Lesaux and Kieffer's study reinforces the well-established link between vocabulary knowledge and reading comprehension; however, their study did not address other components of the reading process, such as genre and text structure, which are also vital components to reading comprehension (Graesser, McNamara, &

Louwerse, 2003). The present study addresses that gap by examining grammar and discourse structure in addition to vocabulary.

Text variability. Recently, text variability and complexity have been examined in more depth as a reason for poor reading achievement in students in grades 4 and up. Broadly speaking, there are two main categories of text genres: narrative and expository. Genre is the broad organizational level of text, and each genre has its own structures (Halliday & Hasan, 1985; Graesser, McNamara, & Louwerse, 2003; Kress, 1987; Lemke, 1994). In general, *text structure* refers to the hierarchical organizational features of text that serve as a frame to guide readers in identifying important information and logical connections between ideas (Dickson, Simmons, & Kameenui, 1998; Pearson & Camperell, 1985). For example, a written narrative in Western cultures is mainly structured by a "story grammar" and will have a "setting + plot + climax + resolution" structure. Expository texts, compared to narrative texts, have a much broader range of organizational structures. These organizational structures include sequencing, description, comparing/contrasting, cause and effect, or persuading (cf. Butler, Bailey, Stevens, Huang, & Lord, 2004; Dickson, Simmons, & Kameenui, 1998). An expository text in science, for example, may have "claim + evidence" structure (cf. Chambliss & Murphy, 2002).

Science texts are nearly all expository texts because they are written to explain, describe, and, at times, persuade. Science texts also encompass a wide-variety of forms and media: they can be academic textbooks, scientific journals, magazine or news articles, or technical manuals (Gee, 2008; Graesser, Leon, & Otero, 2002; Yore, 2004). The forms in which science texts are written depend on the purposes in the communication of scientific information. Three major roles for scientific communication are: communication between scientists, disseminating or popularizing information from the scientific community, and providing or promoting science education (Goldman & Bisanz, 2002). For the purposes of this study, the role of science texts is one way to provide and promote science learning.[1] In this case, science texts tend to focus on well-established science with emphasis on science content including basic facts, concepts, and processes (Bauer, 1992; Kamil & Bernhardt, 2004). Although this type of text is in contrast to the dynamic quality of science writing found in the other two communicative purposes, to date it is the dominant type of science writing found in schools (Goldman & Bisanz, 2002).

There is a strong empirical evidence to indicate that knowledge and awareness of genres and their text structures greatly affect readers' comprehension of text. Readers' expectations and understandings of genres shape the way they interpret and interact with the text, such as employing text-processing strategies or activating specific background knowledge to make sense of the text (Graesser, Millis, & Zwaan, 1997; Zwaan, 1994). Readers' knowledge of text structure resulted in better recall of information read (Armbruster, Anderson, & Ostertag, 1987; Cragg & Nation, 2006; Meyer, Brandt, & Bluth, 1980; Taylor, 1980; Zabrucky & Ratner, 1992). Awareness about text structure also freed working memory capacity which aided in readers' comprehension monitoring (Cain, Oakhill, & Bryant, 2004).

In the upper elementary and middle and high school years, many students hit a "fourth-grade slump," where children's growth in reading skills and achievement become stagnant (Chall & Jacobs, 2003; Chall, Jacobs, & Baldwin, 1990; Snow & Biancarosa, 2003). This slump in reading achievement may be due in part to a shift in school reading practices in which students in grade 4 begin to "read to learn," as opposed to "learn to read" in the primary grades. That is, after third grade, teacher instruction and the purposes for reading focus less on reading as a skill and more on using reading as a tool to for learning content (Torgesen et al., 2007). Coinciding

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[1] Learning from texts is just one of the many ways in which science can be taught. In the TIMSS 1999 Video Study, 26% of US 8th grade teachers who were participants in the study reported that textbooks played a "major role" in the decisions to teach the content (Roth, Druker, Garnier, Lemmens, Chen, Kawanaka, et al., 2006).

with the shift in reading purpose is the change in the types of text, or genres, that students encounter in schools. By fourth grade, expository texts become predominate in classrooms (Kamil, 2003; Snow, 2002). Up until fourth grade, research shows that younger students are rarely exposed to expository texts and have difficulty comprehending it (Donovan & Smolkin, 2002; Duke, 2000; Englert & Hiebert, 1984; Kamberliss, 1999). Langer (1985) investigated students' sensitivity to narrative and expository structures in grades 3, 6, and 9 and found that older students had more knowledge of expository structures than younger students, which suggests that a change of curricular emphases from use of narrative to expository texts is present in schools as students advance in grades.

Accordingly, this study draws upon the idea that students need to comprehend expository text in order to be successful readers and learners in academic settings. Therefore it is important to understand how students draw on knowledge of text structures to comprehend expository writing. Furthermore, as students advance through the grades, they will be required to read content-area texts, such as in science. Like any expository text, science texts can be obscure for students who are not properly prepared to make sense of their text structure (Yore, 2004).

Summary of reading comprehension literature. To summarize the literature in the reading comprehension section, there is substantial research to show that reading skills and sociocultural contexts matter for students to become good readers. Furthermore, for ELL students, oral language development – particularly in vocabulary – and familiarity with school discourse are important for their reading comprehension abilities. With respect to text features, students in grades 4 and up are expected to read increasingly more expository texts, and different reading processes are employed during the reading of expository text then during the reading of narrative text. Comprehension of expository texts is not fully-supported in schools because students show lack of experience with and exposure to expository genres.

With all that is known about how readers and text structures influence comprehension, less is known about the reasons why ELL students are behind native-English speakers in reading comprehension with respect to text-level skills (Goldenberg, Rueda, & August, 2006; Lesaux & Geva, 2006; Lesaux & Kieffer, 2010). The majority of the studies on the reading comprehension of ELL students focus on oral language and the sociocultural contexts that contribute to certain types of prior knowledge valued in schools. There is little research on ELL students' understanding of text structure. The current study will add to this gap in the literature by examining whether ELL students' knowledge of text structure influences their comprehension of expository texts. This research also adds to the growing literature that examines differences between ELL students and fluent-English speakers' comprehension by investigating the aspects of text (e.g., word, sentence, or discourse level) that contribute to or prevent reading comprehension.

Academic Language

Schools are cultural institutions that exert an enormous influence on children's cognitive, language, and academic development. As such, classrooms are contexts with their own rules and procedures, particularly with respect to the tasks that students are asked to perform. Additionally, as cultural institutions, schools value certain types of language and literacy experiences, and they are able to dictate who should be reading what text and for what purposes (Snow, 2002). While the usefulness of the term is increasingly debated, the language used in school contexts is frequently referred to as "academic language" (see Bailey, 2012 for a review).

The academic language construct is a complex concept because it is an area of research that has evolved from several different academic disciplines: the fields of linguistics, applied linguistics, and education have characterized academic language according to their own perspectives. Researchers have started to synthesize the various views of academic language in order to operationalize its features and characteristics for teaching and learning academic language. Through their investigations of the nature of language in academic texts, tests, and classroom discourse, Bailey, Butler, and colleagues included linguistic components (e.g., lexical, grammatical, discourse features) and language functions to their conceptualization of academic language (Bailey & Butler, 2003; Bailey, Butler, & Sato, 2005; Butler et al., 2004). Bailey defines the ability to be academically proficient as “knowing and being able to use general and content-specific vocabulary, specialized or complex grammatical structures, and multifarious language functions and discourse structures” (2007, p. 10).

A review by Anstrom and colleagues (2010) has synthesized the wide-ranging literature on academic language, and they defined academic language as the language used in academic settings and for academic purposes. The authors characterized academic language to be “developmental, with trajectories of increased sophistication in language use from grade to grade, with specific linguistic details that can be the same or vary across content domains” (p. 4). Researchers studying academic language have focused on its specific aspects, such as the grammatical structure of academic language (Schleppegrell, 2001, 2004) or the specific functions or the tasks for acquiring knowledge and skills used in school setting (Chamot & O’Malley, 1994).

A single definition for the academic language construct has yet to emerge, but researchers have agreed that features of academic language include vocabulary, grammar, and discourse structures. These are the features of academic language, which are described in more detail in the following section.

Features of academic language. Academic vocabulary has been the most studied feature of academic language. This is perhaps due in part to the strong relationship between vocabulary knowledge, content knowledge, and reading comprehension. Academic vocabulary words differ from words used in everyday contexts and social conversations because they are usually developed through school-based readings and exposure to content-specific tasks (National Clearinghouse for English Language Acquisition, 2007). There are two main types: general and specialized. General vocabulary is defined as words used across many disciplines, such as the words *conflict* or *result* (Coxhead, 2000). Specialized vocabulary, sometimes referred to as technical, is specific to a discipline, such as the words *hypotenuse* in math and *photosynthesis* in science. In addition, academic vocabulary can be polysemous words within a context-specific area. This means that word with everyday meanings take on a specialized meaning when used in a content area (e.g., the word *matter* has a specific meaning in science). For the content areas such as math, social studies, science, and language arts, academic vocabulary – both general and specialized – is an essential component in learning content-related material (Hyland & Tse, 2007).

The grammar of academic language consists of complex syntax, multiple embedded clauses, passive verb forms, lengthy noun and prepositional phrases, modals, and nominalizations (Bailey, Huang, Shin, Farnsworth, & Butler, 2007; DiCerbo & Anstrom, 2009). Schleppegrell (2003, 2004) has extensively studied academic grammar in K-12 settings and describes the complexity of academic texts as having such features as "elaboration through nominal elements expanded with pre- and post-modification by adjectives" (2004, p. 13). In particular, Schleppegrell observed that the use of nominalizations (or the process of converting entire sentences into phrases that can be embedded into other sentences; e.g., “Henry Ford developed the assembly line” to “The development of the assembly line allowed Henry Ford to mass produce Model Ts”) and dense and embedded clauses enable the language of schooling to present information authoritatively and in highly structured ways. Christie (2003) emphasized the importance of students learning the grammatical features found in schools. “Written language is learned as a feature of schooling, and a major task is to learn the ways in which grammatical organization of writing differs from that of speech” (p. 63). As argued by Christie and Scheppegrell, students need to how to read, recognize, comprehend, and produce complex grammatical structures, such as embedded clauses, in order to prepare students for higher levels of literacy that they will be expected to know later in their academic careers.

The least empirically studied of the three features of academic language is discourse structure. In general, discourse structures are the ways in which written and oral language is organized, such as the overarching text structure and the supporting text features. According to Scarcella (2003), knowledge of discourse is the understanding of its “use in specific academic genres including such devices as transitions and other organizational signals that, in reading, aid in gaining perspectives on what is read” (p. 12). For example, the academic language discourse features of expository text include an introduction with a thesis statement, paragraphs that have topic and supporting sentences, and conclusions that summarize the topic.

Academic language and ELL students. The results of large-scale assessments revealed achievement gaps between ELL- and native-English speakers, and academic language has been seen as a way in which to bridge those gaps. ELL students may be able to use English proficiently in social, everyday situations, but they may struggle with the more formal English language use that is found in schools. As mentioned previously in this literature review, schools represent particular kinds of sociocultural contexts that greatly impact some learners and minimally for others. For all students, academic language is a particular aspect of schooling is language strongly associated with literacy and academic achievement. ELL students may require more structured experiences in academic language (especially in the academic content areas) because many are still developing their proficiency in academic English (American Educational Research Association, 2004; Scarcella, 2003). According to Short and Fitzsimmons (2007), ELL students perform “double the work” of native-English speakers in schools because they are learning English proficiency at the same time they are studying core content areas through English. The National Clearinghouse for English Language Acquisition considers academic language the bridge from English language literacy to content area literacy (2007).

Much has been written about ELL students and academic language proficiency, starting with Cummins’ (1981) seminal work in examining ELL- and native-English speakers. Hakuta, Butler, and Witt (2000) found that oral proficiency in English takes three to five years to develop for ELL students, and that academic English proficiency can take four to seven years. The authors’ analysis also revealed a continuing and widening gap between ELL and native-English speaking students, which illustrates the daunting task that ELL students face in comparison to native-English speakers, who continue to develop their language skills at a pace that few ELL students can match if, in fact, they are still acquiring oral and academic language proficiency.

One explanation for the academic language gap between ELL students and their native-English speaking peers is due to students’ own ELL status and compounded by teachers’ lack of explicitness about the academic language requirements of the task. Solomon and Rhodes (1995) found that ELL students were unfamiliar with the discourse and register of academic language, which lead to problems on performing a retelling task. Furthermore, with respect to reading comprehension, the studies cited in this review suggests that ELL students who do not understand the register of academic language may perform worse in comprehension assessments (formative or formal) even though they comprehend the text.

The academic language feature most studied in ELL students is academic vocabulary due to the strong relationship between vocabulary knowledge and reading comprehension. Interventions focusing on vocabulary development have shown increase in students' vocabulary knowledge and reading comprehension (Carlo, August, McLaughlin, Snow, Dressler, et al., 2004; Snow, Lawrence, & White, 2009). Snow, Lawrence, and White implemented a large-scale, quasi-experimental academic vocabulary intervention focusing on general academic vocabulary, and the results showed that ELL students in the intervention showed greater growth in vocabulary and reading comprehension than the native-English speaking students. Results also showed that ELL students' performance on a researcher-developed measure of reading comprehension predicted performance on the state's large-scale English language arts assessment. However, the authors cautioned that academic vocabulary growth could not fully explain the predictive performance on the state assessment but that other aspects of academic language must be taken account for the growth of ELL students. That is, participation in the intervention was more than just vocabulary instruction but it also focused on other aspects of academic language instruction: deep reading, productive classroom discussion, developing arguments, and producing persuasive essays.

This idea that a focus on academic vocabulary alone is insufficient, especially in the content areas, is echoed in Bruna, Vann, and Escudero's (2007) study on academic language instruction in a high school English learner science class. In a case study, the authors observed that a teacher's focus on teaching academic vocabulary words to ELL students limited their development of conceptual understandings of science. The teacher's emphasis on vocabulary actually obscured important semantic relationships of scientific phenomenon. For example, in the observed lesson on the rock cycle, the teacher focused on having students name, describe, and categorize the types of rocks – igneous, sedimentary, metamorphic – but missed the opportunity to have students express relational information by using prepositional phrases and adverbs, such as "Intrusive rocks form *through the slow solidification and cooling of magma*." The studies above argue that in examining the academic language knowledge of students either in reading or in a content area, attention should be paid to all features of the language and not just vocabulary.

Summary of academic language literature. Much of the research on academic language in K-12 settings has focused on its description and features, evidence of its use in instructional and assessment practices, and its prominence in academic settings (Bailey, 2007; Bailey & Heritage, 2008; Bailey et al., 2007; Scarcella, 2003; Schleppegrell, 2004; Solomon & Rhodes, 1995). In the light of these studies, researchers have pushed for K-12 teachers to help students, especially ELL students whose production and understanding of academic language can be problematic, acquire this register of school language (Meltzer & Hamann, 2005; Short & Fitzsimmons, 2007; Wong Fillmore & Snow, 2000).

Research in academic language has also examined utilizing vocabulary interventions in order to increase reading comprehension for ELL- and native-English speakers who struggle with reading (Carlo et al., 2004; Snow, et al., 2009; Townsend & Collins, 2008). However, these studies on reading comprehension examined only one feature of academic language: vocabulary. While the findings from these studies showed that academic vocabulary learning had an effect on reading comprehension, it is still unclear how the two constructs are related. The current study attempts to add to the literature in the vocabulary and reading comprehension. In addition, this study goes beyond examining just vocabulary and attempts to carefully examine the separate effects of the impact of students' (both ELL- and native-English speakers) academic grammar and discourse knowledge on reading comprehension. While the focus of this study on ELL students and academic language adds to this body of literature, it also examines the academic language knowledge of native-English speakers who maybe struggling readers. Indeed, there is very little research on this population of readers and their use of academic language (cf. Freeman & Freeman, 2008).

Content-Area Reading in Science

Content-area reading for students does not just include understanding the foundations of literacy – that is, decoding, fluency, vocabulary, and basic comprehension – but it also encompasses more sophisticated literary skills that require students to make inferences, draw conclusions, or synthesize information from academic texts that are particular to that academic content area. ELL students, who may still be developing English language literacy skills, must also acquire content knowledge and content area literacy (Francis et al., 2006; Short & Fitzsimmons, 2007). The task is made difficult because each content area has its own set of vocabulary, writing conventions, and critical thinking skills that must be learned for the student to become fully proficient in the content-area topics.

Biancarosa and Snow (2006) reported that language arts teachers, who primarily teach the bulk of reading and writing instruction to students, often focus on literature skills that do not transfer to the content-area texts of science, social studies, and mathematics. These content-area texts are often expository and require different skills than those needed to comprehend literature, which is often written as narratives. Thus, students who usually have mastered the more familiar narrative text structure receive more instruction in it, whereas with content-area text, teachers often neglect to teach the features, structures, and functions that students need to read and understand science, social studies, or mathematics texts (Heller & Greenleaf, 2007). Reading researchers have now focused their attention on content-area literacy for students in grade 4 and beyond.

Most recently, Lee and Spratley (2010) described the more advanced form of literacy required of older readers as “disciplinary literacy” because each academic content area requires students know how to read texts in that discipline. Lee and Spratley consolidated the research in reading strategies and delineated the differences between “generic” and “discipline specific” strategies. Generic strategies include: thinking about prior knowledge, asking questions, making and testing predictions about the text, re-reading, and summarizing. On the other hand, discipline specific strategies include: deconstructing complex sentences, using knowledge of text structures and genres to predict main and subordinate ideas, understanding specialized vocabulary, posing discipline relevant questions, and using norms for reasoning within the discipline. The discipline specific strategies described by Lee and Spratley parallel the features of academic language.

Studies in academic language reveal that there are differences across the content areas. Bailey, Butler, and colleagues (Bailey, Butler, LaFramenta, & Ong, 2004; Butler et al., 2004; Butler, Lord, Stevens, Borrego, & Bailey, 2004) analyzed the academic language characteristics (e.g., lexical, grammatical, discourse, and functions) presented in fifth-grade mathematics, science, and social studies textbooks and found different academic language characteristics across content areas. With respect to academic vocabulary, science textbooks included more technical words and general academic words than social studies or mathematics textbooks. For grammatical features, one finding was that science textbooks had the most passive voice forms per sentence compared to the other subjects. In terms of discourse structure, science text had the most types of dominant organizational features which included classification, description, explanation, and sequencing. Description was the only organizational feature found in math texts; and description, explanation, and sequencing were found in social studies texts.

