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The Effects Of The Vocabulary Think Chart Strategy On Seventh-grade Students' Scientific Vocabulary Knowledge: A Mixed-method Study.

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THE EFFECTS OF THE VOCABULARY THINK CHART STRATEGY ON SEVENTH-GRADE STUDENTS' SCIENTIFIC VOCABULARY KNOWLEDGE: A MIXED-METHOD STUDY

by

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ABSTRACT

This mixed-method study examined the effects of the use of the Vocabulary Think Chart in seventh-grade science students' understanding of scientific vocabulary. Participants included 89 students who attended the only three regular Earth Science classes in the study site. Participants were assigned to the treatment and comparison group according to the teachers' wish on how they wanted to participate in the study. The experimental group received one week long preparation on the use of the Vocabulary Think Chart, followed by five weeks of using the strategy independently. Results of the study did not show a significant change on students' scientific vocabulary understanding and raised questions about vocabulary instruction in science classes. Discussion of the results revolves around the Treatment Teacher's influence in the study, time of intervention, and number of participants.

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THE PROBLEM AND ITS CLARIFYING COMPONENTS

Background of the Study

For many years, the process of reading was viewed as a basic set of skills that were simply applied to different kinds of texts. In the 1990s, many states took on the challenge of improving elementary students' reading skills in the hopes that these basic reading skills would be enough to solve literacy-related tasks later in life (Blair, 1999; Carnegie Council on Advancing Adolescent Literacy, (2010) National Institute for Literacy (NIFL), 2007; Snow & Moje, 2010). At that time, the prevailing ideas were that basic reading skills would automatically evolve into more complex skills and that the basic reading skills were generalizable and adaptable.

Numerous researchers have supported the idea that basic skills do not evolve into more complex skills (Ehren, Lenz, Deshler, 2004; Kamil, 2003). This idea has been supported by data that shows that 8.7 million 4th through 12th graders struggle with reading and writing in school. Additionally, researchers have also suggested that these difficulties encountered by adolescent students in reading and writing might be linked to their decisions to drop out of school (Alliance for Excellent Education, 2004; Ehren et al., 2004). In fact, more than 3,000 students have reportedly dropped out of high school every year; and among the most cited reasons for dropping out were lack of literacy skills, and increasingly challenging curriculum (Biancarosa & Snow, 2004; Kamil, 2003).

The lack of a high school diploma did not significantly impact students' opportunities to achieve economic stability in the 1950s; however, in 2013, this did not hold true (Arc, Phillips, & McKenzie, 2000). Some of the skills related to literacy, such as critical thinking and the ability to become a lifelong learner, have been considered crucial to employers (American Management Association, 2010; Partnership for 21st Century Skills, 2009; Weiner, 2011; Zhang, Majid, & Foo, 2010). Furthermore, between one half and two thirds of new jobs have been estimated to require a college degree and higher level literacy skills (Carnavale & Deroches, 2011; Kirsch, Braun, Yamamoto, & Sum, 2007).

In reality, basic reading skills such as phonics, phonological awareness, and sight vocabulary are present in all reading tasks (Rayner & Pollatsek, 1994). However, as students progress to secondary grades, what is learned becomes less generalizable. Learning in secondary grades becomes more content-specific, technical and even specialized, and content instruction focuses more on vocabulary that is used in specific, more restrained contexts (Coyne, Kame'enui, & Carnine, 2007;Shanahan & Shanahan, 2008; Strickland & Alvermann, 2004). According to Snow and Uccelli (2004), in order to master the literacy skills necessary to read complex secondary texts, students will have to become experienced in using literacy skills such as: purposeful reading, figuring out the meaning of unfamiliar words, resolving conflicting content in different texts, and recognizing the perspective of the author. In secondary grades, students must become familiar with words such as: paradigm, rhombus, and, esoteric. These words have relatively less general applicability, especially when compared to words such as: of, is, and the. These words are found in medical books, newspapers, and many other kinds of documents (Beck, McKeown, & Kucan, 2002; Brozo, 2009).

Although certain students may have mastered basic reading skills by fourth grade, there are many other content-specific practices and reading demands that students must continue to learn (Greenleaf & Hinchman, 2009; Kosanovich, Reed, & Miller, 2010; Torgesen et al., 2007). Two reports (Biancarosa & Snow, 2004; Graham & Perin, 2007) suggested that more than 70% of students in Grades 4-12 experience severe difficulties with reading and writing in content area classes. Other similar studies also indicated that many high school students do not have the literacy skills to keep up with a high school curriculum (Alliance for Excellent Education, 2007; Kamil, 2003). Performing below grade level in reading and writing, according to the U.S. Department of Education (2003) represents an increased chance of retention and ultimately not successfully completing a high school education.

Despite the fact that many students graduate from high school, universities and businesses spend $16 million each year to remedy college students' inadequate reading and writing skills (Graham & Hebert, 2011; Greene, 2000; Stoops, 2004). According to the National Governors Association for Best Practices (2002), two-thirds of high school graduates lack the literacy skills required by employers.

Most of the adolescents who have difficulties with reading struggle with reading comprehension (Alliance for Excellent Education, 2010). For some of these struggling readers, the problem lies in not having enough fluency to facilitate comprehension; others struggle due to a lack of strategies that might help them comprehend what they read. Finally, there are those secondary, struggling readers who might be unable to apply different comprehension strategies to different classroom tasks due to limited amount of experience using them (Alliance for Excellent Education, 2010). Vocabulary learning is among the specific struggles secondary students face with literacy.

There also exists a significant body of work showing the importance of academic knowledge for accessing the content of academic texts and academic talk (Bailey & Heritage, 2008; Guerrero, 2004; Schleppegrell, 2004). The lack of vocabulary knowledge has consistently been identified as an obstacle to student success (Kamil et al., 2008; Snow & Kim, 2007; Torgesen et al., 2007). Further, academic vocabulary has been noted as one of the many factors, e.g., complex text structures, abstract concepts, and multisyllabic words that present decoding challenges, associated with reading difficulties faced by secondary students (Abadiano & Turner, 2002; Baxter & Reddy, 2007; Lenski, Wham, Johns, & Caskey, 2007; Saenz & Funchs, 2002; Vaughn & Bos, 2009). For many years, researchers have explored the association between vocabulary and comprehension (Bryant, Goodwin, Bryant, & Higgins, 2003; Cromley & Azevedo, 2007; NIFL, 2007). For instance, the report of the National Reading Panel (2000) highlighted that it is virtually impossible to comprehend text without understanding the meaning of the majority of words, and this relationship increases as students progress between grades. Because of the strong connection between vocabulary and comprehension, students not only need to know how to derive the meaning of new vocabulary but also how this vocabulary is situated into the larger content it represents (Hairrell, Simmons, & Rupley, 2011). Thus, when the complexity of text outpaces students' academic vocabulary knowledge, content knowledge is severely compromised.

Secondary Student Low Performance

Secondary students' low performance of adolescent students in standardized reading assessments further supports the need for continual literacy instruction to adolescent learners. Since the 1990's literacy experts have shed light on the high number of adolescent students who struggle with reading. According to the 1994 National Assessment for Educational Progress (NAEP) results, the average reading scores of 12th graders declined since 1992; and significant changes in the average proficiency were not noticed in the fourth- and eighth-grade populations. Furthermore, only 30% of fourth graders, 30% of eighth graders, and 36% of 12th graders scored at the proficiency level in reading (NAEP, 1994). In summary, the 1994 NAEP scores showed a significant decline in reading scores across the nation. Similarly, no significant changes occurred in students' NAEP scores in 1998. Based on these scores, 70% of adolescents entering ninth grade, and 60% of 12th graders can be considered reading below grade level (Loomis & Bourque, 2001; NAEP, 1998). In the same decade, the U. S. Department of Education charged the Reading Study Group (RAND) with developing a research agenda based on the most pressing issues in literacy (RAND, 1999). These issues included: (a) lower performance of U.S. students than in other countries, (b) gaps in reading performance between different demographic groups; and (c) an increasing need for higher literacy skills.

Similarly, a long-term examination of the NAEP results (1971-2004) shows that the reading scores of adolescents have remained stagnant (Ramsey et al., 2009). Based on the 2007 NAEP (2007) results, students have continued to score poorly in reading.

Only 34% of eighth graders and 20% of 12th graders performed at "proficient" levels (Salahu-Din, Persky, & Miller, 2008). It has been only recently that schools have begun to recognize that gains in early grades might not be transferred into secondary grades (Alliance for Excellence in Education, 2007; Lutkus, Rampey, & Donahue, 2006; Martin, Mullis, Gonzalez, & Kennedy, 2003).

The future does not seem much brighter for those students who graduate high school in the U.S. Results of the college placement test, American College Testing (ACT) (2009) show only about half of all students have the necessary literacy skills to comprehend college level textbooks (Moje & Tysvaer, 2010). Furthermore, in a longitudinal study conducted by ACT, it was concluded there has been a decline of literacy skills among college-bound secondary students (ACT, 2009). Participants in the same study, scored higher in literacy skills in eighth and in 10th grades than they did in 12th grade (ACT, 2006).

When American adolescents' reading scores are compared to other countries, the results are alarming. According to the UNESCO (2003, 2007) most recent scores, American students underperform once they reach grade eight. In more specific terms, in tenth grade, students score among the lowest in the world (Carnegie Council on Advancing Adolescent Literacy, 2010).

Low reading marks or how reading comprehension impacts science content reading, are not the only reasons why adolescents struggle with reading. The development of the Common Core State Standards (CCSS) has highlighted the advanced practices students need to master in order to acquire the advanced literacy skills for success in college, career and workforce (Marchand-Martella, Martella, Modderman, Peterson, & Pan, 2013). Since its debut in 2010, the CCSS has highlighted the specific standards for literacy such as: comprehension, creating texts, drama, fluency, listening, phonemic awareness, phonics, speaking, vocabulary, and writing. The purpose of the standards is to ensure that all students are proficient language users as they graduate from high school and move on to pursue their own interests (Cassidy & Ortlib, 2012).

In more specific terms, in order for students to master the skills described in the CCSS, teachers should not assume that students arrive at the classroom with the necessary skills to learn from nonfiction text (Guthrie & Klauda, 2012). In secondary science classrooms, for example, the use of different strategies to grapple with the text is crucial for text comprehension (Harvey & Goudvis, 2005; Stephens & Brown, 2000; Moehlman, 2013), as the CCSS places an increased complexity of text understanding on students. Among the English Language Standards for Science and Technical Subjects (2010), some standards stand out as they relate to science and vocabulary learning:

> (a) CCSS.ELA-Literacy.RST 6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics; and based on the established connection between vocabulary understanding and text comprehension; (b) CSS.ELA-Literacy.RST 6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently (National Governors Association & Council of Chief State School Officers [NGA & CCSSO], 2010).

The perspective that basic reading skills do not aid students in comprehending more complex texts also negatively impacts students' learning in content area classes. Often, many secondary content area teachers focus on generalizable strategies with the understanding that reading comprehension is an outcome of the use of generic strategies (Bean & O'Brien, 2012; Lee & Spratley, 2010; Zygouris-Coe, 2012). However, each content area class poses specialized challenges. This is the case in science classes due to the high amount of technical vocabulary; the use of figures, tables, and diagrams; and also because of the level of mathematical literacy required to understand these tables and figures (Boyd, Sullivan, Popp, & Hughes, 2012; Grant & Lapp, 2011; Lee & Spratley, 2010;). Thus, more generalizable strategies such as making comparisons, finding the main idea, and describing the central problem (Faggella-Luby, Graner, Deshler, Drew, 2012; Lee, Grigg, & Donahue, 2007) might not adequately prepare students to meet the literacy and content demands of secondary science texts.

In a most recent report completed by ACT on 11^{th}- grade students' performance relative to CCSS clusters, findings suggested that only 31% of students understood complex texts used in content area classes (ACT, 2011). This was especially true in science classes, where only 24% of students were able to comprehend science-related complex text that would make them ready for college and careers (ACT, 2011). Thus, to increase students' comprehension capacities, in content area classes, states need to prepare content area teachers with the ability to integrate reading instruction within content area instruction (ACT, 2011).

Science students' scores in other standardized tests have also shown no significant increase (NAEP, 2011). According to NAEP (2009), the average eighth-grade scores in science increased by only two points since 2009. Furthermore, there was no change in the percentage of students who performed at the Advanced level since 2009. NAEP's science test assesses students' knowledge and abilities in the areas of physical science, life science, and earth science.

Internationally, average scores of eighth-grade students in science are not impressive either (Trends in Mathematics and Science Study [TIMSS], 2011). Although in fourth grade, U.S. science students are ranked among the top 10 education systems in science, when they reach eighth grade, their ranking plummets. U.S. eighth graders, ranked 23rd among the top education systems in science. Furthermore, there was no measurable difference in the science scores eighth grade U.S. students since 2007 (TIMSS, 2011). The Program of International Assessment (PISA) reported similar science scores (2009). PISA describes six levels of science literacy proficiency ranging from level 1 to level 6, the most advanced. Only 29% of 15-year-olds in the U.S. scored at or above level 4 on the science literacy scale (PISA, 2009). Furthermore, 18% of U.S. students scored at or above level 2 on the same assessment (PISA, 2009). Although U.S. students' average score was lower than the average score of the other 64 countries in the report, there was no difference between the U.S. scores and those of other countries' in 2009.

Due to the aforementioned reasons, which include improving adolescents' reading comprehension scores, college and career readiness through CCSS, and the current scores of students in science assessments, it is undeniable that adolescent students in science classes would benefit from discipline-related literacy instruction (ACT, 2009; Heller & Greenleaf, 2007; Moje & Tysvaer, 2010; NAEP, 2009).

Problem Statement

The national concern for improving adolescent literacy originated primarily from two reports released in the 1980s. In a *Nation at Risk* (National Commission on Excellence in Education [NCEE], 1983), evidence was presented concerning the alarming situation of adolescents' reading abilities. According to the report (NCEE, 1983), "About 13 % of all 17-year-olds in the United States could be considered functionally illiterate" (p. 11), and "functional literacy among minority may run as high as 40 percent" (p. 11). Additionally, the report suggested that the average achievement scores of adolescents on most standardized tests were lower in the 1980s than they had been in the 1950s.

In light of the low average achievement of adolescent students, the commission recommended five basic academic skills students needed to have to graduate from high school: four courses in English, three courses in mathematics, three in science, three in social studies, and half a credit in computer science (*Education Week*, 2013). Although these recommended changes strongly influence educational leaders and policymakers, the report suffered harsh criticism for lack of attention to K-8 education, low sources of data statistics, and a failure to identify the source of educational problems.

In more recent analyses of the results, not much was found to have changed. For instance, the high school graduation rate in the 1970s was about 77%. In 2009, the high school graduation rate was about 72% (*Education Week*, 2013). Similarly, in 1983, only 39% of the US public had a “great deal” or “quite a lot” of confidence in public schools. The same question posed in 2012 resulted in only 29% of the respondents reporting confidence in public schools (*Education Week*, 2013).

. In 1985, another report providing information on the literacy crisis in the nation was released. The *Report Card* (NAEP, 1985) emphatically confirmed the earlier findings by the National Commission on Excellence in Education. Among different concerns in literacy education, the *Report Card*, suggested that 13- and 17-year-old students had either flat-lined or had not significantly improved their scores in most standardized tests since 1971. These two studies led to numerous studies that explored literacy in secondary grades and the infusion of literacy into content-area subjects (Herber, 1970; International Reading Association & National Middle School Association, 2001; Moje, 2008; O’Brien, Moje, & Stewart, 2001; O’Brien, Stewart, & Moje, 1995; Shanahan & Shanahan, 2008).

Traditionally, studies that explored the infusion of literacy into content-area classes stand on the notion that generalizable reading strategies do not facilitate reading comprehension (Moje, 2002, 2008; Moje, Overby, Tysvaer, & Morris, 2008; Ratekin, Simpson, Alveramann, & Dishner, 1985). In other words, complex texts in secondary content area classes draw from relationships particular to each subject (Moje & Speyer, 2008). Thus, to avoid the use of generalizable reading strategies, science teachers should attempt to bridge the activities of practicing scientists into the science inquiry process (Hall & Turow, 2006), to model scientific thinking to students. Others have attempted to develop questions and carry out scientific investigations (Krajcik, Blumenfeld, Marx, Bass, Frederick, & Solloway, 1998). Although these practices attempted to mirror the work of scientists, these practices are not focused in text reading and do not make explicit the necessary knowledge and skills students must possess to understand science-related secondary texts (Moje & Speyer, 2008).

This study attempted to address the need for more discipline-specific strategies in secondary science classes through the use of the Vocabulary Think Chart (VTC) (Fang, Lamme, Pringle, 2010, 2005; Fang, 2006; Freeman & Taylor, 2006). The VTC (Appendix A) is a vocabulary strategy designed to build students' vocabulary knowledge in secondary science classrooms. In addition to supporting struggling adolescent readers, a common occurrence in secondary classrooms (ACT, 2009; Carnegie Council on Advancing Adolescent Literacy, 2010; Moje & Speyer, 2008), the VTC supports the relationship between vocabulary knowledge and reading comprehension (Stahl & Nagy, 2006). The average vocabulary of high school students has been estimated at 40,000 words; however, struggling readers can be thousands of words behind this estimate (Flanigan, Hayes, Templeton, Bear, Invernizzi, Johnston, 2011; Stahl & Nagy, 2006). This gap has a strong potential to negatively impact students' comprehension of technical vocabulary-dense subjects, such as science (Berninger, Abbott, Nagy, & Carlisle, 2010). Thus, the VTC can be used as an instructional tool to facilitate bridging the vocabulary gap in science classes through the focus on content-related vocabulary words in a discipline-specific manner.

Purpose of the Study

Adolescent readers usually encounter content area texts that are composed of patterns and languages that differ significantly from everyday language (Schleppegrell, 2004). Scientists can spend almost two thirds of their time reading. They view reading as an essential part of their practice and as a primary source of creative stimulation (Tenopir & King, 2004). If scientists spend so much time reading and carefully analyzing text and data, what should be happening in science classes? Instructional practices associated with this theory include the explicit teaching of content area vocabulary and other grammatical and discursive patterns in the context of challenging content area texts (Fang, 2012). Several researchers have argued that secondary students need to develop the ability to deal with a more sophisticated type of language in order for them to be able to engage in the educational knowledge at this level, e.g., Moje and Speyer, 2008; Moore, Bean, Birdyshaw, and Rycik, 1999; Shanahan & Shanahan, 2008.