The picture that emerges from the empirical and theoretical literature is that literacy practices in the content areas are distinct from each other. Although there is overlap in the content areas because general reading skills (i.e., getting the main idea, making inferences) will aid students in making sense of the text read, content-specific reading skills and academic language knowledge are necessary for students in grade 4 and up to transition from the "learning to read" to "reading to learn" stage. Moreover, content-area learning is, in fact, at the heart of the secondary school curriculum, and mastering academic content marks a student's success in secondary school education. That said, the following section describes the specific language features of science text and the challenges it poses for students when reading for comprehension.

Science text. Reading of science texts can be quite problematic for many students, and scientific texts pose special challenges to inexperienced and struggling readers. Some of these challenges go beyond the *reading* of text and are based on students' prior knowledge, visual and math literacy, knowledge of scientific reasoning, and the understanding that scientific classification systems represent abstract ways of thinking (Lee & Spratley, 2010). In particular to science texts, Gee (2005) states that "no domain represents academic sorts of language better than science. Science makes demands on students to use language…that epitomize the sorts of representational systems and practices that are the heart of higher levels of school success" (p. 19).

Since science text is expository, it has many of the features already discussed in the previous sections of the literature review. This includes the use of technical vocabulary and complex grammar. With respect to vocabulary, scientific terms often use Greek and Latin roots (e.g., “photo” and “bio”), have very specialized meanings for everyday words (e.g., “force”), or use common terms in specialized ways with specialized modifiers (e.g., “water cycle”) (White, 1998). With grammatical features, for example, scientific texts may describe technical terms through the use of embedded clauses (e.g., “Organisms that live together make up a community”) and nominalizations (e.g., “The interaction of organisms make up a community”) (Gee, 2008; Schleppegrell, 2004; Snow, 2010). Discourse and text structures are distinctive in scientific texts as well. Scientific text structures emphasize description and explanation as well as sequencing, classification, extended definitions, and cause and effect (Bailey et al., 2004). Each type of function has its own text structures, and understanding these text structures helps with comprehension (Cook & Mayer, 1988).

This study’s focus on science text is because it is important for students to comprehend expository text in school settings. The idea of science and literacy learning has gained traction in recent educational research. Pearson, Moje, and Greenleaf (2010) contend that science literacy instruction should engage students in making sense of scientific texts as one form of scientific inquiry. They argue that scientific text should not be abandoned despite the call for texts to be deemphasized in classrooms to avoid the common practice of reading about science in lieu of doing science. They point out that scientists use reading and writing to inquire and communicate about scientific phenomenon. “No scientist simply walks into a lab and starts manipulating materials…Texts are artifacts of past investigations…Scientists use texts to generate new research questions and to provide background necessary for research design and investigation”

(p. 460). There is a growing body of research that examines literacy and science (Otero, Leon, Graesser, 2002; Lee, 2005; Lee & Fradd, 1996, 1998; Staples & Heselden, 2001; Saul, 2004; Varelas, Pappas, Barry, & O'Neill, 2001), but at the elementary school level, research efforts that link literacy to science learning is limited (see Hart & Varelas, 2003). This study addresses this gap in the literature by examining how students process scientific text using academic language knowledge.

Theoretical Framework

By the upper elementary school, students encounter texts that are sophisticated, using language that is specialized in nature and structured in ways that is more complex and technical, compared to the texts (usually narrative) that are used for teaching reading in the primary grades. Older students are faced with the challenge of learning the content areas primarily through text. For ELL students, they have the extra burden of learning the content area while simultaneously learning to become proficient with academic English. Thus, empirical research must generate a nuanced understanding of academic language knowledge on classroom achievement and the reading comprehension process for all students, including English language learners, which can inform effective methods to promote their literacy achievement.

The goal of this study was to develop a better understanding of ELL- and native-English speaking students' comprehension of science text with respect to academic language knowledge. The conceptual frameworks that have informed the research questions for the study include the RAND Study Group's model of reading comprehension (Snow, 2002) and functional linguistics approach to academic language (Bailey, 2007; Snow & Uccelli, 2009).

The current study is based on the premise that reading is the interaction between the reader, text, and tasks. First, the knowledge and skills the reader brings to the task of reading is an important consideration, especially with respect to English language learners who bring to schools a knowledge- and skills-base that may affect their comprehension of text. This includes, but is not limited, to prior knowledge and reading ability. Second, this study recognizes that the types of texts and one's knowledge of the organizational structures of those texts also affect one's comprehension. This study examined students' comprehension of expository texts due to its critical role in students' learning as they move from upper elementary schools to middle and high schools.

The current study also acknowledges the critical role of academic language knowledge in academic settings. There is evidence from the literature to strongly suggest that the knowledge of academic language – particularly its features of vocabulary, grammar, discourse, and functions – are important to students' success in schools. The language of schooling is a unique register of language that students need to master in order to for them to access academic content. As mentioned previously, some ELL- and fluent-English speakers may lack the necessary academic language knowledge needed to make sense of academic texts. This study addresses the features of academic language knowledge that influences students' comprehension of expository texts.

Research Questions

There are three main objectives of this dissertation. First, the current study explored the challenges students identified to the comprehension of science text. The challenges that are identified were further examined to see if they were related to academic language features. Next, the study examined the differences in academic language knowledge and reading comprehension between students of different English language proficiency (ELP) designations: English Only (EO), Initial Fluent English Proficiency (IFEP), Redesignated (or Reclassified) Fluent English

Proficiency (RFEP), and English Language Learner (ELL). Lastly, the study investigated the relationship between the features of academic language knowledge and reading comprehension. The study addressed the following questions:

(1) What challenges to reading comprehension do students identify in science texts?

   a. How do the identified challenges differ by student English language proficiency designation?

   b. Are any of the challenges that students identify related to academic language features commonly documented in the literature?

(2) Do fifth-grade students of different English language proficiency designation differ on knowledge of academic language features and reading comprehension?

(3) How do features of academic knowledge relate to reading comprehension for fifth-grade students? Specifically,

   a. Are students who score high in comprehension more likely to score high in knowledge of academic language features?

   b. Are there relationships between the features of academic language knowledge and reading comprehension? Does students' English language proficiency designation influence these relationships?

   c. Which features of academic language knowledge predict students' reading comprehension scores?

CHAPTER III
Methods

Research Design

The current study was designed to explore and identify students' knowledge of academic language features and to determine how academic language knowledge may play a role in their comprehension of expository text used in science instruction. To address the research questions, the study adopted a concurrent, nested, mixed-methods approach (Creswell, 2003) in which qualitative and quantitative analyses of students' retrospective interview data was conducted. Student interviews were analyzed using grounded theory (Strauss & Corbin, 1998) in order to identify themes related to students' explanations for areas of text difficulty and whether those areas could be attributed to knowledge of academic language. Student responses from specific interview questions with respect to vocabulary, grammar, and discourse knowledge were also analyzed and coded, and these codes were rendered into quantifiable data. Quantitative methods were utilized to determine whether there were differences in the academic language features and reading comprehension by students of different ELP designations. Quantitative methods were also used to examine the relationship between features of academic language and reading comprehension.

Participants

School Demographics. Participants were recruited in the Spring quarter of the 2010-2011 school year from three fifth-grade classrooms within one elementary school. The school is part of a suburban public school district located in Los Angeles County, serving students from kindergarten to eighth-grade. During the 2010-2011 school year, the overall ethnic breakdown for the school was 4% Asian, 94% Latino, and 1% White. In terms of English language proficiency, 31% of students in the elementary school were considered to be fluent in English, and 69% were classified as English language learners. Ninety-six percent of students in the school qualified for free or reduced lunch, and 10% of parents reported that they attended at least some college (with 2% reporting that they have a college degree).

Available measures of the school's progress include Adequate Yearly Progress (AYP) and Academic Performance Index (API) calculated by the State of California for federal and internal accountability, respectively. AYP reporting is mandated by the No Child Left Behind Act (NCLB, 2002), and in the 2010-2011 academic year, the school did not make AYP, meeting 12 out of 17 criteria for yearly progress. API is California's method of comparing schools based on student test scores from the California Standards Tests (CSTs; California Department of Education, 2011). For the 2010-2011 school year, the school's API score was 784, and compared to all elementary schools in California, it ranked 6 out of 10 (10 being highest).

To get a better sense of the school's demographics with respect to the pool of fifth-graders the study drew from, CST scores for the 2010-2011 academic year are reported here. Because the 2010-2011 CST scores were not available when data was being collected, individual student scores for the current school year could not be obtained. Instead, scores from the school's fifth-graders were obtained through public records posted by the state's Department of Education website, which were made publically available months after data was collected. According state records, a total of 89 fifth-graders were enrolled in the school in 2010-2011, and 81 (91%) fifth-grades took the CSTs in the content areas of English/language arts, math, and science. Table 1 displays the CST results for the school's fifth-graders, organized by the student's ELP designations[2] and the levels of proficiency in the three content areas. The state provided results for Fluent English and ELL students. The "Fluent English" group of students include students who were classified as EO, IFEP, and RFEP. For scores aggregated by ELP designations, the Department of Education reported the percentage of students who scored at or above proficient.

Table 1

CST Scores (2010-2011) of Fifth-Graders, By Proficiency Levels in Three Content Areas and English Language Status

Proficiency Levels for Content Areas	ELP Designation Groups		All 5th Graders (N=81)
	Fluent English[a] (n=40)	ELL (n=41)	
English/Language Arts			
Proficient and above	80%	15%	47%
Basic and below	20%	85%	53%
Math			
Proficient and above	83%	43%	63%
Basic and below	17%	57%	37%
Science			
Proficient and above	80%	12%	46%
Basic and below	20%	88%	54%

[a] Fluent English students include EOs (n=15), IFEPs (n=7), and RFEPs (n=18).

The data from Table 1 provide some background context for participants' academic achievement. At least 80% of fluent English students scored at or above proficient in all three

[2]In California, students' ELP designation is initially determined by a home language survey in which parents report the language(s) spoken at home with the students. If students speak only English at home, they are designated as English Only (EO). If students speak a language other than (or in addition to) English, they take an English language proficiency assessment (ELPA). In California, students are classified as Initial Fluent-English Proficient (IFEP) at school entry if it is determined that their English language proficiency is like that of native English speakers. IFEP students do not receive additional English language services. Students who do not reach a certain score on the ELPA are classified as English language learners (ELLs). ELL students receive English language services, and if they reach a level of English proficiency deemed to be fluent, they classified as Redesignated Fluent-English Proficient (RFEP).

content areas. Over 80% of ELL students at this school performed basic or below on the state's English/Language Arts and Science assessments. Math achievement for ELL students was more evenly spilt between students who scored above and below proficiency when compared to the other two assessments. Demographic information for the study participants is presented next.

Participant Demographics. Forty-five fifth-grade students (20 males and 25 females), or 51% of the fifth-graders enrolled in the school, participated in this study.[3] For ethnicity, per student self-report, 6 (13%) students were Asian, 37 (82%) students were Latino, and 2 (4%) students were mixed race. In terms of English language proficiency, 27 (60%) participants were fluent in English, and 18 (40%) were identified as ELL students. ELL students were assigned ELP levels based on their results on the California English Language Development Test (CELDT). ELP levels range from 1-5, 5 being Advanced. The ELP levels of the 18 ELL students are displayed in Table 2. Additional self-reported demographic information, including additional languages spoken and birth country, is displayed in Table 2.

[3] Forty-nine students agreed to participate in the study. Four students did not complete all study tasks; therefore, they were dropped from the final number of participants for this study.

Table 2

Student Demographic Information (N=45)

Demographic Information	n	Percentage
Gender		
Male	20	44%
Female	25	56%
ELP Designation		
EO	8	18%
IFEP	6	13%
RFEP	13	29%
ELL	18	40%
ELP Levels (for ELL students only)		
Level 1 – Beginning	0	0%
Level 2 – Early Intermediate	2	4%
Level 3 – Intermediate	12	27%
Level 4 – Early Advanced	1	2%
Level 5 – Advanced	1	2%
Unknown[a]	2	4%
Language(s) Spoken at Home		
Chinese (any dialect)	1	2%
Chinese & English	1	2%
English	12	26%
Spanish	12	26%
Spanish & English	18	40%
Vietnamese	1	2%
Birth Country		
El Salvador	1	2%
Mexico	7	16%
United States	37	82%

[a]These two students were enrolled in the school after CELDT testing took place and did not have an ELP level recorded in their files. They were designated as ELL students based on parent responses on the home language survey.

Instrumentation and Measures

The major aim of this study was to examine students' comprehension and knowledge of academic language features of expository texts, namely, science writing found in schools. A retrospective interview protocol was the main instrument used to gather students' knowledge of academic language. All instruments (e.g., science texts, retrospective interview protocol, etc.) were written in English and were researcher-developed and reviewed by a group of experts. They were piloted on students approximately the same age as the student participants in the study. Instruments were revised based on results and feedback from the piloting trials prior to their actual use on participants. This section details the development and use of the instruments and measures utilized in this study.

Student Questionnaire. Students completed a questionnaire that gathered demographic and contextual information of the participants (Garcia, 1991; Snow, 2002). Student demographic data, such as gender, ethnicity, age, birth country, number of years in US schools, and language background were collected.

Science Texts. The science texts that students read were two passages about science that explained different processes: the water cycle and soil development. (See Appendix A for copies of the passages.) To address the issue of ecological validity of learning science through reading text instead of through experimentation or observation, the topics of the passages were selected under the following rationales: (1) non-experimental topics (i.e., topics that would be difficult for students to learn through hands-on experimentation; e.g., topics like the solar system instead of magnetism) and (2) processes that would be difficult to observe directly (e.g., plate tectonics). By using the selection criteria above, texts play a particular and more important role in science learning. That is, the teaching and learning of these topics most likely include text.

The texts on the water cycle and soil development are typically found in science textbooks, but the passages were researcher-developed to ensure that specific academic language features of science text were captured. In developing the passages on the water cycle and soil formation, science textbooks in grades 4-8 from several publishers (e.g., Houghton Mifflin, Macmillan/McGraw Hill, National Geographic, Pearson) as well as educational webpages (e.g., organizations such as Cranfield University, Discovery Education, Hudson River Estuary Program, Missouri Botanical Garden, Saving Water Partnership, and the United States Department of Agriculture) designed for children were consulted. Teachers and researchers in the field of literacy and science education reviewed written drafts to verify the accuracy and readability of the texts for fifth-grade students, and their feedback was incorporated into the final version of each passage. In addition, two EO students (a fourth- and fifth-grader) read the passages to make sure that the readability and comprehensibility of the passages were at their readability level.

The features of academic language in the passages included: the use of technical and general academic vocabulary, an impersonal and authoritative voice (usually through the reduced use of personal pronouns as cohesive devices), nominalizations, and complex embedded clauses (Butler et al., 2004; Gee, 2008; Schleppegrell, 2004; Snow, 2010). Table 3 shows the number (token) of academic language features in the two passages, and Table 4 displays the words (type) that correspond to the types of academic language features included in the two passages. Academic vocabulary words were identified by consulting several indices and corpora, including Beck, McKeown, and Kucan, (2002), Coxhead (2000), Chung and Nation (2003), and Marzano (2004). Grammatical and discourse level features were identified by consulting literature related to these areas (Butler et al., 2004; Scarcella, 2003; Schleppegrell, 2001; Wolf et al., 2008).

Table 3

Number of Academic Vocabulary, Grammatical, and Cohesive Features Found in the Passages

Academic Linguistic Features	Soil	Water Cycle
Academic Vocabulary		
General Academic (Token)	9	11
Content-Specific (Token)	2	2
Technical (Token)	10	7
Grammatical Features		
Nominalizations (Token)	9	11
Sentence & Discourse Features		
Cohesive Devices (Token)	11	12
Sentences with Embedded Clauses	15	14

Table 4

Academic Linguistic Features Found in the Passages (by Type)

Academic Linguistic Features	Soil	Water Cycle
General Academic Vocabulary	Contains, Develop, Factor(s), Form(ed), Occurs, Particles, Process	Combine, Constantly, Develop, Eventually, Form, Occurs, Particles
Content-Specific Vocabulary	Matter, Weathered (adj.)	Clouds, Gas
Technical Vocabulary	Atmosphere, Decompose, Humus, Minerals, Natural resources, Nutrients, Organic, Organisms, Soil, Weather (v.)	Atmosphere, Altitudes, Condenses, Evaporates, Runoff, Water cycle, Water vapor
Nominalizations	Forces, Formation, Interaction, Mixture, Weathering	Condensation, Evaporation, Movement, Precipitation
Cohesive Devices	Another, It, One, Their, These, This, Those	Each other, It(s), Most, They, This

Each passage was approximately 300 words in length and had a reading level to be within a fifth-grade reading range, as determined by two readability formulas (see Table 5). Controlling for the level of reading difficulty of the passages was important, particularly for ELL students who tend to have limited vocabulary knowledge and syntactic awareness in English (e.g., Garcia, 1991; Genesee, Lindholm-Leary, Saunders, & Christian, 2005; Low & Siegel, 2005). On the other hand, each passage had to contain sufficient academic language features (i.e., difficult or infrequent vocabulary words such as *decompose*, or nominalizations such as the word *formation*) and scientific context that would be authentic to the types of texts that students would read in school settings, particularly from a science textbook. Given these considerations, each passage was analyzed for its difficulty using Flesch Kincaid and Lexile Analyzer (Stenner, Burdick, Sanford, & Burdick, 2006) in order to ensure the reading level of each passage was not above the level of what was expected a fifth-grader could read (see Table 5 for readability indices of each passage). For the Lexile scale, the two passages fell within the range for fifth grade readability, although they were in the upper bound ranges with scores in the 800s.

Table 5

Readability Indices of Passages

Readability Indices	Soil	Water Cycle
Word Count (including title, headings, captions)	328	318
Word Count (without title, headings, captions)	304	306
Number of Sentences	26	24
Average Words per Sentence	11.65	12.75
Flesch Kincaid Grade Equivalency	5.4	5.6
Lexile Measure[a]	830L	860L

[a] According to the Lexile scale, a typical Lexile measure for Grade 5 students ranges from 565L to 910L (Willliamson, Koons, Sandvik, & Sanford-Moore, 2012).

Interest and Ease Measure. To gauge student perceptions on their interest in the topics presented in the science passages and their thoughts about how easy or difficulty the passages were to read, two Likert items were asked. Students chose one of the following answers for the question on interest: Very interesting, Somewhat interesting, Not interesting, and Not very interesting. For ease/difficulty, students chose one of the following answers: Very easy to read and understand, Easy to read and understand, Hard to read and understand, and Very hard to read and understand.

Retrospective Interview Protocol. Semi-structured, retrospective interviews were conducted after students read the passages (Cohen, 2000). The open-ended interview questions were used to assess student knowledge of the academic language features of vocabulary, grammar, and discourse (cf. Bailey & Huang, 2010; Bailey et al., 2004; Gee, 2008; Schleppegrell, 2004; Snow, 2010). Students were asked to identify academic language features such as academic vocabulary words, cohesive devices, and topic sentences and to explain reasons and thinking behind those choices (see Appendix B for the retrospective interview protocols). Students' responses to interview questions were audio recorded and transcribed to later code for students' academic language knowledge (i.e., vocabulary, grammar, discourse; see Data Analysis Procedures for more detail on coding procedures). Prior to data collection, the researcher piloted the versions of the Retrospective Interview Protocol on four age-appropriate students (two EO students and two ELL students) and made revisions to the final protocol as needed.

Sentence Exercise on Nominalizations. To examine the academic grammar features of nominalizations in more depth, a sentence comparison exercise was developed. The creation of this instrument was in response piloting information, especially the length of and the time it took to administer the Retrospective Interview Protocol. The Sentence Comparison exercise included sentences from the passages that contained nominalizations (see Appendix D). Students were asked to identify the simple predicate (i.e., verb) and the simple subject of the each sentence. Student responses to this task were audio taped and transcribed. (Scoring of student responses to the Sentence Exercise is described in detail in the following section on measures.)

Measures of Student Knowledge. The following section discusses the rating and scoring procedures for each measure. Each measure of student knowledge in comprehension and academic knowledge feature comprised of different numbers of items. Various rating or scoring procedures were used to determine students' comprehension and academic language knowledge. Table 6 provides a brief summary each measure with the number of items and points for each measure. More detailed descriptions of each measure follow the table.

A total of six raters were trained to rate and score student data using researcher-developed rubrics based on the research literature (further discussed for each measure, below).

Two raters were assigned to rate each category, and after the raters individually scored or rated student responses, they discussed their ratings to reach consensus scores. Kappas are reported for the areas that required ratings; Kappas of .65 and higher are viewed as indicating good inter-rater agreement (Landis & Koch, 1977).

Table 6

Descriptions of Study Measures

Measure	Description	Number of Items & Points
Reading Comprehension (Multiple-Choice)	Multiple-choice questions • 16 multiple-choice questions (8 per passage) were scored as correct or incorrect	16 items 16 points
Reading Comprehension (Summary Score)	Oral summaries of each passage rated on number and elaboration of main ideas • 10 points (ideas) for soil; 13 points (ideas) for the water cycle	2 summaries 23 points
Vocabulary	Rated students' responses in academic vocabulary knowledge from Retrospective Interview Protocols • Student definitions of 20 academic vocabulary words were rated on a scale from 0-4	20 items 80 points
Grammar	Rated students' responses in academic grammar knowledge from Retrospective Interview Protocols and Sentence Comparison Exercise • Identification of the referents for 4 cohesive devices was rated on a scale from 0-2 (8 points) • In Sentence Comparison Exercise, identification of simple subjects and predicates from 6 sentences was scored as correct and incorrect (6 points)	10 items 14 points
Discourse	Rated students' responses in academic discourse knowledge from Retrospective Interview Protocols • Identification of the topic sentence for 9 paragraphs was scored as correct or incorrect (9 points) • Identification of types of paragraphs (e.g., introduction, body) in the 2 passages was scored as correct or incorrect (10 points) • Identification of the referents for 3 cohesive devices was rated on a scale from 0-2 (6 points)	22 items 25 points

Reading Comprehension Measure. Students' comprehension of the passages was measured by in two ways: total number of correct answers on multiple-choice questions and students' oral summaries of the two passages. For multiple-choice questions, eight questions were written for each passage (see Appendix C). Researcher-designed comprehension questions have been used in assessing comprehension in the study of narrative (cf. Paris & Paris, 2003) and expository text (cf. Purcell-Gates, Duke, & Martineau, 2007). The multiple-choice questions were constructed after consulting end-of-unit questions in various science textbooks and workbooks, as well as released test questions from state content-area assessments and educational webpages designed for children. The questions included recall/literal, interpretive, inferential, and application aspects of comprehension (cf. Barrett, 1976; Wolf, et al., 2008). Final versions of the questions incorporated feedback from teachers and age-appropriate students who reviewed the passages and questions. Student answers to multiple-choice questions were scored as correct or incorrect. Correct answers were tallied across the two passages.

Students were also asked to summarize the texts after reading them. Oral summaries were another method to assess student comprehension of the texts (Afflerbach, 1990; Alderson, 2000). Students' oral summaries were audio recorded, transcribed, and scored. The summaries were scored at the gist level for number of main ideas in the passages that were included in the students' summaries (Cote, Goldman, & Saul, 1998). Credit was also given for summaries that had more elaborated response of the main ideas (Bailey, Heritage, Chang, & Huang, 2010). The maximum score a summary could receive was 10 points for the soil passage and 13 points for the water cycle passage, based on the main ideas contained in the passages. Two raters rated each summary and they achieved an averaged, weighted kappa of .81. Student summary scores for both passages were combined into one, total summary score.

Academic Language Vocabulary (ALV) Knowledge Measure. ALV knowledge was measured by students' productive vocabulary knowledge of selected academic vocabulary words. The words were selected to cover a range of vocabulary found in the three different categories of academic vocabulary. Table 7 displays the specific words that were asked of students to provide definitions.

Table 7

List of Specific Words Asked

Passage	Academic Language Vocabulary Categories		
	General	Context-Specific	Technical
Soil	Develop Factor Formation Process Interaction	Mixture Matter Organic	Decompose Organic Organisms Weathering
Water Cycle	Eventually Particles	Cycle Gas	Atmosphere Evaporation Water vapor Precipitation

Students' definitions for the 20 words above were rated on a scale from 0-4. The rubric was adapted from Wesche & Paribakht's (1996) Vocabulary Knowledge Scale (see Table 8), and it reflects dimensions of vocabulary knowledge which range from minimal, partial, to full knowledge (Baker, Simmons, & Kameenui, 1998; Baumann & Kameenui, 1991; McKeown & Beck, 1988). Two raters rated each student's definitions and averaged a weighted kappa of .78.

Table 8

Scale Scores and Explanations of the Rubric for Student Vocabulary Knowledge

Scale	Explanation
0	No definition OR definition given is completely wrong
1	An example is given or the word is used in context, but it's unclear that student knows the definition
2	Definition given is partially correct; it lacks information that would suggest a full understanding of the word
3	Definition given is mostly correct, but it lacks some additional detail, elaboration, or precision that would make definition fully correct
4	Definition given is correct and precise, and it may have elaboration (e.g., examples, passage-related contextual information)

Academic Language Grammar (ALG) Knowledge Measure. ALG knowledge was measured on students' identification of correct referents for cohesive devices and simple subjects and predicates of sentences containing nominalizations. For cohesive devices, students were asked to identify the correct referent for references (e.g., what *it* refers to in the sentence). Student responses were rated on a scale from 0-2 depending on the precision of their identifications: 0 – incorrect, 1 – partially correct/not quite precise, and 2 – correct/precise. For example, *they* is one of the cohesive devices that appears in the soil passage; the precise referent for *they* is *Mars and Venus* (which was scored 2 points), but the use of the superordinate category *planets* was also a pragmatically appropriate answer, if not as precise (and was given a score of 1 point). Two raters rated cohesive devices and had weighted kappa of .90. For nominalizations, because they affect the grammatical structure of sentences, students were asked to identify simple subjects and predicates from the Sentence Exercise. Identification of simple subjects and predicates were scored as correct and incorrect.

Academic Language Discourse Knowledge Measure. Students' ALD knowledge was measured by their understanding of the structure of the passages. In particular, students were measured by their correct identification of topic sentences and paragraph type (e.g., introduction, body/supporting paragraph). Their identifications of the topic sentence and paragraph type were scored as correct or incorrect. Additionally, there were three cohesive devices that functioned at the discourse level, and student identification of the referents were rated according to the scale described in Academic Grammar Knowledge Measure section above. The weighted kappa for two raters for these cohesive devices was .89.

Data Collection Procedures

Data collection occurred from May-June, 2011. Data was collected at the end of the school year due to scheduling constraints from the school, namely from preparing and taking the CSTs. The researcher visited each fifth-grade classroom to introduce the study to the teachers and students. Teachers agreed to pass out and collect parent consent forms, which were picked up by the researcher at a later date. All data was collected at the school site during the regular school day and after school programs.

Student participants engaged in a variety of tasks as part of the data collection procedures (see Figure 1). All interviews were conducted in English and were audio recorded. Parts of the Student Questionnaire that did not contain open-ended questions were administered to the participants as a group and not audio recorded. For everything else, students met one-on-one with the researcher in an empty classroom on campus. Completion of all tasks took each student approximately 1-2 hours, depending on the individual student. An attempt was made to complete all tasks consecutively with minimal breaks; however, due to the time it took to administer and conduct the tasks and the interruptions that occurred from school and class schedules (e.g., assemblies, lessons that students could not miss, fire drills, etc.), most students were stopped mid-task and the students had to finish the tasks at later times.

Student Tasks

1. Student Questionnaire
    a. Fill-in Questions
    b. Open-ended Response Questions
2. Science Passage-Water Cycle
    a. Read Aloud
        i. Interest and Ease Questions
    b. Comprehension Check
        i. Oral summary
        ii. Multiple-choice Questions
    c. Retrospective Interview Protocol
3. Science Passage-Soil
    a. Read Aloud
        i. Interest and Ease Questions
    b. Comprehension Questions
        i. Oral summary
        ii. Multiple-choice Questions
    c. Retrospective Interview Protocol
4. Sentence Comparison Exercise

Counter-balanced passages

Figure 1. Order of tasks students engaged in during data collection.

During the one-on-one sessions, the researcher began each session by asking students the open-ended response questions from the Student Questionnaire. When this part was completed, students were asked to read aloud a passage. If they had difficulty pronouncing words, the researcher read the words to them. After reading aloud the passage, students completed statements about their perceptions on the ease of the passage and their interest in the topic of the passage. Students then orally summarized the passage and answered eight multiple-choice comprehension questions. Students answered the multiple-choice questions silently on their own (no audio recording occurred during this segment) and were allowed to consult the text if necessary. Next, the researcher conducted retrospective interview with the student. The order of the passages that students read aloud first (and subsequent segments that followed, such as oral summaries, multiple-choice questions, and retrospective interviews) was counterbalanced to avoid possible order effects on students' performance in reading and comprehension of the passages and their responses to the tasks. Half of the students were given the soil passage first, and the other half was given the water cycle passage first. The last task that students were asked to complete with the researcher was the Sentence Comparison exercise.

Data collection with students yielded about 51.25 hours of audio data. Students ranged from 50-103 minutes (mean of 65 minutes) to complete recorded tasks. Additional time with students that was not audio recorded included the time needed to administer student assent forms, student questionnaire, and multiple-choice comprehension questions.

Data Analysis Procedures

This section describes the qualitative and quantitative analyses procedures used to examine and analyze student data produced from the instruments and measures. Analyses for the qualitative and quantitative data were often performed by groups based on students' English language proficiency (ELP) designation, which was determined from school records. Based on similar groupings from the research literature (Kim & Herman, 2008; McCloskey, Pellegrin, Thompson, & Hakuta, 2008; Parrish et al., 2006), English-only (EO) and Initial fluent English proficient (IFEP) students were placed in a single group, referred to as the EO/IFEP group.

Redesignated fluent English proficient (RFEP) students formed one group, and English language learner (ELL) students formed another group.

Qualitative Analysis Procedures. Student Retrospective Protocol transcripts were examined to answer the first set of research questions. Multiple close readings of each student interview transcript were conducted, and student responses pertaining to challenges to comprehension were coded. There were no predetermined criteria established before the coding process; all the participants' explanations were examined. Through open coding, lists of codes were generated based on student responses. The codes are described in more detail in the results section.

Inter-rater agreement was established by applying the coding schema to the transcripts. Training of the raters involved using the finalized codebook and the actual transcripts. Two raters coded 30% of the student transcripts, and they achieved an inter-rater agreement of 81.4%. The agreement of the ratings was calculated by computing the percentage of exact agreement of codes that each rater assigned to the student responses. Disagreements were resolved through discussion, and consensus codes were reached. Once inter-rater agreement was established, the coding schema was used to analyze all student transcripts. Codes were tallied and frequencies were calculated across all students and between students in each ELP designation group.

In addition to coded responses on the challenges in reading science texts, students were asked to identify any words or sentences that they thought were difficult, and these words and sentences were categorized into academic language types. The words that students identified were classified into academic language vocabulary categories (i.e., general, context-specific, and technical) by consulting published indices and corpora (Butler et al., 2004; Coxhead, 2000; Marzano, 2004; Wolf et al., 2008). For identified words that did not appear in published lists, the research and an expert in the field of academic language reached consensus on the academic language vocabulary type. The sentences that students identified were categorized by sentence type (i.e., simple, compound, complex, compound-complex) using guidelines established in other studies (Butler et al., 2004; Wolf et al., 2008). The identified words and sentences were tallied by categories across all students.

Quantitative Analysis Procedures. In order to examine the relationship between academic language and reading comprehension, a series of quantitative analyses were conducted. First, student scores derived from the measures on comprehension (i.e., multiple-choice and summary scores) and academic language features (i.e., vocabulary, grammar, and discourse) were summed. Then each summed score was converted into a percentage score, which was used for the quantitative analyses described below.

To answer the second research question, one-way between-groups analysis of variance (ANOVA) was conducted to explore the impact of students' ELP designation on vocabulary, grammar, and discourse features of academic language and reading comprehension scores. To answer the third set of questions on the relationship between academic language features and reading comprehension scores, chi-square test for independence was first performed to examine if students who scored high in reading comprehension also scored high in academic language features. For the chi-square analysis, each percentage score a student received on a measure was converted into z-scores, and the z-scores were summed across academic language scores and comprehension scores to create composite z-scores. High and low groups in academic language and comprehension were formed based on student scores that fell above and below the mean: scores that fell above the mean were placed in the high group, and scores that fell below the mean were placed in the low group. Next, correlation analyses were performed to determine whether – and if so, to what degree – there were statistically significant relationships between the three features of academic language knowledge and (a) multiple-choice comprehension scores and (b) summary scores. Lastly, multiple regressions were used to see if the academic language features predicted reading comprehension scores as measured by multiple-choice questions and summary scores.

CHAPTER IV
Results

In this chapter, the results are reported in three main sections based on the research questions.

Challenges to Reading Comprehension of Science Texts as Identified by Students

To investigate the challenges to the comprehension of science text, students answered questions on interest and ease of the passages, provided reasons for passage difficulty, and selected words and sentences they thought were difficult. The following results for the first set of research questions are presented in the order stated above.

Student Perceptions on Interest and Ease of Science Passages. In order to gain a sense of how students perceived the science texts, students were asked to answer two Likert items on interest and ease. Table 9 presents the frequencies and percentages of student responses to the ease and interest questions by passage and ELP designation groups. Overall, most students reported interest in the passages they read; only a few students thought the passages were uninteresting. One student (an RFEP student) rated the water cycle passage as *not very interesting*, and three students (an EO/IFEP student and two RFEP students) reported that either the soil or water cycle passage was *not interesting*. The majority of students reported to have some interest in the passages: 44 students (97.8%) for soil and 42 students (93.3%) for the water cycle. Of those students, 31 students (68.9%) reported that the soil passage was *very interesting* and 22 students (48.9%) thought the water cycle passage was *very interesting*. All ELL students who participated in the study thought that the two passages were at least *somewhat interesting.*

Table 9

Frequencies (Percentages) of Student Perceptions on Ease and Interest of Science Passages by ELP Designation Groups

Perceptions	Soil				Water Cycle			
	EO/IFEP (n=14)	RFEP (n=13)	ELL (n=18)	Total (N=45)	EO/IFEP (n=14)	RFEP (n=13)	ELL (n=18)	Total (N=45)
Interest								
Not very interesting	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (7.7)	0 (0.0)	1 (2.2)
Not interesting	1 (7.1)	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)	2 (15.4)	0 (0.0)	2 (4.4)
Somewhat interesting	4 (28.6)	5 (38.5)	4 (22.2)	13 (28.9)	7 (50.0)	4 (30.8)	9 (50.0)	20 (44.4)
Very interesting	9 (64.3)	8 (61.5)	14 (77.8)	31 (68.9)	7 (50.0)	6 (46.2)	9 (50.0)	22 (48.9)
Ease								
Very hard to read and understand	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Hard to read and understand	2 (14.3)	1 (7.7)	3 (16.7)	6 (13.3)	1 (7.1)	1 (7.7)	2 (11.1)	4 (8.9)
Easy to read and understand	5 (35.7)	9 (69.2)	13 (72.2)	27 (60.0)	7 (50.0)	10 (76.9)	14 (77.8)	31 (68.9)
Very easy to read and understand	7 (50.0)	3 (23.1)	2 (11.1)	12 (26.7)	6 (42.9)	2 (15.4)	1 (5.6)	9 (20.0)
Could not decide	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.6)	1 (2.2)

Note: ELP designation group abbreviations are: EO = English-only speaking students, IFEP = Initial fluent English proficient, RFEP = Redesignated fluent English proficient, ELL = English language learner.

With respect to student perceptions on the ease or difficulty of each passage, no student reported that the passages were *very hard to read and understand*. Most students reported that the passages were easy to read and understand: 39 students (86.7%) stated that the soil passage was easy, and of those students, 12 students (26.7%) thought that the soil passage was *very easy to read and understand*. The majority of RFEP and ELL students stated that the soil passage was *easy* (69.9% and 72.2%, respectively); whereas the majority of EO/IFEP students (50.0%) found the passage to be *very easy* (35.7% of EO/IFEP students stated that the passage was *easy*). For the water cycle passage, 40 students (88.9%) thought that it was *easy*, with 9 students (20.0%) stating that the passage was *very easy to read and understand*. Similar to the soil passage, the majority of RFEP and ELL students stated that the water cycle passage was *easy* (76.9% and 77.8%, respectively). One ELL student could not decide whether the water cycle passage was *easy* or *very easy* for her, so the question was left unanswered.

The ease and difficulty ratings by students were further analyzed to examine whether students were rating the two passages similarly. Correlation analysis showed that there was no relationship between the ease/difficulty ratings between the two passages (r=.227, n=44, p=.138). Note that the sample size for the correlations was 44, not the entire sample size of 45, because one student chose not to answer the question for water cycle. Correlations were conducted between each measure of academic language (vocabulary, grammar, and discourse) and reading comprehension (multiple-choice questions and summary scores) with students' averaged Likert-scale rating on the ease/difficulty of both passages. The ratings were averaged because the Likert-scale ratings were for each passage, but the academic language and reading comprehension measures measured student knowledge across both passages. Students' averaged ratings on the ease/difficulty of passages were positive and significantly correlated with all measures except for discourse. The correlation statistics are as follows: vocabulary (r=.362, p=.014), grammar (r=.344, p=.021), discourse (r=.153, p=.317), multiple-choice (r=.372, p=.012), and summary scores (r=.370, p=.012).