Although the call for integration of literacy instruction in science classes has resonated for many years (Norris & Phillips, 2003; O'Brien et al., 1995; Peacock & Weedon, 2002), most studies have focused on elementary grades (Guthrie, Wigfield, & VonSeeker, 2000; Hapgood & Palincsar, 2007; Lee, 2004; Morrow, Pressley, Smith, & Smith, 1997; Norris et al., 2008; Yore, Pimm, & Taum, 2007) rather than on the secondary grades. In the case of secondary studies, literacy and science education are often explored from the science teachers' perspectives. In other words, most researchers have explored the topic based on the legendary statement of teachers "I assign reading, I do not teach it." (Wellington & Osborne, 2011).

Although many teachers have assumed that secondary science students do not need literacy instruction, survey results have revealed a different perspective (Norris & Phillips, 1994, 2003; Penney, Norris, Phillips, & Clarke, 2003). These surveys have shown that although high school seniors and undergraduates comprehend observation statements and predictions when they read science, they still struggle with several other reading skills. Some of these weaknesses include: confusions between causal and correlation statements; confusions between descriptions of phenomenon and explanations of them. Most importantly, when the readings require readers to make connections among different parts of the texts, participants have often struggled significantly more (Norris et al., 2008).

Other major studies have been conducted to explore literacy and science education based on the premise that the kind of reading instruction that occurs in classrooms is not complex enough to mirror the type of reading scientists must use (Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006; Kesidou & Roseman, 2002; Rowell & Ebbers, 2004). According to these studies, the complex activities, e.g., observations and scientific inquiry, conducted by scientists require higher literacy levels than those required for simply locating information.

Given the complexities of the literacy skills necessary for success in 21st century secondary science classes, the present research was conducted to investigate a vocabulary strategy different from the traditional view of literacy in secondary classes. In reviewing the literature, the researcher noted a need for more studies in the secondary setting that require students to return to what scientists do when they read (Capraro & Slough, 2009).

In summary, there is a need for more studies that evaluate the impact of discipline-specific strategies in science classes (Freeman & Taylor, 2006; Guzzetti & Bang, 2011; Hand et al., 2003).

Theoretical Framework

This study was supported by three educational theories. They were: (a) schema theory of learning, (b) depth of knowledge theory, and (c) zone of proximal development theory.

Schema

Schema theory (Anderson & Pearson, 1984) argues that for comprehension to occur, a reader must bring something to the reading process. The concept that students bring something to the reading process has been named by cognitive psychologists as schema (Anderson & Hite, 2010). Schemas, according to these authors, are a system of structures present in one's memory; they are abstract representations of experiences and knowledge one carries (Harris & Hodges, 1995). Thus, for students to fully comprehend texts, they must make connections between their prior knowledge (schemas) to new knowledge. This notion transforms reading from a passive activity to an active activity, in which the reader constructs knowledge through these connections (Anderson & Pearson, 1984; Anderson, Spiro, & Anderson, 1984).

The downside of the assumption that reading is an active process in which students bring prior knowledge to the process is that a significant number of students do not have prior knowledge (Jenkins & Dixon, 1983; Little & Box, 2011). Thus, because students lack the prior knowledge and technical vocabulary, the reading process becomes a very difficult exercise. Simply said, a large proportion of students' academic difficulties can be traced to their lack of background knowledge (Burns, Roe, & Ross, 1999; Little & Box, 2011).

To remediate this situation, students need to have access to strategies that help students make schemata and connections. Because prior knowledge is essential to the comprehension of complex texts, this process must assist them in building prior knowledge or reminding them of the knowledge they already know. Thus, through the use of the VTC, secondary science teachers were able to give students the necessary assistance to make new connections by reminding them of the knowledge they already had and connecting them with new knowledge.

The complexity of the transfer between the knowledge students already have and the new knowledge students acquire is a process that requires a deep engagement between students and the new material. This type of engagement is likely to allow students to make a deeper connection with the new material, rather than simply memorizing the material for an exam.

Depth of Level Theory

The depth of level theory was first formalized by Craik and Lockhart (1972). This theory posited that the more cognitive energy individuals exert when manipulating and thinking about a concept, the more likely they are to remember that word and be able to use it later.

This theoretical framework has been applied to many impactful studies on vocabulary instruction. For example, in Stahl and Fairbanks (1987), depth of level theory was applied to explain how the activities used to teach new vocabulary words might impact students' retention. In studies of lists of words, participants who engaged with the words in a deeper level retained that information better than students who engaged with the words in a more "shallow" manner (Stahl & Fairbanks, 1987). Deeper levels of engagement, according to the authors, meant using activities such as semantic analysis that require more processing from students. Similarly, Anderson and Reder (1979) argued that students learned new concepts more effectively if they were given the opportunity to make the greatest number of connections with already known information or by being given the most elaborate forms of processing.

The basic principle of depth of processing theory has often been used in studies looking at list learning. However, several reading experts have posited that this theory is also applicable in new vocabulary instruction (Stratton & Nacke, 1974). Stahl (1999) suggested a depth of processing scale for vocabulary instruction, which included three principles: (a) association; (b) comprehension; and (c) sentence generation.

In the association principle, a child learns an association between a new word and either a definition or a single context word. In comprehension, children show that they have learned a new word by engaging in activities such as finding an antonym, classifying words, or showing understanding of the word in a sentence. In the generative principle, children are required to create a novel response, such as a sentence, using the new word. Generative processing seems to involve more cognitive skills because it is a more active process (Slamecka & Graf, 1978).

This theoretical framework was applicable to this study because it supports the individual vocabulary strategies compiled in the VTC (Fang et al., 2010). In more specific terms, the VTC requires from students a deeper engagement with new scientific words through morphemic analysis, semantic analysis, word classification, and sentence generation. Thus, when students complete these interventions, they are more likely to retain the word than if they had engaged with the word in a more shallow way, such as by writing word definitions.

To create the most appropriate classroom environment for students to develop a deep connection to the new vocabulary, students need to receive support from teachers. The support from teachers to learn can be in the form of guided practice or critical feedback.

Zone of Proximal Development

The zone of proximal development emerged from Vygotsky's (1978) theoretical work on socio-cultural theory. This theoretical framework has been used to explain the distance between students' developmental level and their potential level. In order to facilitate this process, according to Vygotsky, teachers should use scaffolding. In this process, the teacher supports students through activities that they would be unable to complete independently. As students become experts in certain activities, the support from teachers can be gradually removed. The value in using scaffolding is two-fold: students are provided with expert guidance in varying degrees and teacher support eventually becomes unnecessary (Pearson & Fielding, 1991).

For example, students often arrive at classrooms with varying degrees of expertise in science (Moje et al., 2008). Most students bring different levels of basic reading skills, personal knowledge of the natural world, and curiosity; and all these components influence their learning of the subject's content. However, an effective teacher capitalizes on these differences by being sensitive to the content, to students' differences, and to ensuring that learning occurs regardless of these differences. In a field of different expertise, teachers must scaffold activities according their audience (Slough & Ripley, 2010). In more specific terms, because vocabulary knowledge is pivotal to the understanding of content-related secondary texts (Baumann, Edwards, Boland, Olejinik, & Kame'enui, 2003; Cromley & Azevedo, 2007; Graves, 2000), students who do not have a comprehensive vocabulary knowledge will struggle with several comprehension gaps (Biemiller, 2004 Chall & Jacobs, 2003). These students will need a great number of strategies to scaffold these needs (Slough & Ripley, 2001). Such strategies must provide students with the appropriate level of difficulty, be accomplished with a variety of materials, and be characterized by an interactive teaching style (Slavin, Cheung, Groff, & Lake, 2008; Slavin, Lake, & Groff, & Lake, 2007).

The framework of the zone of proximal development is also often applied in the context of secondary science and to support scaffolding. For example, when teachers are using the Gradual Release of Responsibility (GRR) (Pearson & Gallagher, 1983), they are also relying on Vygotsky's theory (1962, 1978). Within this framework, students have the opportunity to receive assistance during guided practice as the teacher models how to complete a strategy. This framework had the potential to better assist the participants in the study, because most of the students had limited experience with the VTC, and may have struggled with literacy skills in science that required knowledge of scientific vocabulary for critical thinking about science.

Research Question

To what extent does the use of VTC impact seventh-grade science students' conceptual understanding of scientific vocabulary?

In 2004, Biancarosa and Snow reported that eight million secondary students struggled academically because they lacked the literacy skills to succeed in secondary content area classes. Secondary textbooks often present students with challenges associated with reading such as technical vocabulary, complex text structures, abstract concepts, and multisyllabic words (Armbruster & Anderson, 1988; Baxter & Reddy, 2007; Harmon, Hedrick, & Hedrick, 2005). Among these possible difficulties lies the challenge presented by discipline-specific vocabulary. For years, specialists have explored the association between vocabulary and comprehension. The National Reading Panel, in its 2000 report, for instance, noted that it is virtually impossible to comprehend text without understanding the meaning of majority of words. By learning how to use the VTC, it was anticipated that students would increase their knowledge about the relationship of scientific vocabulary with the decoding of multisyllabic words. Thus, this research was based on the needs of struggling secondary students.

Research Design

This study used a mixed-method research design. This type of research integrates quantitative and qualitative approaches by essentially integrating both types of data in one study (Gay et al., 2006). More specifically, an explanatory sequential mixed design was used. This type of design includes collecting quantitative data and explaining quantitative results with in-depth qualitative data. The two types of data were collected simultaneously. The quantitative data was collected in the form of a pre- and posttest, and the qualitative data was collected in the form of impartial observers' field notes, researcher's field notes, and classroom artifacts. The reason for embedding the qualitative collection of data during the study's intervention was to understand the impact of the use of the VTC on participants' vocabulary and understanding of scientific vocabulary. The impact was anticipated to include factors that acted as barriers and others that acted as facilitators of students' vocabulary development in the participating science classes (Creswell & Plano, 2011).

This research design was appropriate for this study for the following three reasons. First, the VTC is a very complex and multilayered vocabulary instructional tool; thus, qualitative data on how the classroom teacher taught the chart to the students might paint a more accurate picture of the students' pre-and posttest scores. Second, because of the VTC's complexity, qualitative data on how well students understood how to use the chart and how engaged they were with learning science vocabulary, including challenges they encountered with its use, might further support their pre-and posttest scores. Third, the short treatment period might not be sufficient for showing any significant difference in students' pre- and posttest scores; thus, the qualitative data acquired through the participants' charts might show improvement in students' understanding of scientific vocabulary.

Study participants came from a convenience sample obtained from a seventh-grade Earth Science class at a middle school in southeast Florida. According to the Florida Comprehensive Assessment Test [FCAT] (2011) reading scores, 86% of seventh graders achieved a level three or above. Furthermore, 30% of students were in free and reduced lunch (Florida Department of Education, 2011). This school site was selected because of its proximity to the researcher and the willingness of the school principal to allow this research to occur. Other middle schools in the same county did not have teachers or principals who were willing to participate in the study. Unlike the specific requirements to join more advanced science classes, there were no specific prerequisites to register for the Earth Science class. Participants in the study were divided into two groups, treatment and control, and both groups completed the same pre-and posttests. Participants were tested on their understanding of discipline-related technical terms taught in the Earth Science class. This study utilized only one source of quantitative data which was collected at the end of the treatment period (six weeks). This study utilized two sources of qualitative data. The first source consisted of the observations conducted by the researcher and two impartial observers during the treatment phase. The second source of qualitative data was the actual use of the VTCs by students in their science classroom. The findings of this study had the potential to support the findings of comparable studies conducted with similar participants on this topic. The two teachers who participated in this study also comprised a convenience sample. They were willing to participate in the study and were the only two teachers who taught regular seventh-grade classes at the school site.

Assumptions

1. No participants in the study had any prior experience with the VTC.
2. Based on their latest Florida Comprehensive Assessment Test (FCAT) reading scores, participants in the study had similar reading and vocabulary levels.
3. Treatment Teacher's knowledge of the different layers of the VTC.
4. Treatment Teacher's ability to teach the VTC.

Limitations and Delimitations

There were several characteristics of the study that may impact or influence the application or interpretation of its results:

1. A convenience sample was used. Because participants were drawn from an existing Earth Science class, they were not randomly selected or assigned to classes.
2. The FCAT (Florida Department of Education, 2012) reading scores from spring 2012 were used to measure students' reading ability.

3. The sample size was limited. Because the researcher had only four regular science classes available, 54 students were in the comparison group and 37 students were in the experimental group.
4. The study results are generalizable only to similar seventh-grade science classes. This limitation was also extended to studies that explored the impact of vocabulary instruction as it is infused into science curriculum and materials.
5. The assessment used in the study was not a standardized test. The assessment had instructional and content validity only.
6. This was a mixed-method study and not a true experiment. The comparison and treatment groups were not randomly assigned; participants were not randomly assigned to each group because they were drawn from the respective classes established at the beginning of the school year.
7. The study had one source of quantitative data. This is a limitation because only one source of data (the VTC strategy) was not sufficient to represent an actual change in students' learning of scientific vocabulary.
8. The researcher and two impartial observers observed the treatment group to collect qualitative data. Impartial observers also posed limitations.
9. The researcher collected qualitative data during the study's intervention. Researcher bias was also a limitation.

10. The Vocabulary Think Chart (VTC) had never been used in a study before. That represents a limitation because there were no prior data to compare with that obtained in the present study.
11. The Treatment Teacher also represented a limitation. There were some inconsistencies in the teacher training sessions, the instruction, and implementation of the VTC with the participants of the study.

Significance of the Study

The significance of this study lies in the possibility of aiding adolescent students who struggle with reading and learning science vocabulary in seventh grade science general classes (Deshler et al., 2008; Roberts, Torgesen, Boardman, & Scammacca, 2008; Townsend, Filippini, Collins, & Biancarosa, 2012). One of the reasons adolescents struggle with reading and comprehension in content area classes is because of the increasingly complex and discipline-specific language of science textbooks. Thus, the researcher in this study attempted to help close the academic achievement gap of adolescents by empirically examining the use of the VTC in participating seventh-grade students' learning of scientific vocabulary.

There are individual differences as to why students struggle with academic words. Achieving and above-grade-level students usually read more than struggling readers. That might facilitate the process of learning new academic words which are most often found in written form rather than in oral form. However, struggling students often tend to be less prolific readers and have fewer exposures to academic words. Thus, these students might possess fewer skills necessary to infer the meaning of academic words during reading (Townsend et al., 2012). This is true even for students who do not present any reading disabilities, because limited exposure to academic texts might result in reading comprehension difficulties for students from low-socio-economic status and/or language minority students (Zwiers, 2007).

This study is significant because the VTC employs a secondary vocabulary instruction approach that marries morphemic and contextual analysis (Blachowicz & Fischer, 2002; Dale & O'Rourke, 1976). These two aspects of vocabulary instruction can be effective because they have the power to teach students how to determine word meaning by analyzing word parts and by exploring the syntactic and semantic environment that surrounds unfamiliar words (Graves, 1986; Nagy & Anderson, 1984). Thus, in the current study, the researcher examined the possible impact of short-term use of the VTC on seventh-grade Earth Science students' understanding of scientific vocabulary.

Definition of Key Terms

Academic English. According to Bailey (2007), competency in academic English includes the ability to use general and content-specific vocabulary, specialized or complex grammatical structures, and multifarious language functions and discourse structures, all for the purpose of acquiring new knowledge and skills, interacting about a topic, or imparting information with other (pp. 10-11).

Academic Vocabulary. Academic words can be discipline-specific or interdisciplinary in their use. According to Beck et al. (2002), they are usually in one discipline, and have technical meanings. For instance, some discipline-specific words include anti-oxidant, rhombus, and metonymy. Academic words are often abstractions that enable communication of ideas about social and natural phenomenon that are not easily expressed in everyday language (Schleppegrell, 2004).

Comprehension. Reading comprehension is a process that includes a construction of a global mental model that integrates all the sentences in a coherent overall interpretation (Nation & Snowling, 1999; Perfetti, Landi, & Oakhill, 2005).

Content Area. Content area is a term used to define the subjects taught in school. Usually, 10 content area classes are found in K-12 school curriculums: the arts, civics, English/language arts, geography, history, mathematics, science, skills for life, technology, and world languages (McKennna & Robinson, 1990).

Conceptual Understanding in Science. Conceptual understanding is a major part of vocabulary knowledge in secondary content area classes. According to Nieswandt (2007), conceptual knowledge in science is composed of declarative knowledge, procedural knowledge, and conditional knowledge. In the context of this study, the researcher explored conceptual understanding in the declarative knowledge sense. In other words, declarative knowledge deals with specific knowledge of which one is consciously aware (Anderson, 1995). Having declarative knowledge of a term involves linking new knowledge to existing knowledge, organizing acquired knowledge in a way, and elaborating knowledge in a way to make it meaningful for learners (Smith & Ragan, 1993).

Conceptual Sorting. This is a language-based activity that promotes vocabulary understanding in science and other subject area classes (Fang et al., 2010). While using this activity, students are required to identify common properties among core concepts. Thus, given a list of words, students are required to identify the meaning and features of each word and sort the words into distinct categories with words in each category sharing similar features. This activity can be used to assess students' prior knowledge or after a unit to assess their learning (Fang et al., 2010). For the purpose of this study, conceptual sorting was used after reading. Students were asked to identify other words that belonged to the same category of the target word, and to identify the overarching concept for these words.

Disciplinary Literacy. This is a recent term to define an emphasis on the knowledge and skills used by those who create, communicate, and use knowledge within each discipline (Shanahan, 2008; Zygouris-Coe, 2012). The development of this term was supported by reports and studies that showed evidence that each discipline has different purposes, differences in how experts structure their discourse, use their vocabulary, and make grammatical choices (Fang & Schleppegrell, 2008; Halliday & Martin, 1993; Herber, 1970).

Etymology. This term involves the study of word origins and the way which their meanings have changed through history (Merriam-Webster, 2012). In terms of reading comprehension, it might be beneficial to teach students how to break down words and tap into the deep-rooted system of meanings, which compose many of the English words (Graves, 2006; NGA & CCSSO, 2010; Stahl & Nagy, 2006).