Reasons for Passage Difficulty. During the retrospective interviews, students were asked a set of three questions per passage to learn their thoughts and ideas on the challenges that students face when reading and comprehending the two science passages. The first question, *Some fifth-grade students think that this passage was difficult to read and understand. Why do you think these students would find this passage difficult?* was asked to gain a general sense of students' views on the passage as a whole unit. If students indicated that the passage was difficult to them (from the Likert item on ease), the interviewer asked those students why they thought the passage was difficult for them and other fifth-grade students like them. The next two questions asked students to identify challenging aspects of the text at the sentence and word level. Student responses to the first question were coded; the codes are discussed in more detail in the following section. For the sentences and words selected by students as challenging, they were counted and analyzed for aspects of academic language. Sentences were identified by sentence type – simple, compound, complex, or compound-complex. Words that were identified by students as difficult were categorized into types of academic vocabulary.

As stated previously, students' responses for why the science passages they read were difficult were coded, and two broad categories of codes emerged from the data: passage-related and student-related reasons for why the passage could be difficult to students, including themselves. Passage-related reasons included aspects of the text such as language features (i.e., vocabulary, length of sentences), content or the topic of the passage (e.g., steps and materials in soil formation or the concepts of evaporation and condensation in the water cycle), or the amount of information or detail presented in the passage. Students also responded with reasons that were not related to the passage but to the qualities and abilities of the reader, such as engagement with reading activity, prior knowledge of the topic, reading abilities, study habits, or other learning issues. In a few instances, students did not think the passage was difficult. Table 10 (passage-related reasons) and Table 11 (student-related reasons) list the codes with examples from student interviews.

Table 10

Codes, Descriptions, and Examples of Students' Reasons for Passage Difficulty Related to Passage Features

Codes & Descriptions	Examples
Content/Topic (The content area of science was difficult, or the ideas presented in the soil or water cycle passage were difficult or confusing to understand)	"It's kind of difficult to understand science right now, in our age, because, well, we're just starting off with the hard stuff." "Some [students] just don't understand how the water cycle is cycled through the Earth." "I think it would be difficult because rock – first rock, it doesn't have nothing in them, but when you put in where lots of rocks are, they get with soil with dirt all over and then when everything is mixed, with soil and everything, plants starts growing, and actually it gets bigger and bigger and bigger."
Long Sentences (Long sentences made the passage difficult to read)	"How long the sentences are." "And sometimes the sentences might be too long." "They find it difficult 'cause it has long sentences, like seven and eight words."
Too Much Information (Passages had too much information or were too detailed)	"[The passage] gives a lot of information…[compared to] a regular science book, it gives you a sentence, and then its keeps explaining it and explaining it and explaining it, and it mostly says the same things over and over again. And on this one [the passage], it changes it. It tells you this and it gives you an explanation of why it has to happen. And the science books don't." "I think it's too long because of how many details it gives…because of how it's trying to explain everything." "It has ideas, but too many ideas that make kids confusing."
Vocabulary (Specific words students pointed out as difficult or a general statement that words were difficult)	"Maybe some of the words confuse them with other meanings." "It has words like condensation and precipitation." "The vocabulary." "Like humus and some of the words like – sometimes they get confused with interaction. I even got stuck with that one."
Other (Student reasons that could not be grouped together)	"Long paragraphs." "I think it's the [pause] the passage. Sometimes they make it like you can't really understand it."

Table 11

Codes, Descriptions, and Examples of Students' Reasons for Passage Difficulty Related to Student Factors

Codes & Descriptions	Examples
Engagement (Motivation or interest in reading the topic affected comprehension)	"Maybe because they keep wondering why they are learning about soil." "They don't like reading that much 'cause – well, I don't really know, but they just don't like reading."
Prior Knowledge (Background knowledge or experiences not related or relevant to the topic affected comprehension)	"Maybe because they haven't learned that much about soil and they don't understand what's it saying. But some other people since they know most likely what about soil, they'll understand it and it won't be that difficult for them." "I think it's difficult because I think that some students haven't heard about a water cycle before or haven't experienced one." S: Because they might not accept what the author is trying to explain. I: That's interesting that you said that. Why do you say that they might not accept? S: Because they have a different idea of soil and dirt.
Reading Abilities (Low reading ability or skills affected comprehension)	"Maybe it's not their level…because in AR [Accelerated Reader], we have our levels, right? Like 1.7. And this is probably like a higher level than they are." "For me, I feel like kind of reading it too fast and it has – so that's why I don't understand it and I might misunderstand the words and I might not get."
Study Habits (Poor study habits affected comprehension)	"They haven't been paying attention in class." "Maybe when the teacher asks them to do home reading and you don't do it, and that's why they don't understand the passage." "They're not understanding the passage because they just rush through and want to complete it right away."
Other Learning Issues (Reasons related to students that could not be grouped together)	"Maybe the process is slower for them." "They don't remember nothing from their classes." "They've been absent." "They don't understand, like, they have to have a memory to remember it, and they get nervous."

Note: S = Student, I = Interviewer.

The counts for each code are presented in Table 12. Note that each student could have given more than one reason for why each passage was difficult; for example, one student stated that the water cycle passage was difficult because "it has long sentences, a lot of details, and some hard words." Based on the total frequencies for passage difficulty, there seemed to be little difference between the two passages. Vocabulary in both the soil and water cycle passages was the most frequent reason for passage-related difficulties (18 and 17 counts, respectively), with content/topic as the next highest count for passage-related difficulties (eight for soil, nine for the water cycle). In examining the frequencies across students of different English language status, ELL students more frequently stated that the content/topic of both passages was difficult (n=9, across both passages; n=5 in soil, n=4 for the water cycle) compared to EO/IFEP (n=4) and RFEP (n=4) students.

For student-related reasons, students stated the lack of prior knowledge (n=17 across both passages) and poor or low reading abilities (n=17, both passages) as the most popular reasons for why students would have difficulty with reading and comprehending the two science passages. For reading ability, EO/IFEP students more frequently stated that poor or low reading skills attributed to students' difficulty with comprehending the passages (n=9, both passages), whereas four ELL students stated that poor or low reading ability contributed to the difficulty of the water cycle passage only. For prior knowledge, ELL students more frequently stated that prior knowledge was a reason for passage difficulty (n=10, both passages) compared to the other two groups of students (n=7, both groups, across both passages).

Looking across both categories (passage-related and student-related reasons), ELL students stated that the content/topic of the passages and students' prior knowledge of the topic affected comprehension. EO/IFEP students stated that vocabulary words (passage-related) and low or poor reading abilities (student-related) contributed to students' comprehension of the passages. RFEP students fell between the other two groups by stating that vocabulary words (passage-related) and both reading abilities and prior knowledge (student-related) affected comprehension of the passages.

Table 12

Frequencies (Percentages) of Students' Reasons for Passages Difficulty, by ELP Designation

Reasons	Soil				Water Cycle			
	EO/IFEP (n=14)	RFEP (n=13)	ELL (n=18)	Total (N=45)	EO/IFEP (n=14)	RFEP (n=13)	ELL (n=18)	Total (N=45)
Passage-Related Reasons								
Content/Topic	1 (7.1)	2 (15.4)	5 (27.8)	8 (17.8)	3 (21.4)	2 (15.4)	4 (22.2)	9 (20.0)
Long Sentences	0 (0.0)	2 (15.4)	0 (0.0)	2 (4.4)	0 (0.0)	1 (7.7)	1 (5.6)	2 (4.4)
Too Much Information	2 (14.3)	2 (15.4)	0 (0.0)	4 (8.8)	1 (7.1)	1 (7.7)	2 (11.1)	4 (8.8)
Vocabulary	7 (50.0)	4 (30.8)	7 (38.9)	18 (40.0)	7 (50.0)	6 (42.2)	4 (22.2)	17 (37.8)
Other	1 (7.1)	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)	1 (7.7)	0 (0.0)	1 (2.2)
Student-Related Reasons								
Engagement	0 (0.0)	1 (7.7)	0 (0.0)	1 (2.2)	1 (7.1)	0 (0.0)	0 (0.0)	1 (2.2)
Prior Knowledge	1 (7.1)	3 (23.1)	6 (33.3)	10 (22.2)	2 (14.3)	1 (7.7)	4 (22.2)	7 (15.6)
Reading Abilities	6 (42.9)	2 (15.4)	0 (0.0)	8 (17.8)	3 (21.4)	2 (15.4)	4 (22.2)	9 (20.0)
Study Habits	0 (0.0)	1 (7.7)	1 (5.6)	2 (4.4)	2 (14.3)	1 (7.7)	1 (5.6)	4 (8.8)
Other Learning Issues	1 (7.1)	0 (0.0)	1 (5.6)	2 (4.4)	1 (7.1)	1 (7.7)	1 (5.6)	3 (6.7)
No Explanation	0 (0.0)	1 (7.7)	0 (0.0)	1 (2.2)	1 (7.1)	0 (0.0)	1 (5.6)	3 (6.7)
Total Frequencies (by group)	19	18	20	57	21	16	22	59

Challenges to Passage Difficulty Associated with Academic Language. Reasons that were passage-related (not student-related) were examined further to see if they could be associated with the academic language areas of vocabulary, grammar, and discourse. With respect to vocabulary and grammar, every student was asked to identify words and sentences they thought were difficult, and those results are discussed in the following section. What is reported here is whether students provided any rationales for passage difficulty that could be linked to academic language. For vocabulary, of the 28 students who reported that words found in the passage posed a problem to comprehension, they were asked to selected specific words and to explain why those words were difficult.

Student explanations were grouped into similar themes that emerged from the data and then coded across all interviews; the final codes appear in Table 13. Although students selected many words that were academic vocabulary words, none of their explanations could be linked to, and coded as, academic language knowledge (in part because their explanations were short). Instead, what follows are the codes that emerged. Some students could not further explain why the words they selected were difficult, or some students used synonyms for "difficult" (such as "hard" or "high") or said the words were at a higher grade level. These responses were coded as *Difficult*. The *Definition* code included statements that the definitions or meanings of words were confusing, unfamiliar, or difficult. Table 13 provides a list of the coded reasons, examples from students, and the number of times it was mentioned by students (note that a student could state more than one reason).

Table 13

Reasons, Student Examples, and Counts for Why Words are Difficult

Reason	Student Examples	Counts
Definition	"Maybe some of the words confuse them with other meanings." "It has really big words that they can't understand and the definition of the meaning."	12
Difficult	"Authors use hard words that are appropriate to the passage." "High vocabulary." "Some of the words are at actually kind of seventh and sixth [grade] words."	9
Length	"There's a lot of long words." "Because there's some hard words that are long and probably they don't get it or they get stuck on a word."	4
Pronunciation	"'Cause it's just hard to say." "They might think this passage is difficult because some of the words like condensation are like hard to pronounce." "'Cause it looks like you should get tongue twist on them sometimes."	10

Definition was the most popular reason for why the words students selected were difficult, but second most popular reason for why words were difficult was their pronunciation, which was reported by nine students. What is interesting about the *Pronunciation* code was that often times, it was the only reason given for why the selected words were difficult. When the interviewer asked for clarification (e.g., "Is it only how the words are pronounced or the meaning of the words?"), six students were sure it was only the pronunciation of the words that made them difficult. Although the reasons students gave to what makes certain words difficult were not directly related to academic vocabulary, they provided some insight into what students' thoughts on vocabulary and comprehension.

Another passage-related reason that may be associated with academic language was with the code *Long Sentences*. Sentences found in academic writing tend to contain embedded clauses and phrases which add ideas and complexity to the grammatical structure of sentences. Only four students stated that long sentences contributed to difficulty in comprehending the passages, and they had the opportunity to identify the sentences they thought were long and to give further explanations for why they thought so. Two of the students acknowledged that the number of ideas in a sentence contributed to its difficulty, and the other two focused on the number of words in the sentence. One student stated that students would "find it [the water cycle passage] difficult 'cause it has long sentences, like seven and eight words," and also pointed out that "long, difficult" words that were found in those sentences.

Another student also thought that the number of words (and "some hard words") contributed to the difficulty in sentences. Below is an excerpt from that interview. When asked twice by the interviewer if the number of ideas contributed to the difficulty in sentences, the student did not think so in both instances. (A note on the context of the questions: the student stated that water cycle passage had "long sentences," and when the student was asked to identify some, he said he could not find any in the passage. Therefore, the interviewer chose a couple of long sentences and asked the student to explain why they were long.)

S: It’s long, and have some hard words.
I: What makes it [the sentence] long?
S: The words.
I: Do you think it has a lot of ideas in the sentence?
S: No.
…
S: It’s long.
I: What makes the sentence long?
S: [long pause]
I: Lots of ideas or lots of words?
S: Lots of words.

Another student, whose excerpt is below, acknowledged that the number of ideas made sentences difficult.

S: ‘Cause some of the words that they have not heard before in the passage. And sometimes the sentence might be too long for them.
[Student was asked to identify the sentences that he thought were long. From the soil passage, he selected: “Worms and bacteria living in the soil help decompose the soil” and “Without soil, plants could not grow and animals would not survive.” After the student selected the sentences, the following questions were asked.]
I: Why did you pick those sentences?
S: How the sentences are put together.
I: What does that mean? Does that mean that they are too many words or too many ideas or both?
S: Too many ideas.

The last of the four students who reported that long sentences contributed to text difficulty stated both too many words and number of ideas caused sentences to be difficult.

I: Any other reason why you think the passage would be difficult for students?
S: How long the sentences are.
[Student was then asked by the interviewer to select sentences that he thought were long. From the soil passage, he selected: "Fallen leaves, dead plants, and dead animals on the ground become part of the soil" and "Soil formation is a process that occurs over time through the interaction of these various factors." After he selected the sentences, the interview asked the next question.]
I: What makes the sentence long?
S: How many words there are.
I: Why do you think authors write such long sentences?
S: I think they write such long sentences because they try to fit at least three details to them.
I: Why would they want to do that?
S: So that they wouldn't have to give a lot of details?

Although only four students out of the 45 participants in the study cited long sentences as contributing to text difficulty, two students noticed that sentences were made more complex because of the number of ideas embedded in them. This knowledge is related to academic grammar.

With respect to discourse knowledge, students did not provide reasons that could be directly attributed to knowledge of discourse. Although the two reasons coded as *Other* (see Table 10) may allude to discourse structure (e.g., "long paragraphs"), the students did not provide additional information to those statements, and further judgments could not be made to whether those statements were related to academic discourse knowledge.

*Selection of Difficult Vocabulary Words***.** Every student was asked to select words and sentences that they thought were confusing or difficult to read or understand (although some students preempted these questions by stating earlier that difficult words and/or sentences were the reasons for passage difficulty). For the words selected, students identified a total of 54 different words (type) between the two passages, totaling 303 words (token) chosen. It is worth noting that three students did not identify any words. Also six students only selected words in one, not both passages: three students selected no words in the soil passage, and three students selected no words in the water cycle passage. The selected words were categorized into three types of academic language vocabulary (ALV): general, context-specific, and technical.[4] Words that are not considered ALV were labeled non-ALV. Table 14 presents the types and tokens of vocabulary words students selected as challenging.

Table 14

Types (Tokens) of Challenging Vocabulary by Passage and Academic Language Vocabulary (ALV) Category

Passage	ALV Categories			Non-ALV	Total
	General	Context-Specific	Technical		
Soil	17 (55)	5 (15)	11 (95)	9 (13)	42 (178)
Water Cycle	6 (28)	0 (0)	8 (96)	1 (1)	15 (125)
Total[a]	21 (83)	5 (15)	18 (191)	10 (14)	54 (303)

[a]The total for types in General, Technical, and Total (last column on the right) do not add correctly because there were three words that were selected for both the soil and water cycle passages (2 identical words in the General category, and 1 identical word in the Technical category). The totals that are found in the table correctly reflect the true number of types that appear within each category.

More words were selected from the soil passage in both type and token compared to the water cycle passage. Across the soil passage, students selected more types of general vocabulary words (17) than technical (11) and context-specific (5) words, but the technical words had higher numbers of students selecting them as difficult. That is, students more frequently selected technical words (token=95) to be difficult compared to general words (token=55) and context-specific words (token=15). A different trend in word selection occurred in the water cycle passage compared with the soil passage. First, students did not identify any context-specific vocabulary words in the water cycle passage as they did in the soil passage. Second, technical

[4] See methods section for categorization procedures.

ALV had higher type (6) and token (96) counts compared to general ALV (6 and 28, respectively). Looking across the categories, students selected technical vocabulary words as difficult 191 times, more so than any other category.

Table 15 lists all the words that were selected by students, the frequencies, and ALV types.[5] Within words selected from the soil passage, the three most frequent words identified by students as difficult were technical words: *humus* (token=16), *organism* (token=15) and *decompose* (token=12). The most frequent general ALV words selected were *interaction* (token=9) and *formation* (token=8). Note that *interaction* and *formation* are also nominalized forms of *interact* and *form*, and nominalized words can be more difficult to understand than the verb form of the word. In the water cycle passage, the three most frequent words were also technical ALV: *precipitation* (token=25), *condensation* (token=21), and *evaporation* (token=16). It's interesting to note that although *evaporate* (token=7) was also chosen, fewer students found it to be difficult compared to its nominalized form. In comparison to technical words, fewer generalized words were selected from the water cycle passage, and the most frequent generalized word selected by students was *particles* (token=10). *Particles* was one of the three words that were identified in both passages; the other two were *atmospheres* and *occurs*.[6] *Atmosphere* was identified more times in the water cycle passage (token=14) compared to the soil passage (token=9), although it is interesting that so many students identified *atmosphere* in the soil passage as it appeared only once, whereas the word appeared four times in the water cycle passage.

[5] The table also notes if a word is polysemous (i.e., having multiple meanings), or is a nominalization. Polysemous words can be a source of comprehension difficulty, especially for ELLs.

[6] One student selected *particles* as a difficult word in both passages, and five students selected *atmosphere* as difficult in both passages.

Table 15

Vocabulary Words Identified by Students by Passage, Frequency, and Type of Academic Language Vocabulary (ALV)

Soil			Water Cycle		
Word	Frequency	Type of ALV	Word	Frequency	Type of ALV
atmosphere(s)	9	technical	altitude(s)	7	general
bacteria	6	technical	atmosphere	14	technical
between	1	(none)	condensation	21	technical[b]
complex	3	general	condense(s)	8	technical
contain(s)	2	general	constantly	4	general
decompose	12	technical	droplet(s)	3	technical
develop	1	general	evaporate(s)	7	technical
difference	2	general[a]	evaporation	16	technical[b]
directly	2	general	eventually	1	general
factor(s)	1	general[a]	occur(s)	1	general
fingernail(s)	1	(none)	particle(s)	10	general[a]
formation	8	general	precipitation	25	technical[b]
humus	16	technical	runoff	5	general[a]
importance	1	(none)	sleet	1	(none)
important	3	(none)	vapor	2	technical
ingredient(s)	5	context-specific			
interaction(s)	9	general[b]			
living	4	context-specific[a]			
material	1	general			
matter	1	technical[a]			
mineral(s)	3	technical			
mixture	2	context-specific[b]			
natural	2	general			
necessary	5	general			
nutrient(s)	4	technical			
occur(s)	1	general			
once-living	3	context-specific			
organic	10	technical[a]			
organism(s)	15	technical			
particle(s)	3	general[a]			
plenty	1	(none)			
process	5	general			
resource(s)	5	general			
rodent(s)	1	(none)			
stony	2	(none)			
surface	1	context-specific			
survive	1	general			
sweep	1	(none)			
various	4	general			
Venus	2	(none; proper noun)			
weathered	9	technical[b]			
weathering	10	technical			

[a]This word is polysemous (i.e., the word has multiple meanings).
[b]This word is a nominalization.

The words selected by students provided insight into the types of vocabulary that they attended to when reading text. In general, it seems like the most difficult – and salient – words for students were the technical ALV words. To further investigate if any commonalities with the 18 selected technical ALV words exist, the words' lexical properties were examined. Table 16 displays the properties for each word. All the words are multisyllabic, and most are derived from Greek and Latin roots, which are typical in science vocabulary words. Only five of the words could be considered an abstract concept.

Table 16

Lexical Properties of Student Selected Technical Words

Technical ALV Word	Lexical Properties					
	Polysemous	Nominalized Form	Derived Form	Greek/Latin Root	Multi-syllabic	Abstract Concept
atmosphere(s)				x	x	
bacteria				x	x	
condensation		x	x	x	x	x
condense(s)				x	x	
decompose					x	
droplet(s)			x		x	
evaporate(s)				x	x	
evaporation		x	x	x	x	x
humus				x	x	
matter	x				x	x
mineral(s)				x	x	
nutrient(s)				x	x	
organic	x			x	x	x
organism(s)			x	x	x	
precipitation		x	x	x	x	
vapor				x	x	
weathered		x	x		x	
weathering			x		x	x
Total	2	4	7	13	18	5

Selection of Difficult Sentences. Lastly, students were asked to identify sentences that they thought were difficult. Not every student selected sentences; 19 students did not identify any sentence that would be difficult in either passage. Instead, they answered that none of the sentences seemed difficult to them. Additionally, 12 students only identified sentences for one, not both passages: nine students did not select any difficult sentences in the soil passage, and three students did not select any sentences in the soil passage. For the 25 students who selected specific sentences, they identified a total of 71 sentences they considered difficult between the two passages: 39 in the soil passage and 32 in the water cycle passage. The selected sentences were categorized into the four sentence types: simple, compound, complex, and compound-complex.[7] Table 17 displays the counts of student-selected sentences by passage and sentence type. Similar to the type/token distinction used for vocabulary words in previous section, number inside the parentheses refers to the number of sentences that fall into each sentence type, and the number inside the parentheses refers to the number of times each sentence was selected. For example, for the soil passage from Table 17, one compound-complex sentence was selected as difficult by three different students. Similarly, a compound-complex sentence in the water cycle passage was identified by two students as difficult.

[7] Complex and compound-complex sentences contain embedded clauses.

Table 17

Number of Sentences Selected by Students as Difficult, by Passage and Sentence Type

Passage	Sentence Type				Total
	Simple	Compound	Complex	Compound-Complex	
Soil	10 (25)	1 (1)	4 (10)	1 (3)	16 (39)
Water Cycle	5 (7)	0 (0)	10 (23)	1 (2)	16 (32)
Total	15 (32)	1 (1)	14 (33)	2 (5)	32 (71)

Note: The number outside the parentheses refers to the number of sentences that fall into each sentence type, and the number inside the parentheses refers to the total number of sentences that were selected within the types (similar to the idea of tokens). For example, in the soil passage, the same compound-complex sentence was selected as difficult three times; or in the water cycle passage, 10 different complex sentences were selected a total of 23 times.

Across both passages, students mostly selected simple (15) and complex sentences (14) as ones they thought were difficult. However, the trends differ depending on the passage. For the soil passage, students selected simple sentences more times (10) than all the other sentence types combined. For the water cycle passage, students selected complex sentences more times (10) than all the other sentences combined. Compound and compound-complex sentences were rarely selected by students. Table 18 shows the most frequently selected sentences from both passages. (For the complete list of sentences selected by students, see Appendix E.)

Table 18

Most Frequently Selected Sentences by Passage and Sentence Type

Sentence	Frequency Selected	Type of Sentence
Soil Passage		
Living and once-living organisms are necessary for soil to form. [line 16]	7	Simple
Worms and bacteria living in the soil help decompose the dead material into humus. [line 19]	7	Simple
Soil formation is a process that occurs over time through the interaction of these various factors. [line 23]	4	Complex
For example, there is no soil on Mars or Venus even though those planets have plenty of rocks that are weathered by their atmospheres. [line 14]	3	Compound-complex
It is a complex mixture of ingredients that includes minerals, air, water, and organic matter. [line 4]	3	Complex
One tablespoon of soil has more organisms in it than people on Earth. [line 28]	3	Simple
Water Cycle Passage		
When water vapor condenses around dust particles found in the air, cloud droplets form. [line 14]	6	Complex
As water becomes warmer, its particles move more quickly and change from liquid water to water vapor, a gas. [line 7]	3	Complex
The cold air condenses the water vapor, changing it back to a liquid. [line 13]	3	Simple
This is because air becomes cooler at high altitudes. [line 12]	3	Complex
When water evaporates, the water particles rise into the air. [line 9]	3	Complex

Students were further asked to explain why they chose the sentences, and based on their responses, a coding schema similar to the one used in passage-related codes (see Table 10) was applied here. One additional code, *Sentence Structure*, was added because some students became more attuned to sentence structure when asked to explain why they chose specific sentences, either by mentioning how the sentence was "put together" or describing punctuation.

Table 19 presents the codes and their descriptions, examples of student responses, and frequencies for each code. *Vocabulary* was the most frequent reason (22) students gave to explain why a sentence was difficult or confusing, followed by *Ideas/Topic* (7), *Too Much Information* (6), and *Sentence Structure* (6).

Table 19

Codes for Sentence Difficulty with Descriptions, Examples of Student Responses, and Frequencies

Codes & Descriptions	Examples	Frequency
Content/Topic (The content presented in the sentence was difficult or confusing to understand)	"'Cause sometimes they might not know what condense means and then 'the dust particles found in the air,' but then how did they form?" "Because they know that weathered rock could help make soil, but then even if the weathered rock is on Mars, on the different planets, they still don't know why soil won't form."	7
Long Sentences (Sentence was long)	S: I think it's the way the sentence is put together. I: So in that sense, is it long, there are a lot of ideas put in that sentence – [was interrupted by student] S: It's long.	3
Too Much Information (Sentence had too much information or too many ideas)	"It has too many ideas for them not to understand." "It gives a lot of information."	6
Sentence Structure (References to sentence structure, e.g., clause or phrase identified as confusing, how the sentence was written, or sentence punctuation)	"Well it's kind of repetitive because it says, 'As water rises higher and higher' and next it says 'high altitudes.'" S: It's just the way the sentence is written. I: Tell me more about that. What do you mean the way the sentence is written? S: Like some may not understand it as well as others. I: Why? S: Yeah, the way the sentence was put together. "'Formation is a process' [a phrase] is confusing."	6
Vocabulary (Words in the sentence were difficult)	"Because sometimes, I get confused by the atmosphere and the biosphere. And sometimes I think it's like up there or down here." "'Cause it's kind of hard and confusing 'cause 'living and once-living organisms are necessary for soil to form.' I don't really get the 'living and once-living.'"	22
No Explanation (Student did not provide any explanations other than saying the sentence was difficult, or explanation didn't make sense)	S: It's just the way the sentence is written. I: Tell me more about that. What do you mean the way the sentence is written? S: Like some may not understand it as well as others. S: 'Cause it's like confusing. I: What makes it confusing? S: 'Cause it says, "Living and once-living organisms are necessary for soil to form." [This was the exact sentence that the student just selected.]	4

Note: S=Student, I=Interviewer.

The responses that were coded for *Sentence Structure* are interesting to examine in some detail because it was rare for students who participated in this study to talk about sentence how sentences can be constructed. In addition to the student examples provided in Table 19, two student explanations regarding sentence structure are highlighted. In the interview excerpt below, one student talked about predicates and subjects, and how rearranging them in a sentence could be troubling for students. For reference, the sentence for line 9 is: “When water evaporates, the water particles rise into the air.”

S: [Student identifies lines 9 and 16 as confusing sentences] Well, because, it’s not hard for me, but…I think it’s confusing for them because – let’s say, like maybe the words are a little too difficult for them, or like, how it’s structured, like they might think the other way around. Like, so wait, the little particles, like let’s say a hundred of them had to form together and I think they might get confused like that [referring to line 9]. And then sentence 16, because so they’ll think like, “Oh, so the clouds are frozen,” even though they’re gas.
I: So you chose those sentences because it may have difficult –
S: Meanings.
I: I like one thing you said, the way the sentence is structured. Tell me what you mean by structure.
S: Like structured. Some kids are used to like having – like, let’s say since they’re not very good at language arts, they might want to have the predicate in front of the subject, like that.
I: What do you mean by that?
S: [Pointing to line 9] The predicate and the subject – like the predicate is like what they do and the verb and all that, and the subject is the person or the thing, and so some people – some sentences are the other way around that they have the predicate **then** [emphasized by student] the subject.
I: Is that what you think for line 9?
S: Yes.
I: Because it has this phrase: “When water evaporates” comma?
S: Yeah, because a lot of kids, they’re like since – in our writing, when we were small, we’re not used to putting commas and all that, so – it’s the main thing or the main thing to have an error on.

This student used the word “structured” to explain why one of the sentences she chose would be difficult for other students. She also used and correctly defined technical vocabulary words related to grammar (i.e., predicate and subject), and she understood that sentences do not have to follow a subject+predicate structure. She pointed to line 9 when explaining about flipping subjects and predicates ("some sentences are the other way around that they have the predicate then the subject"), and although that was not how the sentence was actually structured (the sentence begins with a relative clause), this student displayed a deeper knowledge of sentence structure than most other participants in this study.

In another excerpt, a student noted the use – or lack of use – of commas in a sentence he chose as confusing.

S: Maybe this one 'cause it's long. [Student identifies line 14: "For example, there is no soil on Mars or Venus even though those planets have plenty of rocks that are weathered by their atmospheres."]
I: Tell me more about that.
S: There's not many commas, and like you can't take a breath. You have to read it straight on, except for this part [student points to the one comma in the sentence], and some – like it gives a lot of information.
I: What do commas do in sentences? Or why would commas make sentences easier?
S: It's kind of like it gives you a break from the sentences. It stops you for like maybe half a second and then you could continue on.
I: What happens with that half second?
S: It allows you to pause and think about it.

For this student, commas helped him read and comprehend sentences (e.g., "It allows to pause and think about it"). It may also be that the student indicated that in long sentences with "a lot of information" need commas to help break those sentences into meaningful chunks of information, which would help with reading comprehension.

Summary. The majority of students who participated in this study found that the science passages they read were easy to read and understand. Students were then asked to explain why some students, including themselves if applicable, would think that the passages were difficult to read or understand. Student responses to this query were grouped into two main categories:

passage-related and student-related responses. For passage-related reasons, the most frequent reason given by students was vocabulary. The content/topic of the passages was the second most frequently stated reason, and more ELL students said that the content/topic of the passages contributed to passage difficulty. That more ELL students stated that the content/topic made passages difficult relates to prior knowledge. ELL students more frequently stated that prior knowledge affected students' comprehension of the passages, compared to EO/IFEP and RFEP students. EO/IFEP students cited poor reading habits as the most popular student-related reason to why the passages would be difficult to read, and RFEP students equally stated that prior knowledge and reading abilities affected comprehension.

Student explanations for reasons for passage difficulty were also examined to see if they related to academic language knowledge. In particular, reasons for the selection of difficult vocabulary words or sentences were examined. Student explanations for selecting specific words as difficult were not related to academic vocabulary. For sentences, two students acknowledged that the number of ideas (which usually appear as embedded clauses) contributed to sentence difficulty. The notion that a single sentence can contain many ideas is related to academic grammar knowledge. In terms of discourse, no student explanations were related to academic discourse knowledge.

Students' selection of words they thought were difficult were, in general, academic vocabulary words. Few of the words selected were non-academic (14 out of the 303 words (token) that were selected were non-academic). Across the two passages, students select slightly more types of general vocabulary words (types=21) compared to technical vocabulary words (types=18), but more students selected technical vocabulary words as difficult (token=191) compared to general academic words (token=83). The most frequent words selected by students as difficult were: *precipitation, condensation, evaporation, humus, organism*, and *atmosphere*, all of which are technical vocabulary words.

For sentence selection, 26 of the 45 students selected sentences they thought were confusing or hard to understand; the other 19 students stated that they did not think any sentence to be confusing or hard to understand. The types of sentences that students selected as difficult were simple and complex sentences. Few compound and compound-complex sentences were chosen as difficult. Students were also asked to explain their reasons for selection, and these explanations were coded. The most frequent reason students gave for sentence difficulty was the vocabulary words found in sentences.

Influence of Students' ELP Designations in Knowledge of Academic Language Features and Reading Comprehension

To investigate whether students of different ELP designations differed on their knowledge of academic language features (vocabulary, grammar, and discourse) and reading comprehension (multiple-choice questions and summary scores), ANOVAs were performed.

Academic Language Vocabulary (ALV) Knowledge. The percentage scores for all students on ALV ranged from 11%-78% (*M*=37.9%, *SD*=18.4). Table 20 displays the means, standard deviations, and the ranges of percentage scores for students by ELP designation: EO/IFEP, RFEP, and ELL. On average, students who were identified as EO/IFEP and RFEP scored about the same percentage correct on vocabulary items (*M*=42.5%, *SD*=19.4 and *M*=46.5%, *SD*=15.7, respectively) compared to ELL students (*M*=25.4%, *SD*=11.9). ANOVA results (see Table 20) indicated that there was a statistically significant difference in ALV knowledge for the three groups, F (2, 42)=9.644, p = .000. Tukey post-hoc comparisons of the three groups indicated that the mean score for ELL students was significantly different from students in the EO/IFEP and RFEP groups. The EO/IFEP and RFEP groups did not differ significantly from each other in ALV knowledge.

Academic Language Grammar (ALG) Knowledge. The percentage score for all students on ALG ranged from 5%-85% (*M*=37.9%, *SD*=18.4). On average, the combined EO/IFEP group of students (*M*=51.4%, *SD*=21.7) and RFEP students (*M*=51.9%, *SD*=17.1) scored about the same percentage correct on grammar items compared with ELL students (*M*=30.0%, *SD*=10.4). Table 20 displays means, standard deviations, ranges, and ANOVA statistics. ANOVA results indicated that there was a statistically significant difference in ALG knowledge for the three groups, F (2, 42)=9.263, p = .000. Tukey post-hoc comparisons of the three groups indicated that the mean score for ELL students was significantly different from students in the EO/IFEP and RFEP groups. The EO/IFEP and RFEP groups did not differ significantly from each other in ALG knowledge.

Academic Language Discourse (ALD) Knowledge. The percentage score for all students on ALD ranged from 27%-81% (*M*=48.9%, *SD*=12.6). As presented in Table 20, on average, RFEP students (*M*=56.2%, *SD*=11.5) scored the highest percent correct on discourse items compared to the EO/IFEP students (*M*=47.3%, *SD*=10.3) and ELL students (*M*=44.9%, *SD*=13.3). ANOVA results indicated that there was a statistically significant difference in ALD knowledge for the three groups, F (2, 42)=3.600, p = .036. Tukey post-hoc comparisons of the three groups indicated that the mean score for RFEP students was significantly different from students in the EO/IFEP and ELL groups. The EO/IFEP and ELL groups did not differ significantly from each other in ALD knowledge.

Reading Comprehension. Reading comprehension was measured in two ways: multiple-choice questions and students' oral summaries of the passages. With respect to the multiple-choice questions, the students ranged from 13%-88% correct on the multiple-choice items (*M*=52.6%, *SD*=18.7). EO/IFEP and RFEP students scored about the same percentage of correct answers on the multiple-choice items (*M*=59.9%, *SD*=17.1 and *M*=60.6%, *SD*=17.2, respectively) compared to ELL students (*M*=41.1%, *SD*=15.4). ANOVA results indicated that there was a statistically significant difference in reading comprehension as measured by multiple-choice questions for the three groups, F (2, 42)=7.327, p = .002 (see Table 20). Tukey post-hoc comparisons of the three groups indicated that the mean score for ELL students was significantly different from students in the EO/IFEP and RFEP groups. The EO/IFEP and RFEP groups did not differ significantly from each other in reading comprehension as measured by multiple-choice questions.

Reading comprehension was also measured through students' oral summaries of the passages. Student summaries were scored based on the number of main ideas they included in their summaries (see Instruments and Measures section for details on scoring). Student scores on their oral summaries for both passages ranged from 4%-48% correct (*M*=23.4%, *SD*=11.5). Overall, students scored much lower on the oral summaries compared to the multiple-choice questions. On average, EO/IFEP students received the highest scores (*M*=27.0%, *SD*=12.7) for their summaries, followed by ELL students (*M*=24.0%, *SD*=11.6), and RFEP students (*M*=18.7%, *SD*=8.9). No statistically significant differences for the summaries were found among ELP designation groups, F (2, 42)=1.861, p = .168 (see Table 20).