Explicit Instruction. This term defines a teaching framework in which the teacher demonstrates a new skill, affords frequent opportunities for student independent practice coupled with specific feedback on students' errors that are particularly important for the students' understanding of a specific skill (Shaywitz, Morris, & Shaywitz, 2008; Stevens, Fanning, Coch, Sanders, Neville, 2008; Temple et al., 2003).

By using this framework, the teacher makes it clear to students what they are learning, and what it looks and sounds when they accomplished. Although teacher demonstrations are important in explicit instruction, the independent practice portion of this framework is beneficial for students gaining mastery of vocabulary, newly learned skills, and concepts (Fields, 2005; Swanson & O'Connor, 2009). In terms of teaching reading, explicit instruction requires students to move beyond a "content approach" to consider a targeted mental process (McKeown, Beck, & Blake, 2009).

Gradual Release of Responsibility (GRR). This framework was rooted on the work of Piaget (1952), Vygotsky (1962, 1978) and Bandura (1965), since it integrates research-based concepts related to cognitive structures and schema, the zone of proximal development, attention, retention, and scaffolding (Grant, Lapp, Fisher, Johnson, & Frey, 2012). The most effective part of this model is that it allows it for a systemic shift of the responsibility from the teacher to the student. In this model, explicit learning plays a significant role, as it is the teacher's opportunity to model a certain skill or behavior (Ross & Frey, 2009). While using this framework, the learner takes the lead as the teacher takes over when the student finds a difficult spot (Pearson & Gallagher, 1983; Ross & Frey, 2009).

Morphemic Analysis. Morphemic analysis, also known as structural analysis, consists of deriving the meaning of a word by examining its meaningful parts: roots, prefixes and suffixes (Baumann & Kame'enui, 2004). Often, instruction of morphemic analysis involves teaching students how to: (a) dissemble words into roots and affixes; (b) acquire the meaning of roots and affixes; and (c) reassemble the meaningful parts to derive meaning (Baumann & Kame'enui, 2004; Fang et al., 2010). Despite the significance of morphemic analysis for the learning of technical vocabulary in science classes, the study of affixes, suffixes and root words are rarely given attention.

Paraphrasing. This is an effective technique for the active process of reading comprehension (Best, Rowe, Ozuru, & McNamara, 2005; Rosenshine & Meister, 1994). The process includes surface characteristics of a sentence by replacing the content words or syntactic structure of a sentence with similar forms. As used in this study, paraphrasing could aid students in handling the very specialized language used in science textbooks. Through this process, students could become more knowledgeable of the particular functions language plays in science learning and more skillful in communicating their knowledge in a scientific context.

Sentence Generation. Also known as "given word sentence" (Fearn & Farnan, 2001). This type of activity is often used to consolidate word knowledge (Frey & Fisher, 2007). Historically, researchers have identified the generation of original sentences with a target word as involving more mental activity than simply memorization of definitions, because it requires students to actively use word knowledge (Anderson & Armbruster, 1982; Slamecka & Graf, 1978; Stahl, 1985). In more recent studies on secondary vocabulary instruction, sentence generation has been shown to be more effective when used in connection with semantically oriented activities (Vitale & Romance, 2007). In these studies, the teacher accepted students having generated new sentences with the target word or with semantically similar words. However, in the VTC, students are required to use the target word to generate a new sentence.

Technical Vocabulary. Technical terms are often used in science classes to convey the specialized knowledge of science (Fang, 2006). Through the use of these words, scientists are able to "construct classes and categories, and establish taxonomic relationships among entities in the natural word" (p. 464). Technical terms found in science textbooks often are multi-morphemic, and they are usually set in bold face in science textbooks. Additionally, they might also be indexed or defined in appended glossaries.

Vocabulary Think Chart (VTC). VTC is composed of six questions about a specific science technical term and is often used to assist secondary students in discipline-related vocabulary building (Fang et al., 2010). The background, development, and characteristics of the chart are detailed as part of the literature review conducted for this study.

Organization of the Study

This chapter was organized to present an overview of the problem and purpose of the study, the theoretical framework, the population, and the research question, which guided the study. Also included in the chapter were assumptions, delimitations and limitations, definitions, and the significance of the study. Chapter 2 contains a review of related literature and Chapter 3 presents the methods and procedures used to conduct the study. Chapter 4 contains the results of the study, and Chapter 5 presents an analysis of the study results, including a detailed discussion of study's limitations, and commendations for future educators.

CHAPTER 2
LITERARTURE REVIEW

Introduction

This chapter presents a review of related literature focused on the short-term use of the VTC in aiding seventh-grade students' conceptual understanding of technical terms. It includes a review of studies addressing the following topics: (a) the current state of adolescent literacy learning, (b) the current state of secondary science learning in the United States, (c) vocabulary instruction in secondary grades, (d) subject-specific vocabulary instruction in the secondary grades, (e) the possible association of a vocabulary instructional strategy with student motivation and engagement; and (f) the VTC strategy for teaching and learning scientific vocabulary. Research on the use of the VTC is presented in the following categories: (a) studies on the use of morphemic analysis to teach academic words; (b) studies on conceptual understanding, in a science classroom context, as measured by paraphrasing; and (c) studies on conceptual understanding, in a science classroom context, as measured by the knowledge of relationship among semantically similar academic words. A brief summary will follow each of the VTC categories of study. This research study was supported by the following theoretical underpinnings: (a) schema, (b) depth of process theory, and (c) zone of proximal development.

State of Adolescent Literacy Learning in the United States

Reading is a key ability for academic success, and the latest advancements in technology and communication require a higher level of literacy in the 21st century than in prior centuries. Thus, American youth has been required to have far more advanced literacy skills than ever before (Biancarosa & Snow, 2006; Carnegie Council on Advancing Adolescent Literacy, 2010; Deshler et al., 2007; Flanigan et al., 2012). The rising correlation between education and income is evidence of the increased requirements in the work place (Arc et al., 2000; Barton & Jenkins, 1995). Though a generation ago, according to Shanahan & Shanahan (2008), jobs in factories, foundries, and mills commonly required no reading skills, this has changed. The goal in improving adolescent literacy has also changed. It should not only include improving graduation rates of students from slightly improved schools. It needs to envision what improvements will be necessary to prepare for tomorrow's challenges (NGA & CCSSO, 2010). Furthermore, advanced literacy skills have become a requirement for health maintenance, avoidance of the criminal justice system, and social civic involvement, which might include voting (American College Testing, 2006; Berkman et al., 2004).

Although high literacy skills have received preeminent attention, the situation of adolescent literacy in the United States in the 21st century has been worrisome. Data from the 2007 NAEP showed that 69% of eighth-grade students fell below the proficient level in their ability to comprehend the meaning of text at their ability level (Lee et al., 2007). According to 2003 NCES data, there were eight million struggling readers in Grades 4-12 in schools across the nation. The low literacy scores have remained especially consistent among 13- and 17-year-olds, whose scores have remained stagnant since 1990s (Rampey et al., 2009). This awareness has obligated school systems to deal with the reality that early performance in reading achievement does not automatically transfer through middle grades (Alliance for Excellent Education, 2007; Lutkus et al., 2006; Martin et al., 2003).

At the time of the present study, the low levels of literacy involving adolescents and literacy were also present in Florida. According to 2009 NCES data, the average reading scores of 12th graders in Florida were lower than the average reading scores of the rest of the nation. Furthermore, the percentage of students who performed at or above the NAEP proficient level was significantly lower than the nation's percentage (NAEP, 2009). The reading scores of adolescents on the Florida Comprehensive Assessment Test (FCAT) 2.0 also revealed a lack of reading skills. In 2011, only 52% of 10th graders performed at or above level 3 in the reading portion of the test (Florida Department of Education, 2012). In 2012, the number declined further. Only 50% of 10th graders performed at or above level 3 in the same section of the FCAT 2.0 (Florida Department of Education, 2012).

The final report titled *Time to Act: An Agenda for Advancing Adolescent Literacy for College and Career Success* (Carnegie Council on Advancing Adolescent Literacy, 2010), which was integral in the formation of the Common Core State Standards (CCSS), also suggested that many adolescent learners are struggling with literacy. The CCSS was a state led initiative that established a set of academic standards for kindergarten through 12th grade, in English language arts and mathematics that states could voluntarily adopt.

The standards were designed to ensure that American students who graduate from high school have the necessary skills to succeed at entry level courses in college programs or the work force (NGA & CCSSO, 2010) and to compete with their peers and abroad.

According to the initial reports which gave rise to the CCSS, the United States has failed to equip students with high literacy skills that were necessary for participation in the job market. As an example, there were estimates that private industry was spending $3.1 billion annually to improve the writing skills of novice workers (National Commission on Writing, 2003). Adolescent students in the United States were not being properly prepared for the demands of higher education and careers (Center for Education Policy, 2007; Perie, Gregg, & Donahue, 2005). The CCSS movement has brought attention to the need for more opportunities for reading complex materials and improving reading comprehension as students progress through the grades (NGA & CCSSO, 2010).

In the first decade of the 21st century, the struggle with literacy skills forced more than 3,000 students to drop out of high school every school day (Alliance for Excellent Education, 2003). In regard to the high number of adolescents who drop out of high school because of literacy issues, NAEP (2009) included a vocabulary and comprehension portion to their reading assessment. The goal of the vocabulary questions in the NAEP assessment was to evaluate how well students are able to use words to gain meaning from the passage they read. According to their results, lower performing fourth graders at or below the 25th percentile in reading comprehension, were at the lowest percentile in the vocabulary portion of the assessment (NAEP, 2011). Further, the vocabulary results of fourth and eighth graders who were eligible for free and reduced lunch (an indicator of low family income) were lower than the scores of students who were not eligible (NAEP, 2011). Only 45% or less of 12th graders who took the NAEP (2011) assessment knew the meaning of words such as “desolusion” and “urbane” (NAEP, 2011).

The low performance of adolescent students in reading assessments has brought to light a recognition that elementary reading skills do not transfer to secondary grades. It would appear, therefore, that reading instruction should continue beyond elementary grades to ensure that students are college- and career-ready by the time they reach graduation (Council of Advancing Adolescent Literacy, 2010). This deficiency in reading skills has, not surprisingly, impacted secondary students’ academic progress in content area classes (NAEP, 2011; Shalahu-Din et al., 2008). According to these sources, more than 70% of students in Grades 4-12 lack the skills to read and write proficiently in subject area classes.

Literacy in Secondary Content Area Classes

Literacy instruction in secondary content area classes is not a new topic. Since the 1970s, educators and policy makers have tried to find the most effective manner to integrate content area instruction with reading and writing (Bean & Readence, 1989; Brozo & Simpson, 1995; Conley, 1992; Dishner & Olson, 1989; Herber, 1970, 1978; Moore, Readence, Rickleman, 1983; Readance, Bean, & Baldwin, 1995). Although researchers and educators have been addressing the need for more support in adolescent literacy, policy makers have only recently began to examine and provide some support for research and improvement of literacy in secondary grades. For example, according to a 2002 report of the U. S. Department of Education, fewer than 3% of eighth graders could analyze and extend information, skills required when reading advanced texts; in 12th grade, fewer than 6% could read at advanced levels. More recently, NAEP data indicated no significant change in the percentage of readers considered proficient in eighth grade from 1992-2007 (Lee et al., 2007). Beyond this problem, remedial support in content area literacy only happens in elementary school, which causes students to continue to struggle with reading in middle and high school (Deshler et al., 2007).

As adolescent students progress through the school years, students are exposed to textbooks that, in order to cover the content, contain more complex words and sentences that are longer and more difficult to understand (Snow, 2010). Seventh-grade students must cope with, as an example, words such as “ancestors” and “characteristics.” These words might be challenging to some students because they do not often use these words in their everyday vocabulary. At 10th grade, students have to cope with words such as “psilophytes” (Biancarosa, 2012). Increase in sentence length and more complex words are not the only changes students are faced with in secondary classes. Textbooks also synthesize information across multiple texts and formats, e.g., tables, graphs, pictures, and figures; and even the way texts incorporate graphical representations changes (Lee & Spratley, 2010).

With adolescent students, the educational circumstance is different from the reading instruction for young children (Shanahan & Shanahan, 2012). Traditionally, reading instruction for young students includes the basic three “Rs” of reading, writing, and arithmetic. However, this is not enough for adolescent learners. Adolescent students are not often assigned to reading classes, and the notion of core reading programs and professional development for secondary teachers is quite unusual. Although adolescent literacy has received very little support from teachers and policy makers, reading instruction in the content area has deep roots.

Strategies supporting adolescent literacy should not subordinate the focus from content learning. On the contrary, because secondary subject learning requires complex literacy skills, learning in the content area should be connected to literacy instruction. During this process, students must learn how to use literacy and language as tools for understanding the texts used in subject area courses. Snow & Moje (2010) have argued that designing literacy instruction for adolescents must have the following three components: (a) continuing development of general language and literacy skills, (b) incorporating literacy into content area instruction, and (c) supporting struggling readers. The two first components of adolescent literacy instruction have led many teachers to believe that struggling readers could be supported by teaching comprehension strategies. For many years, educators believed that, introducing key and academic terms (Snow, Lawrence, & White, 2009), using guided questions to discuss text (Beck & McKeown, 2002), and providing videos, would be sufficient to help students in content area classes. Even though these strategies are effective, they are often insufficient in mathematics, science, or social studies classes.

Disciplinary Literacy Within a Functional Linguistics Framework

Because general secondary content area strategies may not be enough to help students comprehend texts in mathematics, science, or social studies, some reading experts have adopted the notion that reading proficiency should be subject specific (Shanahan & Shanahan, 2012; Shanahan, Shanahan, & Mischia, 2011). This acknowledgment of differences in subject areas has provided a platform for the term, disciplinary literacy (McConachie & Petrosky, 2010; Moje et al., 2008). Disciplinary literacy refers to "the ability to engage in social, semiotic, and cognitive practices consistent with those of concept experts" (Fang, 2012, p. 19). From this vantage point, secondary literacy instruction becomes more focused in the disciplines to improve reading and writing of texts in different content areas, because these are essential parts of disciplinary enculturation and socialization (Moje, 2008).

This study explored disciplinary literacy from a functional linguistics framework (Halliday, 1978; 2007). According to this framework, the reader is focused on the different ways language is used by content experts to present information, the structure of text, and the embedded values in core disciplines such as in science. Consequently, using this perspective, McConachie and Petrosky (2010) argued that it is difficult to separate content learning from the discipline-specific learning of reading and writing. It might be difficult to separate them, because language is essential to the transformation of experience to meaning. According to Halliday (2007), knowledge is often a prototype of language. In more specific details, functional language analysis argues for language-based semiosis and thus can be treated as a part of one's language development

(Halliday, 2007; Hasan, 1996). According to Halliday (2007), there are three stages of language development, starting with infancy. At this stage, children start to construct classes and develop the ability to generalize proper names and common names. At the second stage, which often happens during ages 4-6, children transition from everyday spoken grammar to the grammar of literacy, such as reading and writing? At this stage, children are expected to be ready to move into the educational forms of knowledge. Although each development is important for children, the most critical one is the last stage.

In the last stage of language development, which occurs from ages 9-12, children move from the grammar of written language to the language in the content areas. When faced with the language used in content area classes, students develop the ability to use and understand grammatical metaphors, replacing one grammatical class with another. During this stage, students must learn to reconstruct language in a more theoretical mode. Fang (2012) further explained this final stage, noting that students are expected to engage with technical knowledge of the academic disciplines. Thus, during middle and high school grades, students are confronted with this type of discourse, as technical knowledge becomes the focus of study. From this perspective, disciplinary literacy builds on, rather than excludes, language skills and knowledge that have been developed in the first two stages of language development. This stage continues to develop during the disciplinary literacy state (Fang, 2012).

From a functional linguistic analysis perspective, disciplinary literacy includes developing expertise in the content and the rhetorical processes, genres, methods, inquiries, methods and strategies of the discipline (Ball, Dice, & Bartholomae, 1990; Geisler, 1994; Leinhardt, 1993; Leinhardt & Young, 1998). In other words, learning to read means understanding what counts within each discipline, e.g., such as a good question, evidence, problem, and solution. Furthermore, disciplinary literacy involves crafting arguments in disciplinary ways; for example, mathematicians use proofs in mathematics, historians conduct document analysis in history, and scientists form and evaluate hypothesis-testing in science (McConachie & Petrosky, 2010).

Hasan (1996) further developed the concept of the linguistic differences among disciplines by explaining that what counts as knowing a discipline is having the skills to participate in the discourse of that discipline. This permits discipline content experts and students to conduct and share their work. Thus, through the recognition of the discipline-specific ways of using language, students might be assisted in becoming better readers and writers in each specific discipline (Fang, 2012).

Some content area studies report results that general content area reading strategies might be helpful to struggling readers (O'Brien & Stewart). These reports have not been enough to convince secondary content teachers of implementing these methods and making them part of their classroom practice (Lesley, Watson, & Elliot, 2007; O'Brien & Stewart, 1990; Reehm & Long, 1996; Stewart & O'Brien, 1989). One reason for the lack of enthusiasm for content area reading strategies may be that when someone aspires to be a mathematician or scientist, they follow the routines of experts in these areas rather than following reading instructors. This is quite the opposite of disciplinary literacy, because the insights and approaches are drawn from the disciplines themselves

(Fang, 2012). Instructional practices within this framework includes examinations of the disciplinary texts to enable the creation of more authentic learning, as they are based on the routines followed by the experts in each discipline.

In one of the most significant studies on disciplinary literacy, Shanahan and Shanahan (2008) explored the differences among disciplines in a two-year study conducted with secondary content area teachers. Their study was based on the concept of disciplinary knowledge (Bazerman, 1998; Fang, 2004; Geisler, 1994; Halliday, 1998; Schleppegrell, 2004), which states that although disciplines have some similarities in their use of academic language, they have very particular practices. These differences could originate from an attempt to protect the public from "charlatans," by creating professional organizations with standards and ways of communicating (Geisler, 1994). Another possibility is that the differences among the subjects are differences in the activities in which experts in the area engage. Both of these explanations are persuasive to the premise that texts serve to advance knowledge but at the same time maintain a field's hegemony.