Table 20

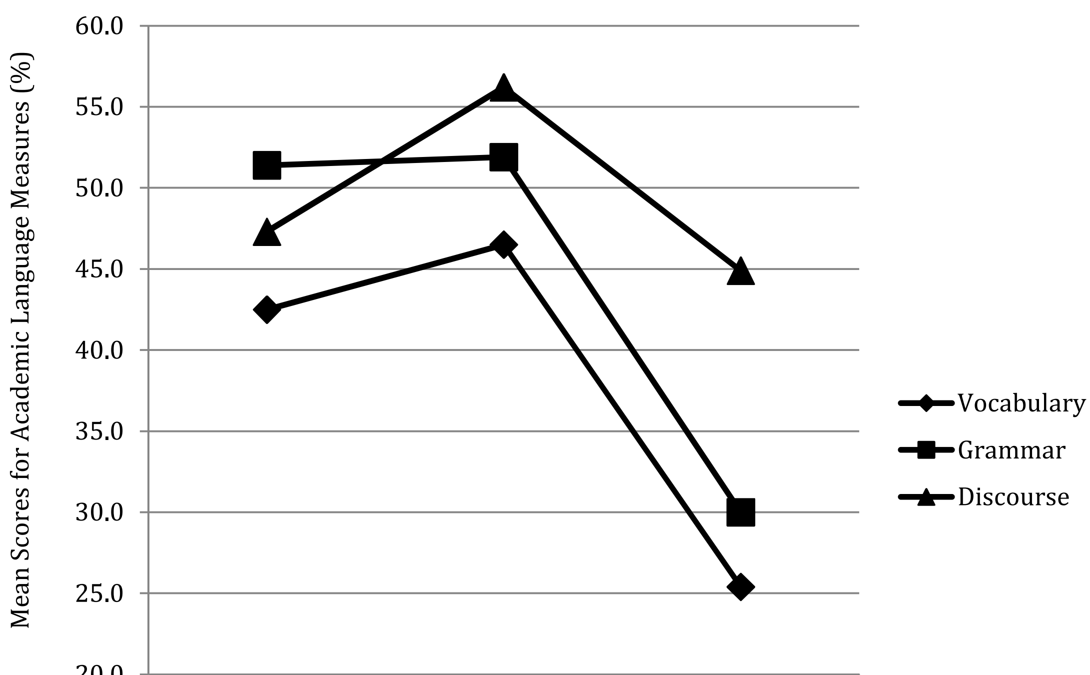
Descriptive Statistics and ANOVA Results for Academic Language Features and Reading Comprehension by ELP Designation Groups

	ELP Designation Groups[a]								
	EO/IFEP (n=14)		RFEP (n=13)		ELL (n=18)				
Measure	*M* (*SD*)	Range	*M* (*SD*)	Range	*M* (*SD*)	Range	*F*	df	*p*
Academic Language Features									
Vocabulary (ALV)	42.5% (19.4)	18%-78%	46.5% (15.7)	18%-74%	25.4% (11.9)	11%-51%	9.644***	2, 42	.000
Grammar (ALG)	51.4% (21.7)	5%-85%	51.9% (17.1)	35%-80%	30.0% (10.4)	15%-45%	9.263***	2, 42	.000
Discourse (ALG)	47.3% (10.3)	27%-62%	56.2% (11.5)	35%-81%	44.9% (13.3)	27%-73%	3.600*	2, 42	.036
Reading Comprehension									
Multiple-Choice Questions	59.9% (17.1)	31%-88%	60.6% (17.2)	31%-81%	41.1% (15.4)	13%-63%	7.327**	2, 42	.002
Summary Score	27.0% (12.7)	4%-48%	18.7% (8.9)	9%-39%	24.0% (11.6)	9%-48%	1.861	2, 42	.168

[a]ELP designation group abbreviations are: EO = English-only speaking students, IFEP = Initial fluent English proficient, RFEP = Redesignated fluent English proficient, ELL = English language learner

**p*<.05. ***p*<.01. ****p*<.001.

Summary. In academic language, students in the EO/IFEP and RFEP group had similar means in the vocabulary and grammar measures, and students in the ELL group had lower means compared to the other two groups. ANOVA results indicated that the means for ELL students in vocabulary and grammar were significantly lower compared to EO/IFEP and RFEP students. For discourse knowledge, the RFEP students had the highest means of any group, but ANOVA results indicated that none of the means for the three groups were statistically significant. See Figure 2 for a means plot for all three measures of academic vocabulary for the three ELP designation groups.



	EO/IFEP	RFEP	ELL
Vocabulary	42.5	46.5	25.4
Grammar	51.4	51.9	30.0
Discourse	47.3	56.2	44.9

ELP Designation Groups

Figure 2. Means for vocabulary, grammar, and discourse measures of academic language by ELP designation groups.

For the measures of reading comprehension, again, EO/IFEP and RFEP students scored nearly the same percentage correct on multiple-choice items, and ELL students as a group had fewer correct answers compared to the other two groups. ANOVA results indicated that the mean scores for the ELL group were significantly lower from the mean scores for the other two groups. For the summary scores, EO/IFEP students had the highest average score for their oral summaries, followed by ELL students and RFEP students. However, the means for the three groups in summary scores were not statistically significant. See Figure 3 for a means plot for the two measures of reading comprehension for the three ELP designation groups.

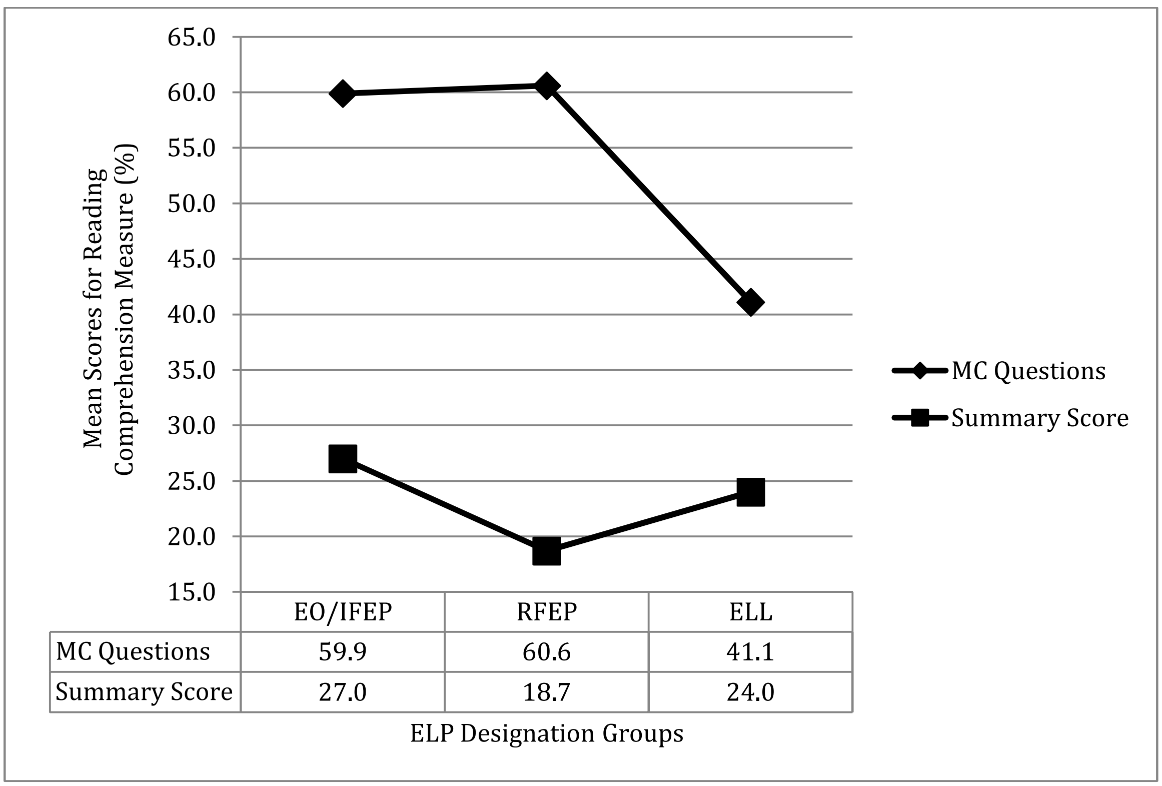


Figure 3. Means for reading comprehension measures by ELP designation groups. Note: Multiple-choice is abbreviated as MC in this figure.

Relationship between Academic Language Knowledge and Reading Comprehension

The third set of research questions investigated the relationship between students' knowledge in academic language features and reading comprehension. First is an exploration of student scores in academic language and reading comprehension using student composite z-scores in academic language and reading comprehension. Student z-scores were plotted and chi-square analysis was performed to examine the relationship between the scores. Next, correlation analysis was used to describe the strength of the relationship between the features of academic language and reading comprehension, and if students' ELP designation influenced these relationships. Last, multiple regression analysis was used to examine if students' knowledge academic language features predicted their reading comprehension scores.

Patterns of Student Knowledge between Academic Language and Reading Comprehension. A scatterplot of student z-scores was created to show the overall patterns between students' academic language knowledge and reading comprehension (see Data Analysis Procedures for more information). The scatterplot (Figure 4) shows that, in terms of reading comprehension scores, more than half of the students in this study (n=27) fell below the mean. One (RFEP) student scored at the mean for reading comprehension, and 17 students scored above the mean. For the students who scored above the mean in reading comprehension, six were EO/IFEP students, five were RFEP students, and six were ELL students. For academic language scores, 21 students scored above the mean, and 24 students scored below the mean. Of the students who scored above the mean for academic language, seven were EO/IFEP students, 10 were RFEP students, and four were ELL students. (Also see Table 22 for student frequencies and percentages for each quadrant.)

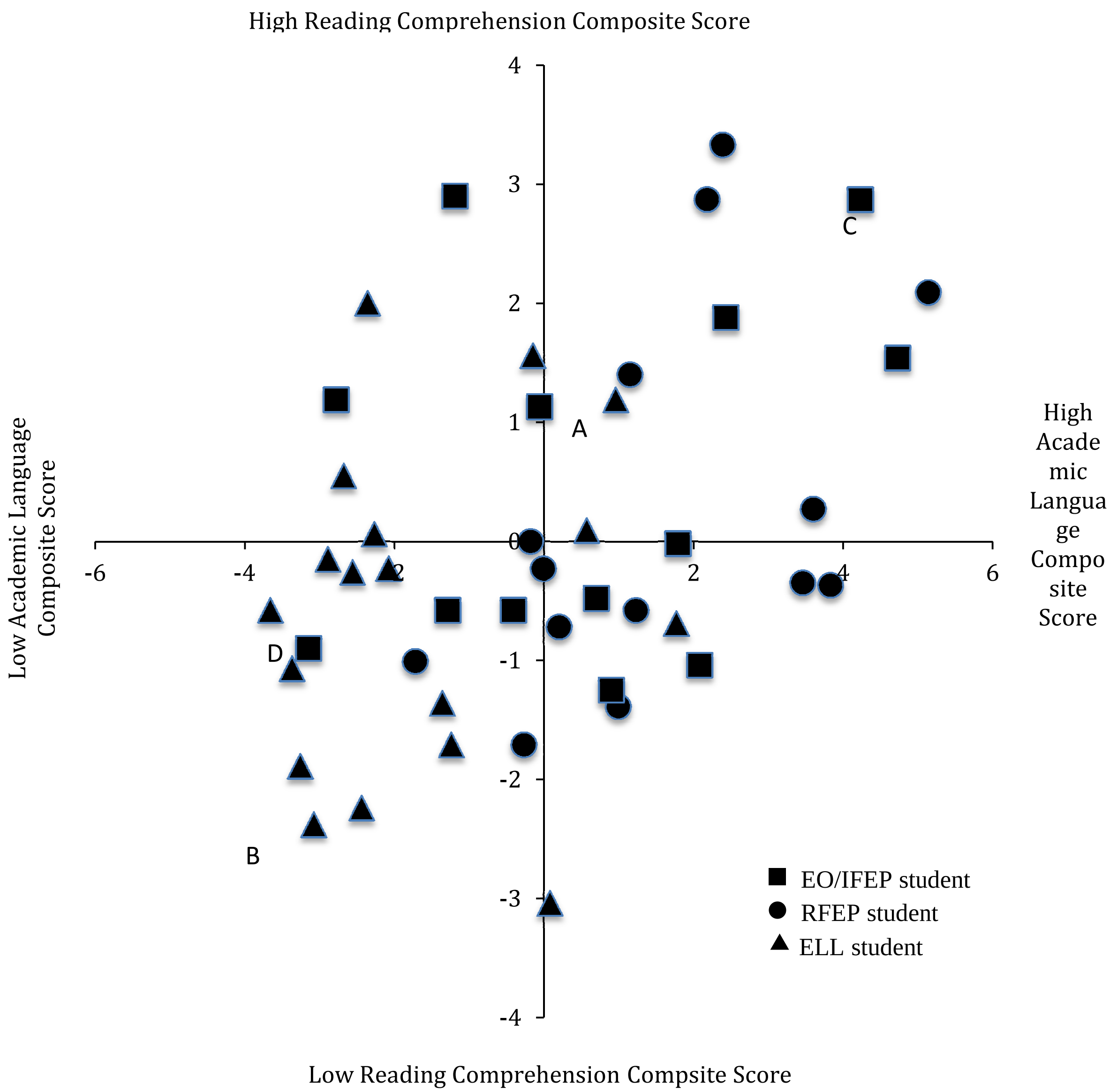


Figure 4. Placement of students by total z-scores in academic language and reading comprehension composite scores. The letters next to specific points on the scatterplot correspond to student profiles that appear in Table 21.

The scatterplot reveals some general trends in the relationship between academic language score totals and reading comprehension score totals, as well as how students of different ELP designations performed on those measures. For example, most students (n=16;

67%) who participated in this study clearly fell into the low comprehension/low academic language quadrant (compared to the number of students in the other three quadrants), and the majority of the students in the low comprehension/low academic knowledge quadrant were ELL students (n=10). Of the nine students who clearly fell into the high comprehension/high academic language quadrant, three were EO/IFEP students, five were RFEP students, and one was an ELL student. To get a better sense of the students who are represented in the scatterplot in Figure 4, four students (2 ELL students and 2 fluent-English students) were selected and their scores on each measure, as well as their ELP designation and gender, are displayed in Table 21.

Table 21

Selected Profiles of Students

			Measures				
Student[1]	ELP Designation	Gender	ALV	ALG	ALD	MC	Sum
A	ELL (Unknown)	M	51	40	54	56	35
B	ELL (3)	F	13	20	42	25	18
C	IFEP	F	78	75	54	81	39
D	EO	M	26	5	42	38	30

[1]Students are identified by letter which appear in Figure 4.

Chi-square test for independence, with Yates' correction for continuity, was performed to investigate whether students who scored high in academic language also scored high in reading comprehension (see Table 22), and there was no relationship between students' composite scores in academic language features and reading comprehension. This means that scoring high in academic language was not associated with scoring high in reading comprehension.

Table 22

Frequencies of Students by High and Low Scores of Academic Language and Reading Comprehension Composite Scores

	Reading Comprehension Score		
	High	Low	Total
Academic Language Score	n (%)	n (%)	n (%)
High	10 (48%)	11 (52%)	21 (100%)
Low	8 (33%)	16 (67%)	24 (100%)
Total	18 (40%)	27 (60%)	45 (100%)

Correlations between Features of Academic Language Knowledge and Reading Comprehension Measures. Reading comprehension was measured in two ways: multiple-choice questions and students' oral summaries of the content of the passages. Correlations (presented in Table 23) between each academic language feature and reading comprehension measures were calculated. Students' scores on the multiple-choice questions for reading comprehension ranged from 13%-81% correct (*M*=52.6%, *SD*=18.7). For summary scores, students ranged from 4%-48% (*M*=23.4%, *SD*=11.5). Between the academic language features, there was a strong, positive correlation between ALV and ALG (*r*=.712, *p*=.000) and a positive correlation between ALG and ALD (*r*=.437, *p*=.003). Between the academic language features and reading comprehension measures, both ALV and ALG were positively correlated comprehension as measured by multiple-choice questions (*r*=.720, *p*=.000 and *r*=.559, *p*=.000, respectively). No academic language feature was significantly correlated with summary scores.

Table 23

Correlations between three Features of Academic Language Knowledge and Multiple-Choice and Summary Score Measures of Reading Comprehension for All Students (N=45)

Measures	1	2	3	4	5
1. ALV	—	.712**	.251	.720**	.280
2. ALG		—	.437**	.559**	.016
3. ALD			—	.201	-.288
4. Multiple-Choice				—	.150
5. Summary Score					—

**p<.01, two-tailed.

Correlations were also calculated for the academic language and reading comprehension measures by ELP designation groups (see Table 24). For the EO/IFEP students, ALV was correlated with ALG (r=.645, p=.013). ALV was also positively correlated with both reading comprehension measures: multiple-choice (r=.646, p=.013) and summary score (r=.565, p=.035). For the RFEP students, ALV was correlated with ALG (r=.629, p=.05). ALV and ALG were correlated only for the multiple-choice measure (r=.733, p=.004 and r=.595, p=.032, respectively). For the ELL students, no academic language feature was significantly correlated with each other or with the reading comprehension measures, although the correlation between ALV and multiple-choice questions approached significance (r=.458, p=.056).

Table 24

Correlations between Features of Academic Language Knowledge and Multiple-Choice and Summary Score Measures, by ELP Designation

Measures	1	2	3	4	5
		EO/IFEP (n=14)			
1. ALV	—	.645*	.207	.646*	.565*
2. ALG		—	.435	.307	.084
3. ALD			—	-.160	-.230
4. Multiple-Choice				—	.278
5. Summary Score					—
		RFEP (n=13)			
1. ALV	—	.629*	.081	.733**	.408
2. ALG		—	.368	.595*	-.117
3. ALD			—	.275	-.149
4. Multiple-Choice				—	.239
5. Summary Score					—
		ELL (n=18)			
1. ALV	—	.360	.117	.458	.155
2. ALG		—	.414	.306	.163
3. ALD			—	.104	-.263
4. Multiple-Choice				—	.142
5. Summary Score					—

*p<.05, two-tailed. **p<.01, two-tailed.

Features of Academic Language Knowledge that Predict Reading Comprehension Scores. Multiple regression analysis was conducted to test if vocabulary, grammar, and discourse features of academic language significantly predicted students' reading comprehension outcomes. Regression analysis for each of the two reading comprehension outcomes, multiple-choice and summary score, was conducted separately. The results of the regression for multiple-choice indicated that the three features explained 52.3% of the variance (R^2=.523, F(3,41)=14.992, p<.001). It was found that vocabulary significantly predicted reading comprehension when measured by multiple-choice questions (β=.653, p<.001). Grammar and discourse did not significantly predict students' reading comprehension in multiple-choice questions. For summary scores, the results of the regression indicated that the three features explained 23.2% of the variance (R^2=.232, F(3,41)=4.119, p<.05). Vocabulary significantly predicted students' summary scores for reading comprehension (β=.504, p<.005). Discourse was also significantly associated with summary scores, but negatively (β=- .327, p<.05). See Table 25 for regression results.

Table 25

Features of Academic Language (Vocabulary, Grammar, Discourse) Regressed on Reading Comprehension Measures (Multiple-Choice and Summary Score)

	Reading Comprehension Measures					
	Multiple-Choice			Summary Score		
Variables	*B*	*SE B*	β	*B*	*SE B*	β
Constant	.238	.084		.312	.066	
Vocabulary (ALV)	.663	.157	.653***	.315	.122	.504*
Grammar (ALG)	.093	.160	.096	-.119	.125	-.200
Discourse (ALD)	-.008	.179	-.006	-.299	.140	-.327*
R^2	.523			.232		
F	14.992***			4.119*		

Note: *B*=unstandardized regression coefficient; β=standardized regression coefficient.
*p<.05. ***p<.001.

Summary. Students were placed according to their combined z-scores for total academic language and reading comprehension scores in a scatterplot to examine general trends. Overall, students who participated in this study performed poorly in the reading comprehension measures;

the majority scored below the mean for comprehension. As a group, the ELL students also performed poorly on the reading comprehension measures. Student performance on the academic language measures was more equally distributed above and below the mean. More students fell into the low reading comprehension/low academic language quadrant than in the other three quadrants (see Figure 4 and Table 22). Chi-square analysis showed that there was no relationship between students' high scores in academic language and high scores in reading comprehension.

Next, correlations were calculated between the academic language measures and reading comprehension measures. For the EO/IFEP and RFEP groups, vocabulary was strongly and positively correlated with the multiple-choice reading measure. For the ELL group, vocabulary multiple-choice approached significance. Summary scores were not correlated with measures of academic language, except for vocabulary with EO/IFEP students.

Multiple regression analysis was conducted to examine whether the three features of academic language predicted reading comprehension as measured by multiple-choice questions or summary scores. Vocabulary scores were the only feature that significantly predicted students' scores on the multiple-choice questions. Vocabulary scores also significantly predicted students' summary scores. However, for summary scores, students' discourse scores were also significant in negatively predicting student outcomes.

CHAPTER V
Discussion

As an initial step toward exploring what features of academic language make science-based expository text difficult for students with different English language proficiency designations, this study investigated students' thoughts on text difficulty related to features of academic language and the relationship between academic language and reading comprehension. The first set of research questions examined the challenges to comprehension of science texts that students identified. In particular, the study examined if these challenges varied for fluent English-speaking students and English language learners, and whether these challenges were related to academic language. The second research question examined the ways in which students of different English language proficiency designations varied in their knowledge of academic knowledge features and reading comprehension. The last set of research questions examined the relationship between academic language features and students' comprehension of science texts, paying attention to how the relationship differed by English language proficiency designations.

Student Thoughts on the Difficulty of Expository Texts in Science. Vocabulary was the prevailing passage-related reason for the difficulty of the science texts for the fifth-grade students in this study. Students were given several opportunities to explain which text-based aspects of the science texts challenged comprehension, with interview questions that tried to focus students' attention toward sentence and text (discourse) structures, but in student explanations, difficult vocabulary was the dominant response. This was true for all groups of students regardless of English language proficiency designations. Moreover, students' overwhelmingly identified technical vocabulary words as the difficult or confusing.

In science, technical vocabulary words may be particularly challenging for students to learn. New vocabulary words introduced in the content area of science are names and labels for core processes and concepts of science knowledge. Furthermore, science-specific vocabulary words tend to be abstract (Lee & Spratley, 2010) and can be about vaguely known ideas that students seldom encounter prior to and outside of school settings (Ebenezer & Erickson, 1996). For example, for the soil passage, the most frequent word identified by students as difficult was *humus*, which is a word rarely found in other content-areas or rarely used in everyday contexts.

The students' focus on vocabulary may also reflect their perception that text difficulty is mostly at the word level. Students in this study gave few sentence-level reasons and no discourse-level reasons for the difficulty of the science passages. Technical vocabulary tends to be the most noticeable feature in science texts (O'Toole, 1996). Moreover, a focus on vocabulary words in reading science text may also reflect teaching practices and the type of exposure students get during science instruction. Teachers often reduce science instruction to teaching vocabulary words as the conceptual, scientific ideas of the unit (Bruna, Vann, Escudero, 2007; Yager, 1983). While science teachers should help students understand technical terms, Quinn, Lee, and Valdes (2012) argue that other features of science text and science talk can be difficult for students, especially ELL students, to understand, and that students need access to good instruction in these areas in order to read or write about a science topic.

Students also cited reading skills and prior knowledge as reasons that affected text comprehension, but the frequencies of those reasons differed by students' English proficiency designations. EO/IFEP students stated more often that low or poor reading abilities caused the science passages to be difficult to comprehend for students; however, ELL students stated more often that prior knowledge (and, related to that, the content/topic) was a source for the difficulty in comprehending the passages. RFEP students fell between EO/IFEP students and ELL students in citing reading abilities and prior knowledge as sources of reading comprehension problems. That students stated poor or low reading skills as an obstacle to comprehension is not surprising, but it is interesting that most of the students who stated reading skills as an issue were the fluent English speakers, who, in this particular sample, were relatively good readers (see Table 1 and Figure 4). ELL students focused more on content of the passages and their prior knowledge of the content. Prior knowledge is an important aspect of text comprehension (Kintsch, 1988; Snow, 2002) and for science learning (Alexander & Kulikowich, 1994; Eaton, Anderson, Smith, 1984; Gee, 2005). ELL students may not have the prior knowledge or experiences that would help them comprehend school-based texts (August & Shanahan, 2006; Garcia, 1991). Graesser, Leon, and Otero (2002) state that a central challenge to reading science texts is that most readers have very little knowledge of science as a subject matter, which makes comprehension of text that is already technical and complex even more of a challenge.

Academic Language Knowledge, Reading Comprehension, and ELP Designation Groups. The series of quantitative analyses performed in the this study were used to investigate whether there were differences between students' academic language knowledge and reading comprehension according to their English language proficiency designations, and some differences were found. EO/IFEP and RFEP students performed relatively similar in all measures, whereas the ELL students tended to perform worse in comparison. Specifically, ANOVA results showed that the mean scores for vocabulary and grammar knowledge and multiple-choice questions were significantly lower for ELL students compared to their EO/IFEP and RFEP peers. There were no significant differences in scores by group for discourse knowledge or summary scores.

To illustrate students' performance on academic language and reading comprehension measures, composite standard scores were plotted to examine general trends. Composite standard scores were created by combining the three features of academic language into one score and the two measures of reading comprehension into one score. The scatterplot revealed that students in this study performed poorly in reading comprehension composite and scored low on measures of academic language knowledge composite. Moreover, results from the chi-square analysis revealed that there was no relationship between students' composite scores in academic language and reading comprehension, meaning that a student score on one composite variable did not influence the student's score on the other composite variable. However, it is noticeable that most students scoring low on academic language also scored lower on reading comprehension suggesting the possibility that students need to reach a certain level – or threshold – of academic language knowledge before that knowledge can be seen to have an effect on reading comprehension scores. However, this explanation is only tentative because of the insignificant result with the small sample size in each cell of the 2 x 2 chi-square analysis. Another possible explanation for why there was no significant relationship between the two composite variables is that composite scores mask the variability of student scores in all the individual measures. The idea that the composite scores may be too general to capture overall student performance is corroborated by subsequent analyses (described below) which showed that vocabulary was the academic language feature that was most significantly related to reading comprehension when measured by multiple-choice questions.

To further examine the relationship between features of academic language and reading comprehension, correlations were calculated. For EO/IFEP students, vocabulary was correlated with grammar and both reading comprehension measures (i.e., multiple-choice and summary score). For the RFEP students, vocabulary was correlated with grammar and multiple-choice questions; grammar scores were also correlated with multiple-choice questions. For ELL students, there were no significant correlations between academic language features or reading comprehension measures, although the correlation between vocabulary and multiple-choice questions approached significance.

The last set of quantitative analyses used multiple regressions to test if the features of academic language knowledge predicted reading comprehension. The three features of academic language explained 52.3% of the variance of the multiple-choice questions but only 23.2% of the variance for summary scores. In both regression models for multiple-choice questions and summary scores, vocabulary scores significantly predicted the scores in reading comprehension. For summary scores, discourse was significant, too, but in a negative direction. While it makes sense that vocabulary would predict summary scores as students need to be able know what vocabulary words mean in order to use them correctly in a summary of the passage, but it is unclear why discourse scores would negatively predict summary scores. The answer may possibly be because of the short summaries. Since the summaries produced were at most three to four sentences in length (see below for an example), they did not display any of the discourse features that were measured (such as identification of topic sentences, the knowledge of introduction/body/conclusion paragraphs, cohesive devices). Another possible answer may be a methodological issue in that in order to code discourse knowledge, its features were measured in discreet components that did not adequately reflect or capture students' comprehension as measured by summary scoring.

Together, the quantitative results show that for this sample of fifth graders, vocabulary played a significant role in EO/IFEP and RFEP students' comprehension when it was measured by multiple-choice questions. The results from this study support the well-established link between vocabulary knowledge and comprehension. The robust research on the relationship between vocabulary and comprehension shows that vocabulary knowledge highly predicts reading achievement for all learners regardless of age or background (Beck, Perfetti, & McKeown, 1982; Blachowicz & Fisher, 2000; Lesaux & Kieffer, 2010; Stahl & Fairbanks, 1986). Indeed, little comprehension occurs when the reader does not understand many of the key words in the text, and as discussed previously, science texts have technical vocabulary words that are often the main processes and ideas of the science topic. Furthermore, it makes sense that vocabulary knowledge was highly correlated, and it significantly predicted, reading comprehension as measured by the multiple-choice questions because many of the key technical words appeared in the questions that were asked. Therefore, if a student knew the definition for the vocabulary word *evaporation*, for example, he would be likely to answer a question on evaporation correctly on the multiple-choice test.

Overall, grammar and discourse features did not play a significant role in students' comprehension, especially when measured by summary scores. Perhaps the components measured in grammar (e.g., referents, sentence structure affected by nominalizations) and discourse (e.g., referents, topic sentences) were not important factors for reading comprehension as measured by multiple-choice questions. Another reason to explain why academic grammar and discourse features were not influential, as mentioned earlier, is the methodological issue. In order to code grammar and discourse knowledge, those features were measured in discreet components that did not adequately reflect or capture students' comprehension, even when measured by summary scoring.

With respect to summary scores, one would assume that grammar and discourse scores should be significantly correlated with that form of measure because summaries that are constructed by students contain sentences (i.e., grammatical features) and an organizing structure (i.e., discourse features). Only vocabulary was significantly correlated with summary scores for just the EO/IFEP students. A possible explanation for why grammar and discourse scores did not correlate significantly with summary scores is because the students' summaries were, overall, very short and did not contain enough information. The mean summary score (for both passages combined) for the participants was 23.4% (*SD*=11.5), with a range of 4%-48%. For example, below is one of the highest-scoring summaries for the soil passage, which scored a 6 out of 10 possible points (60%):

> It's talking about soil, that it's – soil has – it's not dirt and that soil is important 'cause it carries a lot of natural recesses [*sic*, resources], and it takes about – it takes time – it takes time for little rocks to turn into soils, and it probably takes 500 years to be soil. And – well actually, if there's no life, there will be soil. And soil is very important.

Limitations

To understand student knowledge on academic language features and comprehension, this study employed verbal protocols which relied on students' self-reports of their thinking. Measures of academic language knowledge and comprehension were dependent on students verbalizing their answers, and students' verbal abilities may have impacted the reporting of their thinking (Afferbach & Johnston, 1984) and their abilities to summarize, answer questions about the textual features, or to provide explanations of their thinking.

Additionally, since there were no available or published instruments or measures of academic language that fit the aims of this study at the time data was being collected, measures used in this study were researcher-developed. The instruments and measures used in this study were developed with the aim of examining how students performed relative to the science passages they read to see how this sample of students negotiated the language demands of those passages. In order to maximize the validity of these instruments and measures, the research literature related to these topics were extensively consulted, and the instruments and measures were reviewed other researchers and practitioners knowledgeable in the areas of reading comprehension, ELL students, assessment, and science. Instruments were also piloted with students, and the feedback from the pilot sessions and from the researchers and practitioners were incorporated. However, as mentioned earlier, certain measures of academic language features may not have adequately captured student knowledge, especially in ways that would lead to understanding how these features affected reading comprehension. For example, the manner in which comprehension was tested in this study through multiple-choice questions and oral summaries may privilege vocabulary knowledge over grammar and discourse knowledge. If students were to write or have provided longer summaries or retellings based on their reading comprehension, perhaps grammatical and discourse knowledge would have been a more salient finding because there would be more sentences and an organizational structure to the statements produced by students.

Lastly, the students who participated in this study were all from the same school, which may not be a representative sample of fluent English speaking students or ELL students. The differences in state test scores between the fluent English speaking students and ELL students at this school were very apparent, with at least 80% of the fluent English speaking students performing proficient or above on English/language arts and science assessments, and over 80% of ELL students performing basic or below on the same assessment. With these differences in academic achievement between groups of students, it follows that group differences were found in the quantitative analyses.

Implications and Future Research Directions

There are several educational implications and directions for future research to address the issues that emerged from this study. First, the findings in this study regarding academic vocabulary knowledge have contributed to the literature on the strong relationship between vocabulary knowledge and reading comprehension. Numerous studies have emphasized students' vocabulary learning as critical for improved reading outcomes (Kamil, 2004), especially for ELL students (August, Carlo, Dressler, & Snow, 2005; Hickman, Pollard-Durodola, & Vaughn, 2004); and it followed that vocabulary should be the emphasis of language instruction (cf. Bailey, 2010; Gomez, Freeman, & Freeman, 2005). More recently, vocabulary instruction advocates have focused on the types of words that should be taught to students, namely general academic vocabulary words (e.g., "Tier 2" words; Beck, McKewon, & Kucan, 2002) instead of non-academic words (e.g., "Tier 1" words), which findings in this study also support.

However, there is debate on whether learning words in isolation is effective (cf. Quinn, Lee, & Valdes, 2012) as vocabulary knowledge is nuanced and sophisticated. For example, Word Generation is a research-based vocabulary intervention program that emphasizes deep learning of academic word meanings across multiple content areas, and early results of the intervention showed that schools implementing the treatment had better results in the state English/language arts assessment than schools that didn't implement the treatment; additionally, that ELL students in the program had greater gains on the state assessment than fluent-English students

(Snow, Lawrence, & White, 2009). However, the authors recognized that the program was more than just a vocabulary intervention; in order to achieve deep learning of academic vocabulary, vocabulary instruction was embedded within a greater instructional context of language-, literacy-, and content- development, with foci on deep reading, productive classroom discourse, developing arguments, and producing persuasive writing samples, factors which were plausible contributors of student performance.

Moreover, in the framework of academic language (and of reading comprehension), vocabulary is viewed as one aspect within a larger context of language features that are inextricably interrelated. In their review of academic vocabulary, Nagy and Townsend (2010), caution isolating academic vocabulary instruction. Nagy and Townsend use the metaphor "words as tools" for vocabulary because

> being able to use an item of academic vocabulary means being able to use it in service of the functions of academic language. This metaphor carries with it the implication that individual words are parts of larger systems. First of all, word meanings are parts of conceptual networks. The ability to use a tool includes understanding the relationships among related tools (p. 96).

That the students in this study predominantly attended to word-level features and displayed some knowledge of sentence-level and discourse-level features of text may be an indication of the instruction they received, namely, vocabulary instruction in isolation of other instruction in language. Attention to word-level features may be a reflection of their exposure to teachers' instructional preferences. Future research could observe teacher instructional practices in language to examine how much instruction is given to each feature of academic language across different content areas. Particularly in science, some teachers emphasize vocabulary instruction in their science lessons (Bruna, Vann, Escudero, 2007; O'Toole, 1996; Yager, 1983) without using vocabulary in service of the conceptual unit of academic language that Nagy and Townsend discussed.

In light of the discussion of academic vocabulary specifically, and academic language features in general, the results for ELL students are important to address. With respect to vocabulary, findings from this study are consistent with previous research which showed that vocabulary knowledge of ELL students was lower compared with their fluent-English speaking peers (August, Carlo, Lively, Lippman, McLaughlin, & Snow, 1999; Umbel, Pearson, Fernandez, & Oller, 1992). Vocabulary knowledge for ELL students is an important area to address because it is one of the most common obstacles in reading for students who are learning English (August et al., 2005; García, 1991; Jiménez, 1994). Recent studies on adult English language learners have shown that word frequency, word familiarity, word associations were predictive of noun and verb productions for beginning adult learners of English (Crossley & Salsbury, 2010).

The findings from this study also showed that ELLs performed poorly in all measures compared to their fluent-English speaking peers, and their low academic language scores were not correlated with their reading comprehension measures. One explanation could be that ELL students from this study's sample are still acquiring foundational language skills, and academic language skills are not yet proving relevant for them, although the non-significant results could a statistical artifact due to the small sample size and possible lower variation in their scores. The small sample size could also be possible for the non-significant findings for the chi-square analysis.

One way to further explore the relevancy of academic language skills for students and with ELL student in particular is through students' learning progressions. Learning progressions is the idea that understanding and skills within a domain become progressively sophisticated (cf.

Corcoran, Mosher, & Rogat, 2009). Particularly in language progressions, recent research has examined student explanations for increasing complexity in vocabulary, grammar, and discourse features and has captured multiple pathways in students' development of English language proficiency (Bailey, 2013; Bailey, Kelly, Heritage, Jones, & Blackstone-Bernstien, 2013). Language progressions have useful implications for instruction for teachers, as knowledge of how vocabulary, grammar, and discourse sophistication develops allows teachers to teach the linguistic skills students need to advance their development in language learning, especially for ELL students (Walqui & Heritage, 2012). Furthermore, the current research on language progressions from Bailey and colleagues are in student explanations on mathematics tasks, but further research in language progressions could investigate student summaries of expository text or student explanations of science understanding, which is in line with new learning and teaching standards in English language arts and science (Common Core State Standards Initiative, 2010; Achieve, 2013).

Findings from this study also have implications for the use of science texts for science instruction and science assessment. Given that ELL students performed so poorly on the reading comprehension measures on the science texts compared to the fluent-English speakers in this sample, teachers may not want to rely on texts (at least in isolation) to teach science concepts. Moreover, teachers especially may not want to rely on the students' own reading of science texts to learn new information for students' whose reading performance was low. In terms of assessment, this study employed a traditional method of assessing comprehension knowledge – reading text and answering questions based on the text through multiple-choice questions. Large-scale science assessments may not include lengthy texts in which students are asked read.

Additionally, with science knowledge, ELL students may not be able to display knowledge on traditional assessments as the results from this study show.