Findings in significant studies (Fillmore & Snow, 2000; Shanahan & Shanahan, 2008; McConachie & Petrosky, 2010) showed that secondary content area teachers prefer to use strategies that mirror the kinds of thinking and analytic practices common to their practice. Although the participants in the study acknowledged the potential for more general strategies such as KWL, they did not attempt to use these strategies while teaching content area classes. Thus, it would be more effective to expose secondary content area teachers and students to strategies that directly address the needs of the highly specialized reading demands found in chemistry, history, and mathematics (Shanahan & Shanahan, 2008).

Among the disciplines taught in middle and high school, science stands out as a particularly challenging one because it involves the systematic understanding of meaningful questions about the natural world (Fang, 2012; Krajcik & Sutherland, 2010). The research report is the main genre in science; it typically integrates in different ways the five basic genres of science: recount, procedure, report, explanation, and exposition (Fang, 2012). In order to apply the five basic genres of science, text has to be highly specialized; usually exploring a topic that is removed from students' daily lives (Halliday & Martin, 1993). It contains unique lexicon, semantics, and specialized grammar shapes (Bazerman, 1998). Through the construction of scientific texts, scientists are able to conduct special kinds of semiotic and cognitive work, such as establishing clear links among claims, warrants, and evidence to develop scientific theories. Furthermore, scientific texts allow scientists to adopt a critical stance, in reading and evaluating scientific arguments, and to generate and communicate new knowledge (Yore et al., 2004).

Because of the possible challenges in reading scientific texts, many middle and high school students are often characterized as apathetic readers who feel alienated from science (Lemke, 2001; Ley, Shaer, & Dismukes, 1994). Some scholars have suggested that to remediate these problem students should be exposed to science storybooks (Rutherford & Ahlgreen, 1990), but researchers have shown that often scientific meaning cannot be expressed with ordinary language of everyday storytelling. Instead, science has evolved to have its own language, which is functional for constructing scientific concepts, and knowledge (Halliday & Martin, 1993; Reif & Larkin, 1991). Thus, students need to have experiences with authentic texts, because it is the language used by scientists to communicate their understanding of the natural and social worlds.

The best argument to bring attention to the need for more disciplinary literacy instruction in secondary science classes is that language is an integral part of science and science literacy (Douglas, Klentschy, Worth, & Binder, 2006; Germann, Aram, & Burke, 1996; Yore et al., 2004). Language is fundamental in science, because it is a tool to make science and to understand and communicate science. In other words, science literacy is a tool with which to communicate about inquiries, techniques, and procedures so that people can make informed decisions.

Language Challenges in Science Texts

Because of the focus on disciplinary literacy in science classes, numerous studies indicated that students face serious challenges while reading science texts (Cromley & Azevedo, 2007; Koch, 2001; Zion, Michalsky, & Mevarech, 2007). First, these studies indicated that secondary students had difficulty in identifying a science phenomenon (Rop, 2003). Second, when asked to hypothesize on the basis of the text, students often fail to specify variable and relationships among them (Michalsky & Mevarech, 2007; Njoo & De Jong, 1993; Zion et al., 2007). Third, students tend to avoid hypotheses that have a high risk of being rejected (Klahr, Fay, & Dunbar, 1993). Finally, when it comes to experimental evidence, students tend to ignore, reject, or misinterpret data that does not fit into known or existing theories (Chinn & Brewer, 1993; Zion, Cohen, & Amir, 2007).

Other researchers have conducted reviews of the linguistic challenges in science textbooks. Fang (2008) explored these differences based on the work of applied linguists who have explored the language demands of schooling (Fang, 2005; Perera, 1982; Schleppegrell, 2004; Unsworth, 1997; 2001). In his work, Fang (2008) noted some of these linguistic differences in the following categories: (a) prepositions, conjunctions, and pronouns; (b) subordinate clauses; (c) prepositional phrases; (d) abstract nouns; (e) lengthy nouns; and (f) complex sentences. In science texts, not only content words such as nouns, adjectives, and verbs present a challenge to secondary readers. Grammatical words and expressions, commonly found in science textbooks, can also become a challenge. For example, the preposition "on" in the example "An animal in hibernation survives on stored body fat" (Fang, 2008, p. 495) does not convey the usual sense of space. Rather, it shows dependence. Similarly, the conjunction "or" which commonly represents alternative choices, as shown in the following example, "A vaccine is a substance that stimulates the body to produce chemicals that destroy viruses or bacteria" (Fang, 2008, p. 496) is being used to introduce words/phrases that define or synthesize a proceeding term (Yore, Bisanz, & Hand, 2003).

Another common grammatical word that causes difficulties for students as they read scientific texts is the conjunction "while" which can construe multiple logical relationships. For example: "The virus that causes cold sores in humans is an example of a hidden virus. While hidden, the virus causes no symptoms." This conjunction can be confusing because “while” can be considered as either a temporal conjunction (meaning when or at the time) or a conditional conjunction (meaning “if”).

Subordinate clauses also cause some confusion for students reading scientific texts. Subordinate clauses are those whose existence is dependent on the main clause. Different from embedded clauses, they are not part of another clause and are typically introduced by conjunctions, such as “while, because, if, as.” Thus, these clauses can be confusing when the subjects and auxiliary verbs are removed for the sake of linguistic economy, as in “Once fertilized, reptile eggs have another advantage over amphibian eggs.” Another challenge in reading sentences with subordinate clauses is when not only the subject and auxiliary verb are excluded, but the conjunction that is often used is also omitted. For example, “Given time, decomposers can decay the entire body of a large animal that scavengers missed” (Fang, 2008, p. 499; Kinneavy1971; Smith & Frawley, 1983).

Prepositional phrases also present a challenge to adolescent readers of scientific texts. Prepositional phrases are often introduced by “with,” which is a grammatical resource that enables economy in written text (Halliday & Matthiessen, 2004; Hapgood & Palincsar, 2007; Lemke, 2007; Saul, 2004). This kind of “grammatical metaphor” involves the transference of meaning from one grammatical category, such as clause and verb, to another, such as prepositional phase and noun. This linguistic economy, as referred to by Fang (2008), results in a cancellation of the logical-semantic connection between the prepositional phrase and the main clause. Thus, these implicit links require students to infer from the textual context and/or prior knowledge. This process can be very difficult for inexperienced readers of scientific texts as can be viewed in the following sentence. "With almost 10,000 species, birds are the most diverse land dwelling vertebrates."

Abstract nouns, as described by Fang (2004) and Ravelli (1998), also represent a challenge to inexperienced readers in secondary science classes. In scientific language, different from everyday language, one turns concrete events (as expressed by verbs) and attributes, as expressed by adjectives, into abstract entities. This process of transformation is called "nominalization" (Christie, 2001, p. 48). This process allows scientists to construct hierarchies of technical terms; to expand the meaning of things via numbering, describing, classifying, and qualifying them; and to synthesize previous information so that it can be further discussed (Halliday & Matthiessen, 2004; Hyland & Milton, 1997; Martin & Rose, 2003;). For example, "A single cell divides, forming two cells. Then the cells divide, forming four, and so on. This process of cell division does not occur only in pumpkins, though" (Fang, 2008, p. 500). Significant comprehension problems arise when students find sentences packed with abstract nouns. It is important, then, that when students note nominalization, more than rewording occurs. It might also be effective to apply a process of re-meaning (Halliday, 1998).

Similar to abstract nouns, lengthy nouns also might represent a challenge to secondary students reading scientific text. The density of information, commonly found in scientific text, is further developed by the use of lengthy nouns (Unsworth, 1997), because it compresses information that would normally take several sentences to convey. An example is found in the phrase, "A tornado is a rapidly whirling, funnel-shaped cloud that reaches down from a storm cloud to touch Earth's surface" (Fang, 2004, p. 501). In everyday language, the same lengthy sentence would be "A tornado is a kind of cloud. It is shaped like a funnel and moves very quickly." Scientific texts aim to describe and theorize phenomena in the natural world, and lengthy nouns enable scientists to communicate this kind of information.

Nouns that are used as subjects and/or objects of the sentences in science can be very long. Miller (1969), in his essay, described "magical number seven" (p. 21) as the approximate number of items such as simple facts and numbers that a person can hold in their short-term working memory. This means that lengthy nouns can be challenging to students, because they might disrupt reading fluency and put constraints on the comprehension process.

Another linguistic challenge discussed by Fang (2008) was the common use of complex sentences in scientific texts. According to Schleppegrell (2002; 2004), complex sentences in scientific language are clauses connected through logical dependency relationships, which result in hierarchically complex syntactic structures. This type of sentence includes several dependent clauses introduced by subordinate conjunctions such as "when, as if, because." An example is provided in the following sentence, "Stars shine with their own light, while Venus shines because it is reflecting lights from the sun, just as the other planets and moons do" (Fang, 2006, p. 504). Complex sentences can be taxing for reading comprehension because students need a certain amount of time to understand a sentence with multiple dependent clauses (Fang, 2006). Because there is an overemphasis on fluency in speed reading, secondary students may not have enough time to comprehend such complex sentences.

The linguistic challenges in secondary science text just described serve as evidence that scientists do not read, and write the same way (Gee, 2004). Each of the different communication types, such as crafting a research proposal or speaking to large groups of scientists, has different intents and purposes. These different communication types are intended to convey a message without distorting the science, but in this process language shapes science and science shapes language (Lemke, 1990; Locke, 1992). Consequently, educators need to focus more on science language, not just doing and thinking about science (Hand et al., 2003).

Among the previously discussed linguistic challenges in science texts, scientific vocabulary stands out as an obstacle for many secondary science students. In order to understand texts in secondary textbooks, which are often stocked with technical vocabulary, students need well-developed word knowledge (Harmon, Hedrick, & Wood, 2012). These words are often low-frequency words and are not represented in other contexts. The limited number of representations of these words creates an even greater challenge for students in internalizing the word meanings and showing word ownership (Harmon et al., 2012). Consequently, instruction for helping secondary students to learn scientific vocabulary includes not only effective strategies but also instruction based on the unique language needs found in secondary scientific texts.

Based on these challenges, researchers have argued that for students to benefit from reading scientific texts, they need to have access to discipline-related reading strategies (Garner, 1994; Spence, Yore, & Williams, 1999).

Vocabulary Instruction and Reading Comprehension

The notion that vocabulary instruction might support conceptual understanding in science classes is further solidified by the studies that explore the positive connection between vocabulary instruction and reading comprehension (National Institute of Child Health and Human Development, 2000). Stahl and Fairbanks (1987) conducted one of the most cited meta-analysis studies on the possible connection between vocabulary and reading comprehension. In their study, the authors noted that vocabulary instruction had a positive relationship with reading comprehension in passages containing taught words. They also found that vocabulary instruction was positively related to reading comprehension in passages containing words not necessarily taught. These findings suggest that vocabulary instruction might make an impact on reading comprehension with or without taught words, possibly by increasing students' interest (Anderson & Freebody, 1981; Beck, Perfetti, & McKeown, 1982).

In another pivotal study of the possible relationship between vocabulary and reading comprehension, Anderson and Freebody (1981) presented three instrumental hypotheses to explain the possible relationship between vocabulary and reading comprehension. The first hypothesis posited that a large vocabulary implies a large knowledge base, indicating that it is actually world knowledge, not word knowledge that accounts for the relationship between vocabulary and reading comprehension. Based on this hypothesis, teaching vocabulary would increase reading comprehension. The second hypothesis posited that a large vocabulary implies high intelligence. According to this hypothesis, a large vocabulary would not be directly related to reading comprehension. The third hypothesis presented by the researchers posited that vocabulary is causally related to vocabulary. The instrumentalist model used in this study to explain the connection between vocabulary and instruction posited that "individuals who score high on a vocabulary test are likely to know more of the words in most texts they encounter than lower performing students" (Anderson & Freebody, 1981, pp. 80-81).

Anderson and Freebody (1981) believed that teaching vocabulary was positively related to reading comprehension. According to them, the argument for teaching vocabulary to improve reading comprehension would be stronger if there were more studies supporting the possible relationship between the two. However, the existing evidence and common sense argue for teaching vocabulary, in the intrinsically value knowing the words and taught and for the likelihood that additional words will improve their comprehension (Graves & Watts-Taffe, 2008).

More recently, Baumann (2005) conducted an analysis of the most significant work on the possible relationship between vocabulary and reading comprehension. His study included: work on the exact nature of and theoretical explanations for associational or causal connections between word knowledge and comprehension (Anderson & Freebody, 1983; Kame'enui, Dixon, & Carnine, 1987; Nagy, 2005; Stahl, 1999a); the theoretical, empirical, and instructional implications of vocabulary and reading comprehension connection (Beck, McKeown, & Omanson, 1987; Graves, 1986; Nagy, 1988; Ruddell, 1994); and the more recent reviews on the topic (Baumann, Kame'enui, & Ash, 2003; Beck & McKewon, 1991; Beck et al., 2002; Blachowicz & Fisher, 2000; Hiebert & Kamil, 2005; Nagy & Scott, 2000; RAND Reading Study Group, 2002; Stahl, 1999). In their analysis they argued that the evidence linking vocabulary and reading comprehension is long standing and clear. Regardless of whether descriptive in nature, from IQ and achievement tests, or a variety of correlation investigations, it is clear that word knowledge has an irrefutable connection with reading comprehension (Baumann, 2005).

Reading achievement, motivation, and engagement

This study was conducted to investigate the possible effectiveness of a vocabulary instructional strategy for adolescents. It was, therefore, crucial to consider how motivation and engagement might be related to reading achievement.

In terms of reading instruction, engagement is the act of reading to achieve the internal or external expectations (Fredricks, Blumenfeld, & Paris, 2004). Reading engagement can be positive when there is a purpose and intention to learn. In contrast, reading motivation has been labeled in reviews as students' goals, beliefs, dispositions, and views towards reading (Guthrie, Wigfield, & You, 2012).

Researchers have conducted studies on students' reading engagement using different instruments to collect data. For example, self-reported effort (Skinner, Kindermann, & Furrer, 2009); amount of time spent (Guthrie, Wigfield, Metsala, & Cox, 1999); and observed concentration on reading tasks (Jang, 2008). Furthermore, secondary students' selections of courses are also influenced by engagement and motivation. Thus, students' self-efficacy in English and reading classes in Grade 4 predicted what courses they would select in Grade 10 (Durick, Vida, & Eccles, 2006). The opposite was also true, because most secondary students who devalued or were uninterested in school work, correlated negatively with time spent studying or on task.

Since the time a connection between motivation/engagement and reading achievement was established (Durick et al., 2006), much research has focused on how and whether instruction can influence motivation/engagement. Some aspects of instruction have been strongly correlated with academic achievement, such as autonomy support (Greene, Miller, Crowson, Duke, & Akey, 2004; Ryan & Deci, 2004). Autonomy support has been defined by the researchers as a type of instruction that involves students' intrinsic motivation, self-esteem, and beliefs about intellectual capabilities. Thus, this type of instruction allows students to choose of self-direct, and at the same time minimizes the use of controlling pressures. For example, in a Taiwanese study, Lau (2009) found that eighth graders who perceived some sense of autonomy were more likely to be behaviorally engaged. The participants in the study showed more engagement through listening carefully, persisting with hard problems, and participating in classroom discussions.

Instructional relevance has also been observed to increase motivation. For instance, Lau (2009) found that when middle and high school students recognized instruction as relevant to their lives, they showed high reading participation and achievement. Similarly, instruction that supports social interaction, including arranging for peer interaction during instruction, might also be associated with students' intrinsic motivation and active participation in learning (Furrer & Skinner, 2003). Thus, reading instruction that enables secondary students to emphasize on autonomy support, relevance, collaboration, and self-efficacy, is association with the promotion of motivation in correlation and experimental research (Schunk & Zimmerman, 2007).

Vocabulary Instruction in Secondary Science Classes

Based on the idea of a positive connection between vocabulary instruction and reading comprehension, and on the premise that scientists are language users, it is urgent that more studies be conducted in secondary settings to explore the connection between vocabulary instruction and conceptual understanding in science classes. Indeed, scientists are language users because the processes of speaking, writing and reading are highly valued in the scientific community (Yore, 2004). Together, several studies have explored the common tasks, procedures, and reading habits scientists undergo to communicate and create knowledge (Bazerman, 1988; Chaopricha, 1997; Dunbar, 2000; Florence & Yore, 2004; Yore, Hand, & Prain, 2001). A 2007 review of literature conducted by Bravo, Cervetti, Hiebert, and Pearson suggested that an effective science vocabulary program should (a) target a focused set of scientific terms, (b) provide multiple exposures to science terms through different modalities, (c) systematically and explicitly introduce terms in a thematically connected manner, and (d) make connections between targeted words and words students already know.

Targeting a Focused Set of Scientific Terms

Science textbooks expose students to a large number of technical words (Bravo et al., 2008). According to Armstrong and Collier (1990), a high school biology textbook contains 40% to 45% more complex words than a foreign language textbook often presents. Similarly, Yager (1983) and Groves (1995) conducted an analysis of vocabulary load in science textbooks. Their findings suggested that science books often contain more vocabulary than the required grade-level limit for foreign language books, which were 2,500 words. Based on the high number of words contained in each unit, science educators should select "high utility" words. The term high utility words in this context have to do with what have been referred to by Beck et al. (2002) as Tier 2 words. According to them, Tier 2 words are those that are often used by adults and found in other domains. In science, for instance, there are words used in life, earth, and physical science to represent the inquiry process such as examine, investigate, model, and observe.

Tier 2 words are not only central to science teachers because they are viewed as high utility words but also because they help students in developing an understanding of scientific enterprise (DeBoer, 1991). These words are essential to student understanding of the inquiry process and for participation in science activities. Bravo et al. (2008) said it best "These words provide information about scientific processes that are not well-captured by everyday language" (p. 165). In addition to Tier 2 words, science educators often select words that are essential to the understanding of the science content under study. For instance, words such as erosion, composition, marine, and shoreline would be words considered essential to students' understanding of a unit on shorelines.

Providing Multiple Exposures to Words through Multiple Modalities

Researchers have suggested that words are learned incrementally (Meara, 1984; Nation, 1990). This means that word knowledge contains several categories: recognizing the spoken or written form of the word, its grammatical or collocational behavior, the stylistic register of constraints of the word, conceptual meaning of the word, and the association the word has with its related words (Bravo et al., 2008). These categories of word knowledge imply that there are degrees of word knowledge. Higher degrees of knowledge in the context of science instruction mean that students have a conceptual understanding of what a word means. They understand the word in the context and in relation to other words, which together build the understanding of the discipline.

Similarly, Gee (2004) advocated for a type of academic language instruction in science classes that aim to develop "situated meaning." Students have to know more than word definitions because they need to know what a person can do with that object, event, or sentence (Glenberg, 1997). For example, if one asks the question, "How far does the light go?" while lighting a lamp, one is likely to answer, "It goes as far as I can see." In the context of physics, however, one might make a connection between light and rays and further explain that "The light travels forever unless it reflects off a surface" (Gee, 2004, p. 18). In order to use the term, light, in the science context, students must know more than simply the definition.

Because word learning has several degrees of knowledge, students require several exposures and meaningful experiences with new words in order to build active comparison of that word (Biemiller, 2004; Stahl, 1999b). In the same vein, Baumann and

Kame'enui (2004) posited that teachers should take every opportunity to "sprinkle vocabulary instruction" (p. 21). Thus, within the framework of several exposures through different modalities, students might improve their understanding of words, especially through hands-on experiences. For example, in a physics unit, students are often exposed through first hand experiences in investigating properties of various mixes to the words, solution, properties, and substances. Consequently, through a hands-on experience, such as testing individual substances and designing their mixtures, students can have more opportunities to use the target words thereby increasing the potential to influence the understanding of key words (McKeown & Beck, 2004).

Systematic and Explicit Introduction of Thematically Connected Terms

To give students the opportunity to learn unknown words, explicit word teaching must be used (NICHD, 2000). Furthermore, the possible benefits of using explicit word teaching can be amplified if words are exposed in a systemic way (Coyne et al., 2004). There are different strategies science teachers might use when explicitly teaching new words. For example, when introducing students to the process of morphemic analysis (Fang, 2010), teachers focus students' attention on each word individually, on the various parts and on the definition of each word. This process is supported by Fang's 2010 research positing that it is important, especially for English learners, that students develop not only semantic word knowledge but also morphological knowledge. Furthermore, these studies suggest that the integration of word knowledge and subject knowledge can aid students in understanding vocabulary knowledge. Similarly, teaching new words in a networked format provides a rich context to students, as far as how words are related to each other (Stahl, 1999b). Bravo et al. (2008) provided the following clear example

> A term like *organism* would be systemically introduced as referencing such living things as plants and animals, of which an *isopod* is an example, identified by particular *adaptations,* such as seven pairs of legs and a flattened body, and found in floor *habitats,* where it gets what it needs to *survive,* including *shelter*, food, *protection, moisture* and so forth (p. 167)

This example serves to show students how the italicized words are semantically related, and that together they comprise the fundamental knowledge in Earth Science. This type of activity that highlights the connection between conceptual terms facilitates word ownership for students (Johnson, Pittelman, & Heimlich, 1986).

Making Connections between Targeted Words and Words Students Already Know

A major tenet of vocabulary instruction in subject area classes has been that in order to expand students' vocabulary of scientific terms, students must make connections between new words and words they already know (Graves, 2000; Nagy & Scott, 2009). This type of knowledge and awareness of the connections between new words and words students already know provides students with the ability to recognize that some concepts are represented by more than one word, and that certain words represent more than one concept. In secondary science classes, there are several opportunities teachers can use to explicitly show students how to make connections between new words and words they already know, e.g., students might practice this skill by finding every day/science synonyms.

Vocabulary Think Chart

The VTC is a compilation of discipline-specific vocabulary strategies designed by Fang (Fang et al., 2010). According to these researchers, this strategy should be completed as a group and/or an individual activity after the reading of text or at the conclusion of a unit study to review key concepts.

This strategy not only provides an opportunity for students to engage with the new vocabulary. It also answers the most recent need for advanced literacy instruction and improved student attainment. The CCSS aim to standardize the field of academic skills, by aligning college and career readiness standards that students are required to build through their school careers (Zygouris-Coe, 2012). Literacy is at the center of the CCSS in a very similar approach to disciplinary literacy. According to Shanahan and Shanahan (2008), disciplinary literacy requires incorporating discipline-specific strategies and skills into the content area learning. To illustrate this notion, one needs to clearly explore the dimensions that are addressed in the CCSS. The CCSS, in English Language Arts, places a focus on expository text and multiple texts from the earliest grades (NGA & CCSSO, 2010). In secondary grades, the CCSS places critical attention on text complexity and text evidence, academic vocabulary, and informational writing.

Among the key points of the CCSS in Language Arts, the standards expect students to grow their vocabulary through a mix of conversation, direct instruction, and reading (NGA & CCSSO, 2010). In vocabulary instruction, as prescribed by the CCSS, vocabulary and conventions are treated in their own strand. They are not considered in isolation, because vocabulary extends through writing, reading, speaking and listening. This key point of the language standards, as described by the CCSS, is clearly aligned to best prepare students to learn scientific vocabulary with the use of the VTC. The VTC includes direct instruction and morphological and semantic analysis to support deep and applicable learning of scientific vocabulary.

According to the English Language Arts Standards for Literacy in History/Social Studies, Science, and Technical Subjects students are required to focus on increasingly complex informational text and academic vocabulary. For example, in the English Language Arts Standards for Literacy in Science, for Grades 6-8, it is stated under the heading of Craft and Structure: “Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics” (NGA & CCSSO, 2010, 2). Once again, it is clear that secondary students, according to the standards, are required to have more than a definitional knowledge of key vocabulary terms in science classes. Through the use of the VTC, students may have a greater chance of fulfilling such requirements.

Under the English Language Arts Standards for Literacy in Science and the heading of Range of Reading and Text Level Complexity for Grades 6-8, it is stated: “By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently” (NGA & CCSSO, 2010, ¶3). The VTC addresses the vocabulary needs of students in seventh-grade science classes and aims to prepare them to continue to read, learn, use, and produce science (Anderson & Freebody, 1983; Nagy, 2005; Stahl, 1993).

Vocabulary Think Chart and the Next Generation Science Standards

In addition to examining the role of literacy in middle grades science as outlined by the CCSS, the VTC is also aligned with the NGSS guidelines for science instruction and student learning. As one example, in the NGSS for Grade 7, under Big Idea 1 The Practice of Science, the benchmark number SC.7.N.1.1 stated:

> Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions (Florida Department of Education, 2012, p. 4).

The VTC can accommodate the educational skills of this standard in the sense that students need to know the discipline-specific vocabulary to understand, plan, and carry out investigations

A further example of this alignment can be found in Chapter 4 of the science textbook that was used during the treatment phase of this study. The course materials were aligned with the NGSS Big Idea 6 Earth Structure. Under Big Idea 6 Earth Structure, benchmark number SC.7.E.6.1 stated: "Describe the layers of the solid Earth, including the lithosphere, the hot convecting mantle, and the dense metallic liquid and solid cores" (Florida Department of Education [FLDOE], 2012, p. 3). In order to meet this standard, students must have command of the vocabulary used in the chapter. The VTC can provide students with an opportunity to engage with science vocabulary development and learning.

Chapter 5, the second chapter utilized in the treatment phase of this study, was aligned with SC.7.E.6.4 which stated: "Explain how evidence supports scientific theories that Earth has evolved over geologic time" (FLDOE, 2012, p. 5). As with the previously mentioned benchmarks, students need to have a deep understanding of the vocabulary in this chapter to meet this benchmark. This benchmark requires students to develop more than a superficial knowledge of the vocabulary words in order that they are able to explain how evidence supports different scientific theories.

Vocabulary Think Chart and Disciplinary Literacy

In addition to providing a platform to meet the literacy requirements associated with the CCSS and the standards required by the NGSS, the VTC exposes students to discipline-related vocabulary instructional strategies that can facilitate future scientific vocabulary learning. Integral to VTC are four components: (a) morphemic analysis, (b) semantic analysis, (c) word sorting, and (d) sentence generation. These components are described in the following paragraphs.

Explicit Morphemic Analysis. Morphemic analysis, also known as structural analysis, involves deriving the meaning of a word by examining its meaningful parts.

Such parts include roots, prefixes, and suffixes (Beck et al., 2002). Historically, morphemic analysis and morphological awareness has been positively linked to reading comprehension (Carlisle, 2000; Goodwin, Gilbert, & Sun-Joo, 2013; Pacheco& Goodwin, 2013). However, other researchers have revealed limited and sometimes equivocal findings on this topic (Johnson & Baumann, 1984; Nagy, 1988). Despite the lack of unanimity of opinion in this regard, it has been determined that instruction of morphemic analysis may be appropriate for students from about the fourth grade on (Nagy, Diakidoy, & Anderson, 1993; White, Power, & White, 1989).

Morphemic analysis has also been used in several significant studies in secondary schools. It has often been used in scientific vocabulary studies because the technical concepts in science often have Greek and Latin words in their naming system. Thus, direct instruction of roots and affixes can help students develop comparison over the technical vocabulary of science and promote a more precise understanding of science (Fang et al., 2010). As one example, Robinson (2005) found that teaching vocabulary focused exclusively on meaning, rather than on the structure of words, with the result that students did not know how to express their understanding of the words. This finding resulted in the researcher supporting additional, decontextualized, and language-focused vocabulary teaching.

In their quasi-experimental study around the same time, Baumann et al. (2002) compared the efficacy of morphemic and contextual analysis in the vocabulary learning of 157 eighth-grade social studies students. They also found, as did a number of other researchers, that morphemic analysis was beneficial for word learning in middle and high school grades (White, Sowell, & Yanagihara, 1989). Baumann et al. (2002) also suggested that when given the opportunity to use morphemic analysis, students might use this process to learn words independently.

In a follow-up study, Baumann et al. (2003) researched morphemic and contextual analysis with 78 students embedded in a social studies class. Teachers taught Civil War vocabulary daily for 15 minutes using the social studies textbook. Findings in this research suggested that morphemic analysis, especially when integrated with contextual analysis, was effective in promoting students' vocabulary growth.

Baumann and Kame'enui (2010) offered four practical guidelines for teaching common affixes and roots (Irwin & Baker, 1989; Johnson & Pearson, 1978). The guidelines included: (a) providing explicit instruction in how morphemic analysis works, (b) using word families to promote vocabulary growth, (c) promoting independent use of morphemic analysis, and (d) enhancing students' awareness that morphemic analysis does not always work.

Although there have been many studies confirming the effectiveness of using morphemic analysis in secondary classes to improve vocabulary knowledge, there are few focused on learning Latin and Greek roots. Schmitt (2008) posited that learning word parts could be confusing because the various word parts might be misleading as to the true meaning of words. For example, "unassuming" may be analyzed as "not supposing" instead of "modest." Despite this pitfall, Baumann and Kame'enui (2002) believed that morphemic analysis instruction was warranted because of the evident support for its efficacy.

Semantic Analysis. Historically, the integration of new words with new knowledge has been considered as effective vocabulary instruction (Nagy, 1989) The emphasis on semantic analysis is an outgrowth from Schema Theory in the sense that knowledge is considered to be structured as opposed to a list of facts. Furthermore, Schema Theory, as it relates to semantic analysis, suggests that new information is understood by relating to students' prior knowledge (Nagy, 1989).

Traditionally, semantic analysis has been used as a vocabulary instructional strategy in the form of "brainstorming" or "semantic mapping." Thus, some historical studies on the topic such as those of Johnson and Pearson (1984) and Johnson, Toms-Bronowski, and Pittelman (1982) are more significant than others. Stahl and Vancil (1986) also published a follow-up to the earlier work of colleagues. They focused on what makes semantic maps and strategies that require word relationships effective in improving vocabulary knowledge. According to these authors, semantic maps, alone, are not enough to teach students new vocabulary. It would be more effective to use this strategy in combination with classroom discussions. Discussions are a critical element of strategies that require word relationships, because they forces students to process words more actively and one must show more understanding of the meaning of a word to recognize the correct information (Barron & Melnik, 1973; Rupley, Logan & Nichols, 1999).

Concept mapping has received more recent attention as a vocabulary strategy. It requires semantic analysis and has been used to improve students' comprehension of scientific text (Guastello, Beasley, & Sinatra, 2000). Guastello et al. (2000) conducted a quasi-experimental study that included 62 seventh-grade science students and found that concept mapping could be expected to improve reading comprehension scores of the low-achieving students in their study. The significant impact found in the treatment group was attributed to students' active participation in constructing the maps. The active participation in building the maps was associated with the students' process of forming cognitive schemas as they assimilated a new topic (Guastello et al., 2000; Little & Box, 2011).

Sentence Generation. Sentence generation is required in the VTC in two different ways: paraphrasing and using the key concept in a scientific way. Both types of sentence generation are explored individually and from a secondary vocabulary instruction perspective in the following paragraphs.

Paraphrasing has long been identified as a strategy skillful readers use (Kletzien, 1991, 1992; Kletzien & Dreher, 2004), but it has not received much attention from researchers when compared to other strategies such as visualization and questioning. Some studies have been conducted to explore the use of paraphrasing in conjunction with other strategies, and the results have been positive.

Ellis and Graves (1990) measured the impact of the effects of using paraphrasing and repeated readings with seventh-grade students. The participants in the study were randomly assigned to one of four conditions: (a) paraphrasing strategy, (b) repeated reading strategy, (c) paraphrasing strategy with repeated reading, and (d) control. The findings suggested that the treatment group outperformed the comparison group on immediate comprehension measures and delayed tests.

In Kletzien's 1991 study, 48 high school students were divided into good comprehenders and half comprehenders by reading three expository texts of increasing reading difficulty. As part of the study, each student was asked to fill-in-the-blanks by randomly deleting 12 content-related words. After this process, students were asked about their reasoning in order to identify the reading comprehension applied. Subjects in the study said they relied on paraphrasing when they substituted original key words.

In the science context, Fang (2006) identified paraphrasing as a strategy that might help students translate scientific text to everyday language (Fang, 2006). This finding supported Lemke's (1990) earlier suggestion that one problem with learning science through text was that of translating the patterns of written language to spoken language. By spoken language, Lemke (1989) referred to the way individuals reason and talk their way through problems to answer scientific questions. On the same topic, Reif and Larkin (1991) argued that doing exercises that require translation from scientific language to everyday language can be helpful in improving reading comprehension. However, they noted that it was important to remember that there are aspects of scientific language that cannot be translated into everyday language and that such a process would cause a "simplistic transfer of ways of thinking" (p. 756). Sentence generation has been used not only to aid in reading comprehension. It has also been referred to as a writing strategy (Fearn & Farnan, 2001; Fisher & Frey, 2003) to aid students in writing in a more sophisticated manner.

Sentence creation has been associated with vocabulary instruction in integration with other strategies. In the action research of Jensen and Duffelmeyer (1996), students using sentence generation were observed collaborating in finding words that were related to the key words being studied. The authors considered that using sentence generation in integration with a collaborative activity strengthened the use of sentence generation, and the understanding of expository texts.

Word Sorting. Word sorting, as it is used in the VTC, requires students to identify the overarching concept to which a key word belongs. Concept classification, sometimes referred as word sorting, is a language-based activity that can promote vocabulary growth in subject area course (Fisher, Brozo, Frey, & Ivey, 2011; Vacca, Vacca, & Mraz, 2011). It is an active way of engaging students in word learning, especially when the vocabulary in question is concept-related (Bear, Invernizzi, Templeton, Johnston, 2012). This process is encouraging for vocabulary understanding, because it requires students to use hierarchical thinking (Flanigan et al., 2011). Schmitt and McCarthy (1997) associated the cognitive process required when completing sorting activities with one that will support students' in remembering the new vocabulary words more than they would by only using definitions. According to DeLuca (2010), word sorting might be especially helpful to students in building their vocabulary knowledge and to negotiate new meanings as they revisit definitions several times.

Although no studies on the impact of word sorting as a sole vocabulary strategy in the context of science learning were found in the literature review, studies in which word sorting has been integrated with other strategies were located. Nixon, Saunders, and Fishback (2012) conducted an online survey of 40 science teachers online about effective vocabulary strategies, and word sorting was identified as one of the top three strategies. The top five strategies included: using graphic organizers, word sorting, using a knowledge rating chart, concept definition mapping and categorizing words from text. According to the participants in the study, the top five strategies were beneficial because they increased students' independence, resulting in "I can do it" attitudes.

The VTC was initially developed as part of a study (Fang, 2008) on strategies to aid students overcome language challenges in science classes. It did not have a history of research associated with its effectiveness. The individual components of the VTC had, however, been identified as effective vocabulary strategies, making this strategy an appropriate tool for use in conducting further research.

Summary

It is clear from national assessment data that the United States faces a significant challenge in the area of adolescent literacy knowledge, skills, and performance. It is also clear that comprehension is a complex process and that vocabulary plays a significant role in adolescents' understanding of text and content. However, the type of vocabulary learning that supports reading comprehension, especially in science classes, needs to be more engaging (Beck et al., 2002). Traditional vocabulary strategies that focus on shallow word definitions are not enough to aid in support reading comprehension. What is required is vocabulary instruction that is discipline-specific and that requires in-depth word knowledge (Fisher & Frey, 2003).

Research reviewed in this chapter showed that vocabulary instruction can have a positive impact on reading comprehension. This is especially true as related to science because of its high reliance on technical vocabulary. Furthermore, other recent literature requirements imposed by the CCSS (NGA & CCSSO, 2010) also suggest that language and subject area content area should be integrated in learning. For college and career readiness, as described in the CCSS, students are exposed to more complex expository texts. In order to comprehend this type of information, and to share it with others, students must have a deep understanding of discipline-specific vocabulary.

Other academic and language challenges are imposed on secondary students through the NGSS (2012), which organized the content curriculum using Big Ideas and benchmarks. These Big Ideas require students not only to know the science content, including its scientific concepts, but also to understand how these concepts relate to each other and to Big Ideas. Thus, definitional word knowledge would be insufficient to fulfill the requirements in these benchmarks.

Although the VTC had not been used as a focus of research in a study prior to its use in the present study, its components (morphemic analysis, semantic analysis, sentence generation, and word classification) have been identified as effective vocabulary instructional strategies. Together, these strategies have the potential to take students further than definitional theory and aid them in developing a deeper conceptual knowledge of each target word.

Secondary students in the United States are in need of vocabulary instruction that is discipline-specific and that takes students beyond the definitional level of word knowledge. According to Pinker (1999), there is an increasingly positive connection between knowing words and reading comprehension. This implies that teaching students a high number of words should be the first priority for increasing vocabulary knowledge when reading and understanding texts. This review of the literature provided the rationale for further investigation of the components of the VTC as effective strategies for adolescent science students when learning new vocabulary.