To further investigate students' knowledge of the features of academic language and how that affects reading comprehension, a deeper exploration into student scores on academic vocabulary, grammar, and discourse should be conducted. Similar to Valencia and Bully's (2004) study in which profiles of poor readers were created, scores on each feature of academic language for students who were poor comprehenders would be analyzed for similar patterns. For example, one profile of a poor reader could be that she scored high in academic vocabulary knowledge but low in the other two features, but another poor reader scored low in academic vocabulary and grammar, but high in discourse knowledge. The profiles that emerge would provide information to teachers for more targeted instruction.

Lastly, teachers need to make students aware of text difficulties so children can better evaluate their own needs and challenges. The students in this student were not aware of discourse-level features of text which contributed to text difficulty, and few students attended to grammatical features of text. Again, as stated earlier, student attention on vocabulary could be a reflection of the instruction they received. In order to help students better attend to all features of text, which would increase students' reading comprehension, teachers need to have a deep knowledge of linguistics (Wong Fillmore & Snow, 2000; Wong Filmore & Filmore, 2012) and tools (e.g., language learning progressions and academic language profiles) to help assess and address student knowledge in these areas.

This study was a preliminary step toward understanding the features of academic language that make science-based expository text difficult for fluent-English speaking students and ELL students. The findings from this study – namely, the predominance of vocabulary in students' perceptions as the main feature that makes the science texts difficult and the significance of vocabulary in relation to students' reading comprehension – corroborates the research on the link between vocabulary and reading comprehension. However, academic vocabulary knowledge is just one link in a chain of academic language skills that affect reading comprehension, and future research should address the roles of all three levels of academic language features – vocabulary, grammar, discourse – in students' comprehension of expository texts.

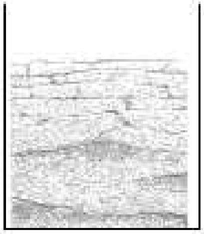
Appendix A:
Science Passages

Soil

Soil is Not Dirt

What's the difference between soil and dirt? Dirt is what you find under your fingernails or what you sweep off the kitchen floor. Soil is the land under your feet. It is a complex mixture of ingredients that includes minerals, air, water, and organic matter.

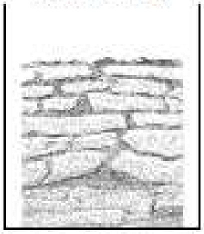
rock surface



Formation of Soil

Soil formation begins with weathering. Little or nothing will grow directly in rock. Before plants can grow, the rock first needs to be broken down. Wind, rain, snow, and ice break rocks down into smaller and smaller pieces. This process is called weathering. It takes thousands to millions of years to weather down a stony surface into tiny grains. Minerals found in soil come from weathered rock.

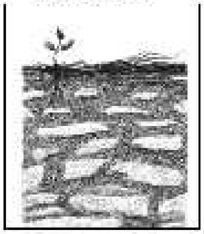
weathered rock



Another important factor in soil formation is organic matter. Without life, there would be no soil. For example, there is no soil on Mars or Venus even though those planets have plenty of rocks that are weathered by their atmospheres. Living and once-living organisms are necessary for soil to form.

Fallen leaves, dead plants, and dead animals on the ground become part of the soil. Worms and bacteria living in the soil help decompose the dead material into humus. Animals living in the ground such as insects, rodents, and snakes leave holes that fill with air and water. When air and water mix with humus and rock particles, soil is formed.

organic matter and humus



Soil formation is a process that occurs over time through the interaction of these various factors. It can take over 500 years to develop one inch of soil.

Importance of Soil

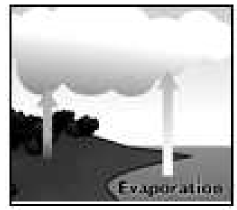
Soil contains all the nutrients needed by plants to survive. Without soil, plants could not grow and animals would not survive. It is also home to billions of organisms. One tablespoon of soil has more organisms in it than people on Earth. Soil is one of the world's most important natural resources.

soil with living and non-living organisms

The Water Cycle

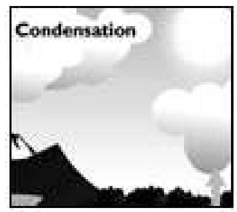
Water is constantly on the move. Rain falling where you live may have been water in the ocean just days before. And the water you see in a river may have been snow on a mountaintop. Water can be on land, in the ocean, and in the atmosphere. The movement of water from Earth's surface to the atmosphere and back again is called the water cycle.

Evaporation



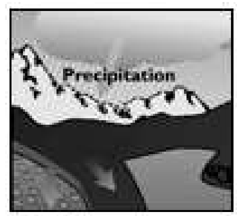
Water enters the atmosphere mostly through evaporation. When the sun shines on water, it heats the water's surface. As water becomes warmer, its particles move more quickly and change from liquid water to water vapor, a gas. The change from a liquid to a gas is called evaporation. When water evaporates, the water particles rise into the air.

Condensation



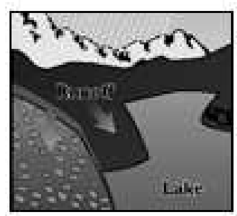
As water vapor rises higher and higher into the air, it cools down. This is because air becomes cooler at high altitudes. The cold air condenses the water vapor, changing it back to a liquid. Condensation is change from a gas to a liquid. When water vapor condenses around dust particles found in the air, cloud droplets form. Clouds develop if there are enough cloud droplets in the atmosphere.

Precipitation



Cloud droplets are light. However, as the tiny droplets combine with each other, they grow larger and eventually become too heavy to stay in the air. When this happens, they fall to Earth as precipitation. Rain, snow, sleet, and hail are types of precipitation.

Runoff



The water cycle is completed when water returns to Earth's surface through precipitation. Most of the precipitation that falls to land becomes runoff, or water that flows over land into rivers, lakes, or the oceans. Runoff is an important part of the water cycle because it allows much of the water to return to the oceans, where a great deal of evaporation occurs. Then the water cycle begins again.›

Appendix B:
Retrospective Interview Protocol

Student Retrospective Interview Protocol

Like I said earlier, the words and sentences that you just read were put there for a reason. I'm going to ask you questions that ask about your thinking. I'm also going to ask you some questions where I want you to think about why the authors put those words or sentences there.

1. Some students think that this passage was difficult to read and understand.
    a. Why do you think these students would find this passage difficult?
        i. [*redirect if answer is about students*] You talked about the people, which is fine, but I would like you to focus on the passage, and how it would be difficult to understand.
    b. Are there any words that you think they would find confusing or hard to understand? [*underline them*] Why?
    c. Are there any sentences that you think they would find confusing or hard to read or understand? [*underline them*] Why?
2. What does this word/phrase mean? [*can give a synonym*] How do you know? Why did you say that? Have you heard of that word before? Did you know about/hear/learn about that word at home or school?

    SOIL

    a. Organic (content-specific vocab) **line 5**
    b. Process (general vocab) **line 10**
    c. Matter (content-specific vocab) **line 13**
    d. Organisms (technical vocab) **line 16**
    e. Decompose (technical vocab) **line 19**
    f. Develop (general vocab) **line 24**
    g. Factor (general vocab) **line 24**

    WATER CYCLE

    a. Atmosphere (technical vocab) **line 4**
    b. Particles (general vocab) **line 10**
    c. Water vapor (technical vocab; somewhat defined in text) **line 12**
    d. Gas (content-specific vocab) **line 14**

   e. Clouds (content-specific vocab) **line 16**
   f. Eventually (general vocab) **line 19**
   g. Cycle (content-specific; inferred in text) **line 27**

3. What does this word/phrase mean? How do you know? Why did you say that? Have you heard of that word before? Did you know about/hear/learn about that word at home or school?

   SOIL

   a. Mixture (nominalization) **line 4**
   b. Formation (nominalization) **line 6**
   c. Weathering (nominalization) **line 7**
   d. Interaction (nominalization) **line 23**

   WATER CYCLE

   a. Movement (nominalization) **line 3**
   b. Evaporation (nominalization) **line 6**
   c. Condensation (nominalization) **line 11**
   d. Precipitation (nominalization) **line 24**

- **Going back to those words, can you think of a verb for each of these words?** *[ask students to go through all nominalizations as a group after they answered questions for each word above]*
  - __________ is a noun (person, place, or thing). What verb did that word come from? For example, 'decision' is the noun, 'decide' is the verb it came from. Or 'demonstration' is a noun, 'demonstrate' is the verb.

4. What's the difference <u>in meaning</u> between…[*verb and nominalization*]?

   SOIL

   a. To mix and mixture **line 4, 21**
   b. To form and formation **line 17, 6**
   c. To weather and weathering **line 11, 8**
   d. To interact and interaction **line 23**

   WATER CYCLE

   a. move and movement **line 1, 3**
   b. evaporate and evaporation **line 9, 6**

    c. condense and condensation **line 13, 14**

5. Some students think that this sentence is difficult for them to understand: *For example, there is no soil on Mars or Venus even though those planets have plenty of rocks that are weathered by their atmospheres*. **Line 14 SOIL**
    a. Can you explain to me why they would say this was a difficult sentence?
        i. Is it the words or the way the sentence was put together that makes the sentence difficult? Why do you say that?
    b. Can you use your own words to explain what this sentence is means? What is this sentence saying in your own words?
6. What about this sentence? *Soil formation is a process that occurs over time through the interaction of these various factors*. **Line 23 SOIL**
    a. Can you explain to me why they would say this was a difficult sentence?
        i. Is it the words or the way the sentence was put together that makes the sentence difficult? Why do you say that?
    b. Can you use your own words to explain what this sentence is means? What is this sentence saying in your own words?
7. Some students think that this sentence is difficult for them to understand: *However, as the tiny droplets combine with each other, they grow larger and eventually become too heavy to stay in the air*. **Line 18 WATER CYCLE**
    a. Can you explain to me why they would say this was a difficult sentence?
        i. Is it the words or the way the sentence was put together that makes the sentence difficult? Why do you say that?
    b. Can you use your own words to explain what this sentence is means? What is this sentence saying in your own words?
8. What about this sentence? *Runoff is an important part of the water cycle because it allows much of the water to return to the oceans, where a great deal of evaporation occurs.* **Line 25 WATER CYCLE**
    a. Can you explain to me why they would say this was a difficult sentence?
        i. Is it the words or the way the sentence was put together that makes the sentence difficult? Why do you say that?

b. Can you use your own words to explain what this sentence is means? What is this sentence saying in your own words?

9. Authors will use some types of words to replace other words in writing. For example [*point to example*], "The dog ran. It ran to the park." What does the word 'it' refers to, or <u>stands</u> for? [*have students answer*] How do you know?

Okay, now you're going to tell me what the following words stand/refer to.

SOIL

a. What does "it" mean? **Line 4** How do you know?
b. What does "those" mean? **Line 15** How do you know?
c. What does "these [various factors]" mean? **Line 27** How do you know?
    i. Can you point to where in the passage that tells you where "this" means?

WATER CYCLE

a. What does "it" mean? **Line 12** How do you know?
b. What does "they" mean? **Line 19** How do you know?
c. What does "this [is because]" mean? **Line 12** How do you know?
    i. Can you point to where in the passage that tells you where "this" means?
d. What does "[when] this [happens]" mean? **Line 19** How do you know?
    i. Can you point to where in the passage that tells you where "this" means?

d. Why does the author use words like *it*, *those*, *these*?
    - Do these words make understanding the passage easier or better? Are they helpful? Why?

10. Tell me the sentence that gives me the main idea for each paragraph.
    a. 1st paragraph
    b. 2nd paragraph
    c. 3rd paragraph
    d. 4th paragraph
    e. Last paragraph

11. The author organized the passage in a certain way. Can you figure out <u>how</u> the author organized the passage?

[*If student doesn't understand the question, go with more specific prompts below*:]

- [Why did the author write the 1st paragraph? [*if student tries to summarize, redirect to the organizational structure*]
    a. Does the _____ paragraph:
        i. Introduce a point/topic
        ii. Give supporting details to a point/topic

        } Why did you say that?

12. Why do you think the author wrote this passage? *Redirect: What is the purpose of writing this passage?*
    i. Entertain you
    ii. Inform you

    } Why did you say that?

    [*If student said inform, ask:*]
    1. Explain a process
    2. Describe a thing

    } Why did you say that?

Appendix C:
Multiple-Choice Comprehension Questions

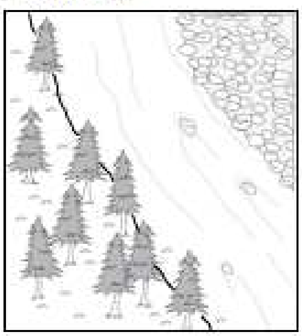
SOIL
Comprehension Questions

Name ______________________

1. A soil sample contains living and nonliving materials. Which material was once living?
    a. sand particles
    b. decomposing leaves
    c. small pebbles
    d. water droplets

2. Which of these is **not** a part of soil?
    a. minerals
    b. air
    c. sun
    d. water

Look carefully at the picture below to answer question 3.



3. What causes fewer plants to grow on the rocky side of the river?
    a. There is not enough soil.
    b. There is not enough sunlight.
    c. There is not enough water.
    d. There is not enough air.

4. Why does soil not form on the moon?
    a. There is no life on the moon.
    b. The rock surface of the moon is too hard.
    c. There is no wind on the moon.
    d. The gravitational pull of the moon is too weak.

5. Humus in soil is made from ___________.
    a. weathered rock
    b. acid rain
    c. decayed plants and animals
    d. carbon dioxide

6. Which of the following is **not** a factor in the formation of soil?
    a. weathered rock
    b. humus
    c. living organisms
    d. nutrients

7. Why is it important to protect soil?
    a. It is home to many living organisms.
    b. It has nutrients used by plants to grow.
    c. It is a natural resource.
    d. All of the above.

8. Soil helps trees because soil —
    a. makes food for the trees
    b. gives nutrients to the trees
    c. turns the roots into new trees
    d. moves the tree seeds to new places

WATER CYCLE
Comprehension Questions

Name ______________________

1. Which of the following is **not** an example of precipitation?
   a. sleet
   b. rain
   c. clouds
   d. snow

2. What is the main cause of evaporation?
   a. the sun
   b. runoff
   c. rain
   d. water vapor

3. Clouds are mainly made up of masses of ______________________.
   a. frozen rain
   b. dust particles
   c. evaporated water
   d. condensed water vapors

4. For her science project, Amy will study precipitation. Which of these would be the best information to use in her project?
   a. how different kinds of clouds are formed
   b. how water changes from liquid to solid
   c. the yearly amount of rain in her city
   d. average monthly temperatures in her city

5. What is the main cause of precipitation?
   a. the sun
   b. cold weather
   c. warm weather
   d. weight of the clouds

6. The most amount of water evaporates from the ______________________.
   a. ice from glaciers
   b. salt water from the oceans
   c. fresh water from lakes and ponds
   d. runoff on Earth's surface

7. What is the main cause of condensation?
   a. cooler temperatures
   b. warmer temperatures
   c. dust particles
   d. the atmosphere

8. Runoff is important because it ______________________.
   a. flows over land
   b. returns water back to the oceans
   c. allows the water cycle to be complete
   d. moves water quickly

Appendix D:
Sentence Exercise with Nominalizations

[Students will have a copy of only the sentences (not the directions) to view on a separate piece of paper.]

A. The development of one inch of soil takes 500 years.
B. Soil is a mixture of many ingredients.
C. The interaction of many factors makes soil.
D. The formation of clouds occurs when water vapor condenses.
E. Evaporation turns water into water vapor.
F. Condensation of water vapor happens in cold air.

For every sentence, ask:

- In Sentence __, what is the action (e.g., the verb)?
    - What is doing the action?
- In Sentence __, what is the action?
    - What is doing the action?

Appendix E:
Difficult Sentences Selected by Students

Soil Sentences

Sentence	Frequency Selected	Type of Sentence
Living and once-living organisms are necessary for soil to form. [line 16]	7	Simple
Worms and bacteria living in the soil help decompose the dead material into humus. [line 19]	7	Simple
Soil formation is a process that occurs over time through the interaction of these various factors. [line 23]	4	Complex
For example, there is no soil on Mars or Venus even though those planets have plenty of rocks that are weathered by their atmospheres. [line 14]	3	Compound-complex
It is a complex mixture of ingredients that includes minerals, air, water, and organic matter. [line 4]	3	Complex
One tablespoon of soil has more organisms in it than people on Earth. [line 28]	3	Simple
Fallen leaves, dead plants, and dead animals on the ground become part of the soil. [line 18]	2	Simple
When air and water mix with humus and rock particles, soil is formed. [line 21]	2	Complex
Animals living in the ground such as insects, rodents, and snakes leave holes that fill with air and water. [line 20]	1	Complex
Another important factor in soil formation is organic matter. [line 13]	1	Simple
It takes thousands to millions of years to weather down a stony surface into tiny grains. [line 10]	1	Simple
Soil contains all the nutrients needed by plants to survive. [line 26]	1	Simple
Soil formation begins with weathering. [line 7]	1	Simple
Soil is one of the world's most important nutrients. [line 29]	1	Simple
This process is called weathering. [line 9]	1	Simple
Without soil, plants could not grow and animals would not survive. [line 26]	1	Compound

Water Cycle Sentences

Sentence	Frequency Selected	Type of Sentence
When water vapor condenses around dust particles found in the air, cloud droplets form. [line 14]	6	Complex
As water becomes warmer, its particles move more quickly and change from liquid water to water vapor, a gas. [line 7]	3	Complex
The cold air condenses the water vapor, changing it back to a liquid. [line 13]	3	Simple
This is because air becomes cooler at high altitudes. [line 12]	3	Complex
When water evaporates, the water particles rise into the air. [line 9]	3	Complex
However, as the tiny droplets combine with each other, they grow larger and eventually become too heavy to stay in the air. [line 18]	2	Complex
Runoff is an important part of the water cycle because it allows much of the water to return to the oceans, where a great deal of evaporation occurs. [line 25]	2	Compound-complex
When this happens, they fall to Earth as precipitation. [line 19]	2	Complex
As water vapor rises higher and higher into the air, it cools down. [line 12]	1	Complex
Clouds develop if there are enough cloud droplets in the atmosphere. [line 16]	1	Complex
Rain falling where you live may have been water in the ocean just days before. [Line 1]	1	Complex
Rain, snow, sleet, and hail are all types of precipitation. [line 20]	1	Simple
The change from liquid to gas is called evaporation. [line 8]	1	Simple
The movement of water from Earth's surface to the atmosphere and back again is called the water cycle. [line 3]	1	Simple
The water cycle is completed when water returns to Earth's surface through precipitation. [line 23]	1	Complex
Water enters the atmosphere mostly through evaporation. [line 6]	1	Simple

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