CHAPTER 3
METHODOLOGY

Introduction

This chapter contains a description of the research design and the methods used in conducting the study. Included are, a restatement of the purpose of the study, a description of the participants, as well as the process used to gain approval for the study. The methodology section provides details about the instruments used to conduct the research, including their reliability and validity. The data collection and analyses procedures that were used in this mixed method research study are also discussed.

Purpose of the Study

The purpose of this study was to measure the impact of use of the VTC on seventh-grade science students' conceptual understanding of scientific vocabulary.

Participants

Students

The researcher used a convenience sample of participants from a middle school in southeast Florida that agreed to become a research site. Student participants in the study were seventh-grade science students who attend a seventh-grade regular science class, Comprehensive Science II, during the 2012-2013 school year. The term, regular science class, means that students had no prerequisites to their entrance into the class as opposed to advanced science classes for which students must have a certain grade point average and be referred by other teachers in order to be registered. Often, and in this study, students who are enrolled in Comprehensive Science II are students who struggle with reading. It is part of the school culture, to register students who achieve level three and four in the reading portion of the FCAT in more advanced classes.

Classes were formed by the school principal at the beginning of the school year using no specific criteria for placing students in the five regular classes except to balance class sizes. A total of 89 students participated in the study, with 36 students in the treatment group and 53 students in the comparison group. The reason for the discrepancy in the number of participants in the comparison and treatment groups was due to the teachers' own selection. The Comparison Teacher had more regular science students (three classes) and was only willing to participate in the study as the comparison group teacher. The Treatment Teacher had fewer regular science students (two classes), but she was willing to participate in the study as the experimental teacher. Because this study used a convenience sample, the researcher had no comparison over student assignment to the two groups.

As shown in Table, the treatment group of 36 students was drawn from two regular science classes, 11 from one class and 25 from a second class. There were 16 males and 20 females. The comparison group was drawn from three regular science classes, 15 students from one class, 20 students from a second class, and 18 students from a third class. In the comparison group of 53 students, 23 were female and 30 were male.

During the study, three students in the treatment group were expelled. Eight of the treatment group students took the pretest only and one student took only the posttest.

Some students were absent on the assessment days and the Treatment Teacher did not offer them a chance to re-take the assessment. Thus, a total of 27 students in the treatment group completed both assessments, and only their scores were used in the statistical analysis.

In the comparison group, four students took the pretest and not the posttest, and 12 students took only the posttest. Thus, a total of 37 students in the comparison group took both tests and only their results were used in the statistical analysis.

At the research site, the students' reading achievement was evaluated based on their 2012 FCAT reading scores the school made available to the researcher. The achievement level scores used in the FCAT represent the success a student had in achieving the Florida Sunshine State Standards. The achievement level scores were based on both scale scores and development scale scores, and ranged between one (lowest) and five (highest). According to the Achievement Policy Definitions (FLDOE, 2008), levels one and two mean that the student has little success with the challenging content of the Sunshine State Standards. For seventh-graders, the reading scores at level one varies between 100-266 points for level one and 267-299 points for level two. Level three means that students have partial success with the challenging content of the Sunshine State Standards, but performs inconsistently. For seventh-graders, the reading scores at level three vary between 300-343. Level four means that students have success with the challenging content of the Sunshine State Standards. For seventh-graders, the reading scores at level four vary between 344-388. The highest level, five, means that students have success with the most challenging content of the Sunshine State Standards.

A student who scores level five answers most of the questions correctly, even the most challenging ones. For seventh-graders, the reading scores at level five vary between 389-500.

In the treatment group, two students scored a level one in the FCAT reading assessment, 13 students scored a level two, 15 students scored a level three, and only one student scored a level four. In the comparison group, 11 students scored a level one on the reading portion of the FCAT; 16 students scored a level two in the same evaluation; 14 students scored a level three; and only three students scored a level four. Four students did not have FCAT reading scores, because they had just moved from another state. Twelve students in the treatment group had 504 plans. Section 504 of the Rehabilitation Act of 1973 is a civil rights law that prohibits the discrimination of students on the basis of disability in programs and activities (National Center for Learning Disabilities, 2013). Schools that receive federal funding are obliged to serve students under this section with academic support. This support might include providing a computer for writing assignments, dividing reading excerpts in smaller parts, and reading testing items aloud. Additionally, 10 students had specific learning disabilities, one student had been diagnosed with autism, and three students had been classified as English Speakers of Other Language (ESOL).

The comparison group breakdown included 32 females and 23 males. Eleven students scored a level one in the reading portion of the FCAT; 16 students scored a level two in the reading portion of the FCAT; 14 students scored a level three in the reading portion of the FCAT; and three students scored a level four in the reading portion of the

FCAT. Further, 17 students had 504 plans. The FCAT scores of five students in the comparison group were not available because students had just moved into Florida.

Table 1

Treatment and Comparison Group Participant Information

Groups	Females	Males	FCAT levels one and two	FCAT levels three and four	504 Plans
Treatment	16	20	18	17	17
Comparison	32	23	27	17	12

Fifty-five participants in the study had been attending remedial reading classes since the beginning of the academic year. The decision to register students in remedial reading classes has been based on their FCAT scores and is a state policy decision. Students who scored lower than a level 3 in the reading portion of the assessment, were required by law to attend remedial reading course. Thus, there was a concern that participants who attended these classes would receive extra reading instruction during the study. To avoid this possibility, the researcher interviewed the participants' remedial reading teachers. Both teachers focused their instruction on the use of fiction texts, provided in the remedial reading textbooks. Fiction texts include a setting, plot, characters, viewpoint and a theme.

In contrast, the VTC focuses on informational text that includes historical, scientific, and technical texts with factual information about the world (Greene, 2012).

This type of text includes text features such as headlines, vocabulary words, and bold words. Thus, participants in the study who had been attending remedial reading classes had not been exposed to the same type of vocabulary or vocabulary instructional strategies as used with the VTC.

Teachers

Two seventh-grade teachers participated in the study, one in the treatment group and one in the comparison group. The Treatment Teacher had 14 years of teaching experience. She had taught remedial reading for seven years at the same school where the study was conducted. For the two years prior to the study, the Treatment Teacher had been teaching seventh-grade science. Prior to beginning the study, she indicated that she used several vocabulary instructional strategies in her classes, i.e., foldables, definitions and question-and-answer exchanges. She was certified to teach ESOL and reading. The Comparison Teacher had 15 years of experience teaching science. He had only taught science but was also certified to teach ESOL. When queried about his classroom vocabulary instructional activities, he indicated he used academic word walls and definitions.

The Role of the Researcher

Because this study employed a mixed-method design, qualitative data were also collected. Thus, the researcher assumed the role of a passive observer. For a portion of her classroom visits, the researcher gathered data on the use of the VTC without interfering with classroom instruction or student learning. In order to gather enough data, and to be accepted by the individuals in the classroom, the researcher visited once during Phase I, and once a week during Phase II of the study. In Phase I, explicit instruction was provided on the use of the VTC. In Phase II, students worked independently on the strategy.

During the observation sessions, the researcher used the same fidelity protocol used by the impartial observers. Also, the researcher listened to students' questions, observed students' challenges with learning scientific vocabulary, and evaluated their level of engagement with the VTC. This process of observation helped the researcher to collect data on how the students learned the VTC and how they used it. Creswell (1998) supported qualitative researchers taking the role of observers.

Research Design

The researcher selected a mixed-methods design that included two different groups of participants (comparison and treatment) and two types of data (qualitative and quantitative). Both groups were composed of seventh-grade regular science students. The Treatment Teacher and the Comparison Teacher had the option to select how they would like to participate in the study. When invited to participate in the study, the Comparison Teacher said he did not want much involvement in the study. Findings of seminal studies on secondary vocabulary instruction revealed that students showed gains with relatively short periods of intervention several times in a given week (Bos & Anders, 1990; Condus, Marshall, & Miller, 1986; Mastropieri, Scruggs, Levin, Gaffney,

& McLoone, 1985). The intervention portion of the study was divided into two phases: Phase I, which included explicit instruction on the use of the VTC; and Phase II, when students worked independently on the strategy.

In terms of the quantitative sources of data, the researcher established certain criteria. First, it was necessary to insure that only the treatment group had access to the VTC, and second, it was important to determine how familiar the treatment participants were with this strategy. As mentioned previously, the researcher contacted the remedial reading teachers to insure that the Comparison Teacher did not use the VTC. Furthermore, the researcher conducted one observation of the comparison group, to insure that the Comparison Teacher did not use a similar strategy during class. After taking these steps, it was safe to assume that the participants in the study had limited experience with the VTC and its components.

In terms of the qualitative data, the impartial observers were selected based on their prior experience with reading instruction. Impartial Observer A had a master's degree in reading instruction, had taught numerous secondary reading instruction courses at a large metropolitan university in central Florida, and was currently a doctoral student in education there. Furthermore, Impartial Observer A had been a literacy coach at a local high school for the last five years. Impartial Observer B, had a master's degree in reading education, had a doctoral degree in Educational Leadership, and was currently working as a director of teacher training in the same county were the study was conducted.

Prior to beginning the study, the researcher conducted a three-day training session for the Treatment Teacher on how to use and teach the VTC. The training sessions included modeling of the chart, examples of each of the layers that comprised the chart, and discussions on how vocabulary instruction might be beneficial to science learning. Following this phase, the Treatment Teacher and the researcher prepared to administer a pretest to the treatment group, before Phase I.

During Phase I, the Treatment Teacher administered five-days of training for the treatment group. Phase I was based on the Pearson and Gallagher's (1983) GRR framework which included: (a) purpose and modeling; (b) guided instruction; and (d) independent tasks. This instructional model requires that teachers transmit the responsibility from themselves to the students. Through this process, teachers can mentor students to become capable thinkers and learners while handling activities at which they are not experts (Duke & Pearson, 2002). The GRR framework may occur over a week, month, or year, and it has been documented as an effective approach for writing improvement (Fisher & Frey, 2003), vocabulary instruction (Grant et al., 2012).

During the week of training, the impartial observers and the researcher conducted one observation of the Treatment Teacher. To conduct this observation, the researcher and the impartial observers used a fidelity observation protocol, in which they evaluated how well the Treatment Teacher had implemented the VTC in her science classroom. This evaluation included whether the Treatment Teacher had modeled each layer in the VTC, provided enough meaningful examples, and kept students engaged in vocabulary learning. Additionally, the impartial observers had the opportunity to take notes on how the VTC might impact the participants' learning of scientific vocabulary.

Phase II followed the one-week training session. In Phase II, the treatment participants were required to use the VTC for six weeks as a post-reading activity. During this time, the Treatment Teacher read the science textbook with her students using the popcorn method in which students take turn reading parts of the text aloud. After they finished reading each chapter, they turned to the VTC and used it as a vocabulary instructional strategy. The treatment in this study lasted six weeks because vocabulary acquisition studies have shown that students improve in new word acquisition after six weeks of treatment (Gilliam et al., 2008; O'Connor, 2000; Torgensen et al., 2001). Gilliam et al. (2008) attributed the success of vocabulary intervention specifically to the social interaction, linguistic exchanges, sustained attention, and immediate feedback. Following Phase II, the Treatment Teacher administered a posttest to the treatment group, to evaluate any improvement in the scientific vocabulary understanding of the participants in the study.

Research Question

To what extent does the use of VTC impact seventh-grade science students' conceptual understanding of scientific vocabulary?

Sources and Collection of data

Instrumentation

Treatment and comparison groups completed a pre-and posttest assessment to assess their knowledge of the scientific vocabulary used in Chapters 4 (Earth's History) and 5 (Plate Tectonics) of the participants' science textbooks (Buckley, Zipporah, Padilla, Thornton, & Wysession, 2012).

The pre-and posttest were comprised of 37 matching vocabulary questions with a word bank selected by the Treatment Teacher from the question bank available in the science textbook (Buckley et al., 2012). After the Treatment Teacher compiled the assessment, the Comparison Teacher, the science department chair, and five other science teachers reviewed the questions selected to ensure that there was a question for each vocabulary word and that the questions were written at an appropriate, challenging level. The researcher used this data to calculate the assessment's internal validity.

Observation Fidelity Protocol

The impartial observers received a copy of the fidelity observation protocol (see Appendix B). This chart allowed them to evaluate how the Treatment Teacher instructed the participants on each of the chart's layers. Additionally, the protocol required the impartial observers to evaluate if the Treatment Teacher provided enough examples of each layer and if these examples were sufficiently meaningful. Finally, the protocol contained a question about how and whether this instructional strategy might influence students' scientific vocabulary learning. The observations allowed the researcher to collect first-hand experiences, e.g., any unusual aspects, with the participants in the study. The researcher also assumed the role of an observer in this study, by using the same fidelity observation protocol.

After the posttest, the researcher collected all of the fidelity observation protocols and analyzed them for patterns and themes (Creswell, 2008). Specifically, the researcher used systematic steps to analyze the data, going beyond a generic analysis of the qualitative data (Corbin & Strauss, 2007; Strauss & Corbin, 1990, 1998). These steps included (a) open coding (developing categories of information); (b) axil coding (selecting one of the categories and positioning it within a theoretical model; and (c) selective coding (explicating a story from the interconnection of these categories).

Analysis of Students' Work Samples

Another source of qualitative data in this study was the participants' completed VTCs. The researcher collected all of the charts at the end of each week during the treatment phase and compared them to the teacher model charts (See appendix) created by the researcher. To create the teacher model charts the researcher used the *Interactive Science* (Buckley et al., 2010) textbook used by the Treatment Teacher, and *Language and Literacy in Inquiry-Based Science: Classroom Grades 3-8* (Fang, et al., 2010).

Reliability and Validity

To assess students' knowledge of scientific concepts in Chapters 4 and 5 of the textbook during the study, the researcher used the science textbook's bank of questions (Buckley et al., 2012). There are multiple reasons for using the textbook's question bank. First, since all the science teachers were required to use the same textbook tests, the researcher did not wish to interfere with the standard assessment norms of the school. Thus, the researcher elected to use a textbook test to ensure content and instructional validity.

The process of developing the pre-and posttest included several steps to ensure instructional validity. The Treatment Teacher and the Comparison Teacher taught all the vocabulary concepts required by the textbook chapters. When designing the pre- and posttest assessment, the Treatment Teacher selected 37 matching questions from the textbook's question bank that assessed students' knowledge of these science concepts that had been taught. Participants were not tested on any science concepts the Treatment and the Comparison Teacher did not teach.

After the Treatment Teacher designed the pre-and posttest, five different science teachers reviewed the assessment to ensure the vocabulary words had been properly assessed. Three of these reviewers taught in a high school in the same county where the study was conducted, and two of the teachers taught in the same school where the study took place. In order to assess the pre-and posttest, the science teachers completed a three-point scale content validity chart (see Appendix C). The scores of the validity chart were calculated using Software Package for Social Science (SPSS), version 20. A brief qualitative analysis of the raters' scores showed an even score among raters, especially Raters A and B. In order to supplement this information, the researcher conducted a series of analyses using SPSS, and it showed similar results. According to a paired t-test, Raters A and D, A and E, B and C, and B and D had significant results ($p = < .005$). Raters A and B differed from the other Raters. The means for the five Raters, shown in Table 1, were as follows: Rater A ,1.87; Rater B, 2.08; Rater C, 3.00; Rater D, 2.91; Rater E, 2.83. A more specific analysis showed that the key vocabulary words with the lowest means, according to the raters, were: carbon film (2.20) and rift valley (2.20). The key vocabulary words with the highest means, according to the raters, were: fossil (3.00), mold (2.80), and cast (3.00).

The low level of correlation between the raters can be explained by three different characteristics that were peculiar to this study. First, because there were only three available possibilities for rating (non-proficient, fairly proficient, and proficient), and there was not much variation between the three. Secondly, Rater C did not have any variation in his rating (he rated every word as proficient). Third, Rater D and Rater E were very similar, with almost no variance between them.

Table 2

Raters' Mean Scores: Pre- and Posttest

Raters	Means
A	1.87
B	2.08
C	3.00
D	2.91
E	2.83

To further enhance the validity of this assessment, it should be noted that Chapters 4 and 5 of the text were already aligned with the NGSS (FLDOE, 2012). For example, in reference to the concept “Fossil,” the science textbook aligned its definition with SC.7.E.6.4, “ Explain and give examples of how physical evidence supports scientific theories that Earth has evolved over geologic time due to natural processes” (FLDOE, 2012, 4). Consequently, the questions in the assessment were also aligned with NGSS. Although the reliability of this assessment was not calculated because this was not a standardized test, the researcher calculated its internal validity after the study was initiated.

Approval to Conduct the Study

The researcher followed the protocol for receiving approval to conduct research, as required by the University of Central Florida’s Internal Review Board. In order to fulfill all the requirements, the researcher submitted an application, a consent form, and a Human Research Protocol. The parental consent form was not necessary to conduct the study because of the nature of the data collected in the study.

After approval from the University of Central Florida was received (see Appendix D), the researcher sought approval to conduct the study from the Brevard County Public School District. This process included an application, and a copy of the approval to conduct the study granted by the University of Central Florida. In addition, the researcher personally contacted the Brevard County Public Schools to clarify any questions about the study. Once the researcher was granted permission by the school district's office of research to conduct the study (see Appendix E), she contacted the principal of the school where the study would take place. Once the school's principal granted permission to conduct the study (see Appendix F), the teachers were contacted.. Their only requirement prior to the beginning of the study was to receive copies of the UCF authorization and the Brevard County Public School District's study authorization form.

Finally, to ensure that the author of the VTC authorized the use of his chart in this study, the researcher obtained written permission, via email, to use it in this study (see Appendix G).

Procedures

The researcher had three informal conversations with the science teachers to assess their familiarity with types of vocabulary strategies. Based on these conversations, the researcher determined that they had been using more traditional vocabulary strategies throughout the academic year, e.g., word walls and vocabulary definitions. Because the Treatment Teacher had a limited amount of experience with vocabulary strategies that required more engagement between the student and the new concepts (O'Brien et al., 1995), and because preparing science teachers to use such strategies can be a lengthy process (Brown, Pressley, van Meter, & Schuder, 1996), the researcher provided her with training in the use of the VTC. The training consisted of three hour-long sessions prior to the beginning of the study.

In consideration of the Treatment Teacher's experience in teaching remedial reading classes, her training was based on Bean, Eichelberger, Swan, and Tucker's (1999) evolutional model of professional development for content area teachers (Fang & Wei, 2010). Using this theory, the researcher worked with the Treatment Teacher to bring about more integration of vocabulary instruction in a collaborative setting. The researcher selected this training model because it allowed the researcher to support the teacher without being intimidating or overwhelming (Fang & Wei, 2010).

Because the VTC had not been previously used in a research study, there were no comparable studies to establish why the treatment phase was proposed to last for a period of six weeks. However, the researcher reviewed the parameters established in similar studies that explored vocabulary instruction and science teaching. This decision was based on the difficulty subject area teachers have historically demonstrated in incorporating reading instruction into content area learning (O'Brien et al., 1995). From a practical standpoint, the study had to be conducted in a relatively short time frame because of other dates on the school calendar that needed to be considered, e.g., spring break, preparation for end-of-course exams, and administration of the FCAT.

Day-by-Day Schedule of Treatment Teacher Training

Day 1. Because the VTC is composed of a multilayer of reading strategies, it was necessary to conduct training sessions for the Treatment Teacher. The researcher asked her several questions to evaluate her knowledge of the VTC, and her pedagogical views of science learning.

1. What is the best way for students to learn science?
2. Do you believe there is a connection between reading and science learning? If so, what is the nature of that connection?
3. How do you use text in your science classes?
4. How do you promote scientific vocabulary understanding in your class?

From these questions, the researcher was able to gain insight into the Treatment Teacher's pedagogical beliefs. According to her beliefs, science instruction should include hands-on activities and students should have the opportunity to try experiments in class. She explained:

> Students should have the opportunity to try out experiments in class, but in most classes we do not have the time or the funding to accomplish that. So I do it as much as possible. The textbook comes with experiments.

The Treatment Teacher also understood the connections between reading and science instruction. This seemed to be a clear connection for her because she had completed the Florida Add-on Reading Endorsement, a state policy initiative developed for building content area teachers' knowledge about effective reading instruction. This endorsement was equivalent to 300 professional development points. According to the FLDOE (2013), a candidate needs to complete the following competencies in order to complete a reading endorsement: (a) foundations of language and cognition; (b) foundations of research based practices; (c) foundations of assessment; (d) foundations of differentiation; (e) application of differentiated instruction; (f) demonstration of accomplishment. Furthermore, she had been teaching reading for 13 years. According to her, the nature of the connection between reading and science learning rested in the students' ability to read the textbook. She did not introduce other texts during class because of time restrictions.

The Treatment Teacher answered the last two questions in a literal format. She used strategies such as foldables and interactive notebooks to take notes on new vocabulary definitions and also for teaching scientific vocabulary. In terms of reading infusion during the science class, she used popcorn reading with students taking turns in reading parts of the text aloud and silent reading. Although the Treatment Teacher was open to the possible connection between reading and science learning, none of the strategies she mentioned were supported by research on effective vocabulary instruction in secondary science classrooms. The strategies she used were general and dealt with note taking rather than discipline-specific vocabulary instruction.

After these preliminary questions had been answered, the researcher moved on to more specific questions that addressed the Treatment Teacher's knowledge of the VTC. The first question was: "What is your understanding of morphemic analysis?" The Treatment Teacher was somewhat familiar with this strategy because she knew it involved breaking down words in smaller parts. Because she showed some understanding of morphemic analysis, the researcher asked: "When and how do you use morphemic analysis in your classroom?" The Treatment Teacher explained:

> I use morphemic analysis when my students find a word in the textbook they don't know. I ask them: Do you know any parts of this word? Do you recognize any parts of the word? Do you know any context clues?

The only word part participants in the study were familiar with was the prefix, *ex*. The Treatment Teacher indicated that she had asked students to write this prefix in their interactive notebook. When students found different prefixes or suffixes being used in different science-related vocabulary, the Treatment Teacher asked them to use a dictionary to find the definitions.

The researcher moved on to the next layer of the VTC, asking "Are you familiar with semantic analysis? If so, how and when do you use it in your classroom?" Although the Treatment Teacher indicated that she was familiar with this strategy, her explanation was of a different strategy.

> I use semantic analysis with my students with comprehension questions students might have. I use the comprehension questions in the textbook and they have to use the new words in their answers, and similar words. That is how I know they are making connections among words.

The third level of the VTC included paraphrasing. The researcher queried the Treatment Teacher: "Are you familiar with paraphrasing? If so, how and when do you use with your students?" The Treatment Teacher replied that she had little experience with paraphrasing, indicating that she had never used it with her students and she needed more clarification.

The next level of the VTC involved sentence generation. The researcher asked the Treatment Teacher: “Are you familiar with sentence generation? If so, how and when do you use it in your class?” Similar to paraphrasing, the Treatment Teacher said she had very little knowledge of how to use sentence generation, and that she did not use it in her classes.

The last level of the VTC included an overarching scientific concept. The researcher asked: “How and when do you teach students about overarching scientific concepts?” The Treatment Teacher said she did not have much experience with this layer of the VTC. She said:

> I can refer to the textbook and ask them: In which chapter or page did we find this vocabulary word? What are the clues and titles that can show us other concepts similar to our vocabulary word?

After answering these questions, the researcher showed the Treatment Teacher a completed VTC. The researcher modeled how to complete the chart and addressed any questions the teacher had about it, At the end of the modeling, the Treatment Teacher said that she would need to have deep knowledge of each vocabulary word. She also asked if the researcher could prepare each chart for her, because she would not have time to prepare one prior to each time she used the chart and she wanted students to have accurate information. The researcher agreed, and also offered to prepare all the copies of blank VTCs. The teacher did add information to the prepared charts as needed. The first VTC training session lasted 69 minutes.

Day 2. After some reflection of the Treatment Teacher's knowledge level of the layers that compose the VTC, the researcher prepared for Day 2 with several examples of each of the layers. All of the examples involved effective vocabulary instruction strategies in accordance with experts in the reading instruction area.

The second session began with a discussion of word knowledge. The researcher illustrated this concept using a continuum of shallow to deep word knowledge (Frey & Fisher, 2006). The researcher reinforced the value of the VTC by saying that it could be an effective vehicle to take students from shallow word knowledge to deep word knowledge. To these comments, the Treatment Teacher showed excitement about using the chart as part of her science instruction.

Following this brief discussion, the researcher provided instruction and modeling on each of the VTC's layers. To instruct the Treatment Teacher on morphemic analysis, the researcher modeled the breakdown of the word, *dermatitis*. The researcher used the white board available in the classroom, and highlighted each part of this word. To make the example even more meaningful, the researcher added the word, *dermatologist*, and used a think-aloud to show the Treatment Teacher how knowing the parts of the word, *dermatitis*, can help students infer the meaning of *dermatologist* (Fang et al., 2010). Because this was new knowledge to her, the Treatment Teacher was interested in learning more word parts. She asked for more resources she could use to teach her students. The researcher gave her a copy of the most commonly used prefixes and suffixes in scientific texts (Fang et al, 2010).

Next, the researcher began a discussion about semantic analysis and explained that the purpose of semantic analysis was to develop students' vocabulary, construct connections among words, and organize information. She explained that it could also be used to bring different students' experiences with new vocabulary together. To illustrate an example, the researcher used Pike and Mumper's (2004) book on reading strategies for non-fiction text comprehension and Frey and Fisher's (2006) example of concept mapping in their book, *Learning Words Inside & Out: Vocabulary Instruction That Boosts Achievement in All Subject Areas*. To further the discussion and make a connection with the study, the researcher explained that semantic analysis could promote student engagement by having students contribute with different words. At this point, the Treatment Teacher had a few questions: "Can students contribute with any questions or only the bold questions in the book? And when they are doing the chart, should they draw this chart in the back?"

In response, the researcher explained that the VTC did not require students to draw the chart; however, drawing a chart could be a good scaffolding technique to learn how to complete the chart. Ideally, students would only write down words that were semantically similar to the key word. To illustrate how semantic analysis should be used in classrooms and in this study, the researcher used the word, *granite,* noting that it reminded her of the words, *rock,* and *foliated rocks*. It also reminded her of her kitchen because she had granite counters. She explained that these kinds of connections were fine as long as teachers and students could explain how words or concepts were connected.

The next discussion topic was paraphrasing. When using this strategy, the participants of the study were supposed to substitute scientific words with similar words. The Treatment Teacher said that she had not discussed this strategy many times, but that she had used it in explaining how to avoid plagiarism. Because she had limited experience with this strategy, the researcher offered the following scaffolding. First, she could tell the students that they were working at a radio station and their job was to make science news accessible to everyone (Fang et al., 2010). For example, how would they share with their peers the meaning of *sediment*? To support this scaffolding practice, researcher shared a list of common exchanges that might be useful when paraphrasing: (a) one reason-because; (b) failure of many patients to take--many patients do not take; (c) spread of bacteria-bacteria spread.

Sentence generation was another one of the layers discussed during training. Because this strategy required deep word knowledge, the researcher warned the Treatment Teacher that some students might experience difficulties with it. Thus, she made it clear that modeling of this strategy was paramount for students' understanding. Further, the researcher said that sentence generation did not have to be used to reproduce the key vocabulary definition. To avoid this, students should use their own experiences and classroom connections in new sentences.

To illustrate how to teach students sentence generation, the researcher showed Frey and Fisher's (2006) suggestions. At the early stages of this process, the Treatment

Teacher should tell students where to place the key word: "When you are first teaching sentence generation, you might say that the key word should be the first word in the sentence. As they improve you might say that the key word should be the third" (Frey & Fisher, 2006, p. 110)

The Treatment Teacher kept a copy of this page and the researcher moved on to a discussion on how to bring students' attention to the larger scientific concept. The Treatment Teacher said that she was hoping to use the textbook to indicate to students the major word families in which the key vocabulary belonged. The researcher indicated to her that a good idea to help students rely less on the textbook would be to introduce this strategy by offering different scientific words and asking students to put them in larger scientific families. The Treatment Teacher was not interested in this process. At the end of this session, the Treatment Teacher had the following questions:

> How should I motivate students to complete this chart? How about the students who need accommodations; can I read the pre- and posttest to them? Can you [the researcher] prepare the chart for me every week, because I will not have time to prepare?

The researcher suggested that she could motivate students, at first, by explaining to them the possible benefits of using the chart to learn scientific words. Further, she could motivate students with verbal praise, and by showing excitement and commitment to the chart. The Treatment Teacher volunteered that she should include classroom discussions on vocabulary using the VTC which, in turn, could improve student engagement and motivation. Engagement can be a positive addition to the VTC because individual work undermines intrinsic motivation (Applebee, Langer, Nystrand, & Gamaron, 2003). The researcher also explained how the Treatment Teacher could make the necessary instructional changes some students would require, and she provided relevant examples. This meeting lasted 40 minutes. The researcher allotted time in this session for the Treatment Teacher to prepare for the next day's activity, which required the Treatment Teacher to prepare and model a VTC.

Day 3. The training was initiated by answering any additional questions the Treatment Teacher had with the implementation of the VTC or the study. The researcher used a brief checklist to go over possible topics of questions: (a) pre- and posttest; (b) frequency of using the chart; (c) preparation of the chart. The Treatment Teacher did not have any new questions, indicating that as long as the researcher could prepare each layer of the VTC she would be ready to begin.

The Treatment Teacher began with her presentation. She selected the word, *dermatologist*. This was not considered original work since the researcher had already used the word, *dermatitis*, a word from the same family. She modeled that she would read the question about morphemic analysis, write it on the board, and analyze the word parts. She would involve students in this process. Additionally, she pulled out the computer screen and consulted an online dictionary to show the origin of the word. The researcher gave her feedback about the purpose of morphemic analysis, i.e., to teach students different prefixes and suffixes so they could infer the meaning of new words. The Treatment Teacher responded as follows:

> This is not going to be easy for my students, especially without the dictionary. I'm not giving them the answers, so they have to participate. They need to find the word parts by themselves and that is why I am showing the dictionary. Then I will talk to them about where they have seen these words, like a zoo or a museum.

In the semantic analysis part of the chart, the Treatment Teacher associated the word with the word, *paleontologist*. This is also another word that the researcher used during the training with the Treatment Teacher. She said that she struggled with finding another word to associate with the key word. Seeing that the Treatment Teacher had very little motivation to use the training and suggestions already offered, the researcher moved on to the next layer. In explanation, the Treatment Teacher's lack of motivation could have originated from her lack of familiarity with each layer in the VTC. It could also have been that the use of the chart did not fit within the Treatment Teacher's pedagogical beliefs on teaching science and reading.

On the paraphrasing layer of the chart, the Treatment Teacher used the same examples and scaffolding strategies offered by the researcher during the training: "I will write the definition on the board and ask myself how can I re-write this sentence? Then I will do it. When we are working together, I will ask them how can I make this accessible to everyone?"

On the sentence generation section of the VTC, the Treatment Teacher also used the same strategies and scaffolding techniques offered by the researcher during the training: "I will show them how I came up with a new sentence, using the key word as the first word in the sentence. All they are going to come up with is definition type sentences."

After going over the chart, the Treatment Teacher asked the researcher to prepare every chart for her, during the treatment phase of the study. According to her, the VTC takes a significant amount of time to prepare, and she did not have enough time to devout to that. Thus, the researcher created a teacher sample for every week of the treatment phase, and delivered to the Treatment Teacher at the beginning of every week. The Treatment Teacher selected what terms she would use the VTC with, before the beginning of every week.

In response to the concern that students would only write definition type sentences, the researcher responded that it could be a good starting point. However, as students spent more time using the chart, they would be able to outgrow definitional sentences and write more complex ones. Moving into the larger scientific concept, the Treatment Teacher took a different approach than the one discussed during the training sessions: "I will ask students where you found the key word? Now let's go back to the textbook page and try to find out what is the larger scientific concept."

The researcher suggested that the Treatment Teacher discuss with students their background knowledge about that word and then move on to a discussion of similar words that could be considered a larger scientific concept. The Treatment Teacher said: "But they can find that information in the book. I have the following acceptable answer: fossil [pause] because that is what the book says."

Although the training session did not quite reach the expected level of knowledge, the researcher did not have additional time to devote to training on this topic, and moved on to the selection of new words for the first week of the study. The schedule for the three days of training for the Treatment Teacher is displayed in Table 2.

Table 3

Day-by-Day Schedule of Treatment Teacher Training

Days	Activities	Resources	Duration
Day 1	Discussion by researcher and Treatment Teacher of views on reading and science learning; modeled the chart.	Fang et al.(2010)	1 hour
Day 2	Researcher modeled use of the Vocabulary Think Chart (VTC) with the concept *dermatitis*; Discussion of each of the VTC's levels.	The VTC (Fang et al., 2005, 2010; Frey & Fisher, 2006)	1.5 hours
Day 3	Treatment Teacher modeled VTC with the concept *dermatologist;* Discussed possible questions when teaching students how to use the strategy. Introduced the Fidelity Chart	Interactive Science Textbook	1 hour

Treatment Fidelity

To ensure treatment fidelity, the researcher took two precautionary steps. The researcher observed the treatment phase of the study once a week during the treatment period. .In addition, two reading experts with background knowledge in reading instruction conducted one observation during Phase I and one observation during Phase II of the study. This measure was taken to ensure that impartial observers assessed the implementation of the study. In order to prepare the impartial observers for their observation, the researcher modeled for them how to use the VTC and conducted a 20-minute question-and-answer session with them. With this advance preparation of the impartial observers, the researcher provided them with practical experience with the VTC. The appropriate preparation of the observers, in addition to their extensive background knowledge and experience with reading instruction, prepared them for their observational task.

The fidelity chart that the Treatment Teacher completed represented the second measure to ensure treatment fidelity (see Appendix H). The chart included the date and the words students used to complete the VTC. The intent of this chart was to ensure that the Treatment Teacher used the strategy at the end of each chapter. Fidelity was an important part of this study because it determined a connection between delivering teacher training and evaluating subsequent child outcomes (Pence, Justice, & Wiggins, 2008). There are several types of implementation fidelity, such as (a) program differentiation, (b) program adherence, and (c) quality of program delivery (Dane & Schneider, 1998; Dusenbury, Brannigan, Falco, & Hasen, 2003).

Intervention--Phase I

The first week of the treatment phase included a four- step procedure to introduce the participants to the VTC. Using Pearson and Gallagher's (1983) gradual release of responsibility framework, participants received four days of training on the VTC. The main goal in using this model is to transition the teacher from having all of the responsibility to students having all the responsibility (Pearson & Duke, 2002). While implementing this instructional framework, the teacher is to be engaged in assessing, monitoring, and self-monitoring the efficacy of the strategy. The GRR model (Pearson & Gallagher, 1984) was used to teach students how to use the VTC because the model encouraged that each step (introduction, modeling, guided practice, and independent practice) be implemented in a linear form (Grant et al., 2012). Furthermore, systemic and purposeful forms of teaching, such as in GRR, allowed teachers to focus on disciplinary literacy (from basic to more sophisticated-discipline related skills) (Ross & Frey, 2009).

Day 1—Introduction. On Day 1 of the treatment phase, all students completed a 30-minute (estimated) pretest. This estimated amount of time was finalized with the Treatment Teacher in consideration of the time students in her class typically take to finish assessments. After the pretest, the Treatment Teacher introduced the VTC as the vocabulary strategy that would be used during the six-week period when Chapters 4 and 5 of the text were studied. The Treatment Teacher briefly explained each component of the strategy: morphemic analysis, semantic analysis, concept classification, and sentence generation. After that, the Treatment Teacher modeled the use of the VTC with the vocabulary term, *lithosphere* (Appendix I). This term most participants were familiar with because they had been introduced to it in Chapters 2 and 3 of their science textbook. After modeling the use of the VTC with one scientific term, the teacher focused on other aspects of the class. This process required one entire class period.

Days 2 and 3--Modeling and Discussion. Days 2 and 3 of strategy instruction included modeling the use of the VTC with the following scientific terms: *radiation* (see Appendix J), *convection* (see Appendix K), and *conduction* (see Appendix L). These words were selected by the Treatment Teacher because they were fundamental to the understanding of Chapter 3 concepts (Earth's Structure and Materials) and because they were words students were going to encounter in future science classes (Beck et al., 2002; Ruddell, 1994). During the modeling session, the teacher prompted students with questions such as: "What is my next step?" or "What do we do next?" Additionally, the teacher gave students positive feedback for participating in the modeling, saying: "Good job." This process required 30 minutes on each of the second and third days.

Day 4--Guided Practice. During guided practice, the Treatment Teacher gave each student a copy of the VTC, and requested that, working in pairs, it be completed. During this period, the Treatment Teacher gave students plenty of guidance through purposeful modeling and scaffolding. The Treatment Teacher accomplished this by engaging students in the use of the VTC with different words and thinking aloud how she made connections among the different scientific concepts. By hearing how experts think, students had the opportunity to fill in any vocabulary gaps (Grant & Fisher, 2010), and access prior knowledge. The teacher used *cementation* (see Appendix M) in this process. These two words were found in Chapter 3 of the science textbook. This process required 20 minutes of class time on day 4.

Day 5– Independent Practice. During independent practice, students worked in pairs to complete the VTC. This portion of the intervention occurred after the Treatment Teacher had provided students with plenty of modeling and scaffolding during the guided practice. During the independent practice, students had the opportunity to wrestle with their ideas and develop their own meaning for the new scientific concepts. By having the chance to write and discuss about the new scientific concepts, it was intended that students would be better able to internalize the new information (Grant & Fisher, 2010). The word selected for this day was *uniformitarianism* (see Appendix N). This word was part of Chapter 4, a chapter that was studied during Phase II of the treatment period. After students had finished completing the chart, the teacher reviewed it with students, giving time for any discussions that might arise (Beck et al., 2002). Table 3 displays the days, activities, concepts, and duration of activities associated with Phase I of the intervention.

Table 4

Intervention Phase I: Week 1 Activities, Concepts, and Duration

Day	Activity	Concepts	Minutes
Day 1 Introduction	Participants took pretest. Treatment Teacher introduced VTC, providing all students with copies, explaining each component. Teacher modeled the use of the strategy.	Lithosphere Trace Fossil	20
Day 2 Modeling and Discussion	Treatment Teacher modeled the use of the strategy and answered questions related to the strategy.	radiation, convection	20
Day 3 Modeling and Discussion	Treatment Teacher modeled the use of the strategy and answered questions related to the strategy.	Conduction Carbon Film	20
Day 4 Guided Practice	Treatment Teacher asked students to complete the VTC in pairs as the she circulated the room to answer questions. Teacher modeled during this session.	Cementation Paleontologis t	20
Day 5 Independent Practice	Treatment students worked in pairs to complete the VTC. Treatment Teacher answered individual questions	Uniformitariani sm Mold	20

Intervention--Phase II

During Phase II of the intervention, participants used the VTC independently as a post-reading vocabulary strategy (Fang et al., 2010). The portion of the study lasted six weeks. After the Treatment Teacher completed the respective sections in Chapters 4 and 5, she allowed students time to complete a VTC for some of the vocabulary terms. In Chapter 4, the vocabulary terms were: *fossil, mold, cast, and carbon film, trace fossil, paleontologist, evolution, extinction, relative age, absolute age, law of superposition, extrusion, intrusion, unconformity, radioactive decay, half-life, geologic time scale, era, period, and uniformatarianism*. Chapter 5 included the following vocabulary: *continental drift, Pangaea, mid-ocean ridge, subduction, plate, divergent boundary, convergent boundary, transform boundary, plate tectonics, and rift valley*. It was estimated that participants required approximately 20 minutes to complete a chart for these words at the end of each chapter. Table 4 displays the chapters, sections, and concepts associated with Phase II of the intervention.

Comparison Group

The comparison group received instruction in the same vocabulary for Chapters 4 and 5, and the Comparison Teacher used traditional vocabulary strategies such as academic word walls and definitions as part of her regular vocabulary instruction. According to the Comparison Teacher, students spent 15 to 20 minutes of class time in vocabulary instruction. To insure that the comparison group did not receive a similar type of vocabulary instruction, as the treatment group, the researcher conducted one classroom observation. The observation suggested that the comparison group did not receive any type of vocabulary instruction similar to the treatment group.

Table 5

Intervention Phase II: Chapters, Sections, and Concepts Addressed

Chapters	Section	Concepts
Chapter 4 Earth's History	Lesson 1: Fossil	Fossil, mold, cast, petrified fossil, carbon film, trace fossil, paleontologist, evolution, extinct
Chapter 4 Earth's History	Lesson 2: The relative age of rocks	Relative age, absolute age, law of superposition, extrusion, intrusion, fault, index fossil, unconformity
Chapter 4 Earth's History	Lesson 3: Radioactive dating	Radioactive decay, half-life
Chapter 4 Earth's History	Lesson 4: Geologic Time	Geologic Time scale, era, period, uniformitarianism
Chapter 5 Plate Tectonics	Lesson 1: Drifting Continents	Continental drift, Pangaea, fossil
Chapter 5 Plate Tectonics	Lesson 2: Sea-Floor Spreading	Mid-ocean ridge, sea-floor spreading, deep-ocean trench, subduction
Chapter 5 Plate Tectonics	Lesson 3: The Theory of Plate Tectonics	Plate, divergent boundary, convergent boundary, transform boundary, plate tectonics, fault, rift valley

Variables

Instruction on the VTC was the independent variable in this study. This variable was manipulated in the study by allowing only the treatment group to use the strategy. The dependent variable was the students' ability to accurately answer the vocabulary questions after reading each chapter.

Reading levels were a confounding variable, because the researcher did not have access to the participants' reading levels until the beginning of the study. The students' reading levels might have impacted their ability to use the strategy. The reason for this possible negative impact was due to lower level students' possible lacking skills in accessing prior knowledge (Samuel, 2006).

Data Analysis

The pre-and posttest data were entered into SPSS for data analysis, to compare the data results, the researcher used a mixed design ANOVA (Gay, Mills, & Airasian, 2006). The test was used to measure any significant difference between two or more independent groups while subjecting participants to repeated measures. The researcher selected this type of inferential analysis because, through multiple comparisons, the researcher was able to identify which means are significantly different from other means (Gay et al., 2002). Because of the large number of tests, included in this type of analysis, there is a greater chance that a significant difference will be obtained (Gay et al., 2002).

The different types of qualitative data were also analyzed. The impartial observer field notes and the researcher field notes were coded for similar themes, and issues that would have the researcher understand the quantitative results of this study. The classroom artifacts collected were compared to the teacher model charts created by the researcher, and the participants' answers for the sentence generation layer of the VTC were analyzed using the Flesch-Kincaid Ease of Reading Test [FKERT] (Flesch, 1952).

Summary

This chapter described in detail the procedures and data collection and analyses processes that were used in this study. Included in this chapter were a reinstatement of the purpose, a description of the population, and the research question which guided the study. Additionally, the pre-and posttests were described in detail. Procedures used to conduct the study, Phases I and II, have been described in detail. Finally, the data analysis process was also explained.

CHAPTER 4
DATA ANALYSIS

Introduction

The purpose of this mixed-methods study was to measure the effect of using the VTC to improve seventh-grade science students' understanding of scientific vocabulary. Following the pretest, the participants received one week of instruction on how to use the VTC followed by six weeks of using the chart independently. After the treatment period, the participants took a posttest to evaluate their understanding of the scientific vocabulary they learned during the treatment period. The pre- and posttest scores were the only quantitative data collected. To analyze the quantitative data, the researcher conducted a mixed-method design ANOVA using SPSS, and reported it. The researcher also reported inferential tests, effect size, and confidence intervals.

During the treatment period, the researcher collected qualitative data in three different forms: classroom observations (researcher); classroom observations (impartial observers); and classroom artifacts. Both types of classroom observations were reviewed and categorized according to two different themes that emerged: effective instructional strategies (strategies that were in accordance with experts in the area of reading instruction); and practices that motivated student engagement (practices that promoted questions/discussion among students and the Treatment Teacher). Because this study lasted only six weeks and it generated a limited amount of data, the researcher did not use a computer software program to analyze qualitative data. The classroom artifacts were analyzed using the Flesch-Kincaid Ease of Reading Test (FKERT) to identify any improvements in sentence generation complexity, and the variety of sentences created.

Research Question

To what extent does the use of VTC impact seventh-grade science students' conceptual understanding of scientific vocabulary?

Results

Assumptions

The pre- and posttests were evaluated for any violations of assumptions related to the statistical tests. First, a normality test was conducted to detect any violations of the normality assumptions. Because the data set was small, the Wilkins-Test was used. The p-value for the pretest of .405 enabled the conclusion that the data came from a normal distribution. The p-value for the posttest of .531 also indicated that data came from a normal distribution. Additionally, the researcher conducted a Test of Homogeneity of Variance. This test indicated that the p-value of .080 increased the confidence that the confidences were equal and the homogeneity of variance assumptions were met. This means that the variances of the populations from which different samples were drawn were equal. The skewness and kurtosis of the pre- and posttests were also calculated and results were within the normal range, which means that the assumption of normality was met. It is important to meet the assumption of normality because it implies that the scores of the pre- and posttests have a normal distribution (with well-behaved tails). The results of the analysis are displayed in Table 5.

Table 6

Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Test	Statistic	Df	Sig.	Statistic	df	Sig.
Pretest	.111	64	.048	.980	64	.405
Posttest	.087	64	.200*	.983	64	.531

Statistics

Descriptors	Pretest (*N* = *64*)	Posttest (*N* = *64*)
Skewness	.086	-.409
Standard Error of Skewness	.299	.299
Kurtosis	-.011	.462
Standard Error of Kurtosis	.590	.590

A Box Test of Covariance Matrix was conducted, and results, as shown in Table 6, indicated it was of null significance, .144. This was meaningful because MANOVA makes the assumption that within-group covariances are equal.

Table 7

Box's Test of Equality of Covariance Matrix[a]

Box's M	F	df1	df2	Sig.
5.614	1.804	3	287439.332	.144

Similarly, the Mauchly's Test of Sphericity (1.000) showed the researcher failed to reject the null hypothesis that the variances were equal. This results means that the variances between all possible pairs of groups (independent and dependent variables) are equal. The results of this analysis are shown in Table 7.

Table 8

Mauchly's Test of Sphericity

					Epsilon		
Within Subjects Effect	Mauchly's W	Approximate Chi-Square	df	Sig.	Greenhouse -Geisser	Huynh-Feldt	Lower-bound
Test	1.000	.000	0		1.000	1.000	1.000

Finally, Levene's Test of Equality was performed. This within subjects design test tests the null hypothesis to determine if the error variance of the dependent variable is equal across groups. This test showed that both scores (pre- and posttest) were larger than the alpha value. This implied a failure to reject the null hypothesis and indicated that there was no difference between the variances in this population. The results of Levene's Test of Equality are shown in Table 8.

Table 9

Levene's Test of Equality of Error Variances for the Pre- and Posttests

Test	F	df1	df2	Sig.
Pretest	2.645	1	62	.109
Posttest	3.497	1	62	.066

Graphic Representations of Scientific Vocabulary Understanding of Pre- and Posttest

The pre- and posttest data are represented in the following tables. The lowest possible score was a 0 and the highest possible score was a 37. For the treatment group, the pre-test scores ranged from 10 to 28. Consequently, the mean score for the pre-test was 16.48. For the treatment group, posttest scores ranged from 11 to 29, and the mean score was 20.41.

For the comparison group, the pre-test scores ranged from 0 to 29. Consequently, the mean score was 16.05. For the comparison group, the posttest scores from 1 to 30. Thus, the mean score was 19.59.

Analysis of Variance

The study data were analyzed using IBM SPSS 20 for Windows. A 2 (Pre- and Post) x 2 (treatment and control) group mixed design measures ANOVA was conducted. The results of the analysis showed that the mean score on the pretest for the treatment group was 16.48 and for the comparison group was 16.05. The standard deviations for the pretest scores were 5.003 for the treatment group and 6.900 for the comparison group. The mean scores on the posttest were 20.41 for the treatment group and 19.59 for the comparison group. The standard deviations for the posttest scores were 4.758 for the treatment group and 6.930 for the comparison group. These results are displayed in Table 9.

Table 10

Pre- and Posttest Means and Standard Deviations for Treatment and Comparison Groups

Group	Mean	Standard Deviation	N
Pretest			
Treatment	16.48	5.003	27
Control	16.05	6.900	37
Total	16.23	6.130	64
Posttest			
Treatment	20.41	4.758	27
Control	19.59	6.930	37
Total	19.94	6.079	64

No significant difference was found in the pre-and posttest results of the two groups (.067), p = .057, eta2 = .003, power = .797. In all the results, there was a small effect size. These results are displayed in Figure 1, Table 10 and Table 11.

The lack of significant statistical results can be attributed to the type of instruction received by students (Pugach et al., 2012; Williams et al., 2009; Wood, 2002), the duration of the treatment (Mastropieri, Scruggs, Graetz, 2003; Scruggs & Mastropieri, 2002), and the Treatment Teacher's prior views on literacy and science learning (Draper, 2007; Norris & Phillips, 2003a).

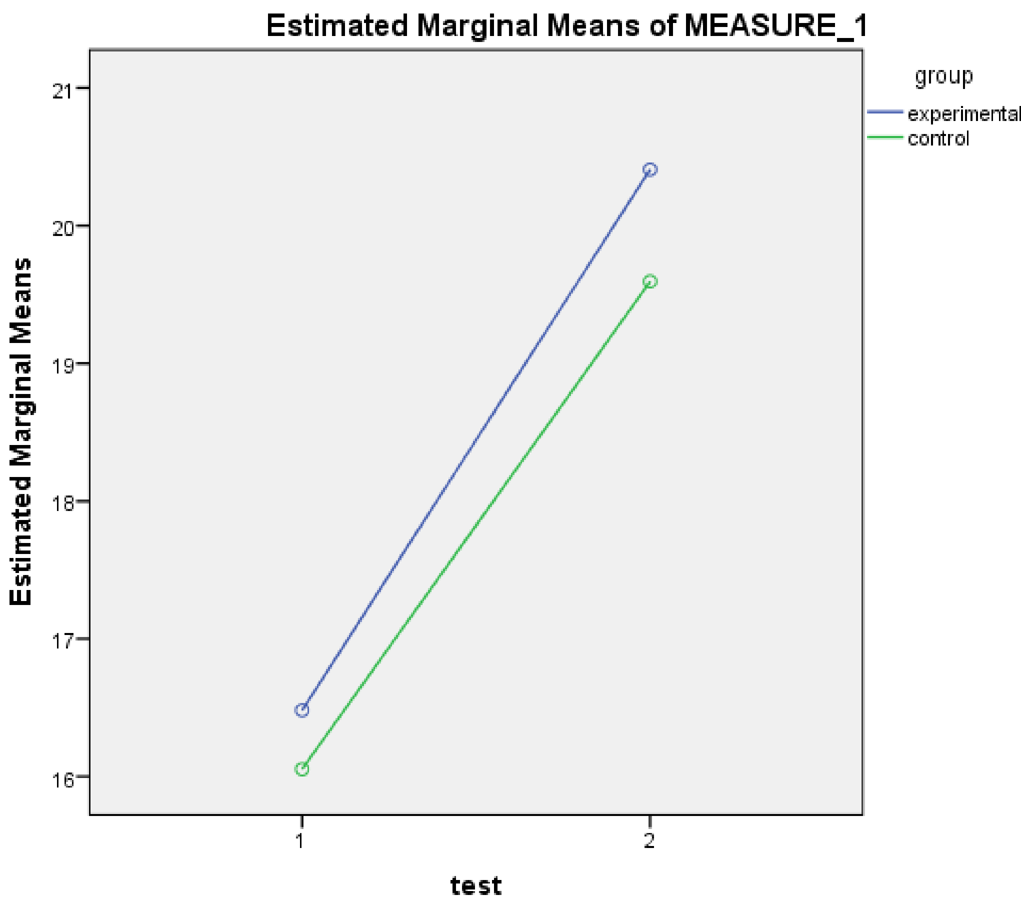


Figure 1. Estimated Marginal Means of Treatment and Comparison Groups

Table 11

Tests of Within-Subject Effects and Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Test	435.097	1	435.097	24.989	.000	.287
Test * group	1.159	1	1.159	.067	.797	.001
Error Test	1079.521	62	17.412			

p = < .05

Test of Between-Subject Effects and Contrasts

Source	Type III Sum of Squared	df	Mean Squared	F	Sig.	Partial Eta Squared
Test	41065.880	1	41065.880	706.745	.000	.919
Test*group	12.005	1	12.005	.207	.651	.003
Error Test	3602.550	62	58.106			

p = < .05

Field Notes, Impartial Observations, and Classroom Artifacts

Field notes and impartial observations were also used to answer the research question and further understand the quantitative results derived from the pre- and posttest analysis. These research instruments were used to monitor how well the lessons went, reflections about the lessons, how well students used the VTC, and how the use of this specific strategy changed throughout the study. In order to collect these data, the following process was implemented. First, the researcher became an active participant in the study and conducted weekly observations of the treatment group. Second, two impartial observers, with extensive experience in reading instruction conducted two observations of the treatment group.

In order to analyze the collected data, the researcher read through the field notes, highlighted points of interest, and assigned each point of interest to a category. Notes and categories were compared to avoid redundancy. Three categories emerged from this analysis: (a) effective instructional practices; (b) ineffective instructional practices; and (c) practices that motivated student engagement.

To analyze the classroom artifact, the researcher used the teacher model charts, she created for the Treatment Teacher. To create the teacher model charts the researcher used the *Interactive Science* (Buckley et al., 2010) textbook used by the Treatment Teacher, and *Language and Literacy in Inquiry-Based Science: Classroom Grades 3-8* (Fang et al., 2010). The researcher used the classroom artifact analysis to insure treatment fidelity, and the participants' understanding of the VTC.

Field Notes and Impartial Observations During Phase I

Field notes were taken throughout the study. Through analysis of these notes, three categories of observed practices emerged: (a) effective instructional practices, as supported by reading experts; (b) ineffective instructional practices, not supported by reading experts; and, (c) practices that motivated students' engagement with the VTC. The analyses of qualitative data further supported the quantitative findings.

In the first observation conducted during Phase I of the study, the researcher noted some inconsistencies between the Treatment Teacher's training session activities and her classroom practices. This was evidenced in the practice related to a word(s) selected by the Treatment Teacher, *trace fossil.*

Although these are root words, the Treatment Teacher asked students to use the dictionary to find the Latin origin of the word, *fossil.* This practice has not been supported by reading experts because the goal of morphemic analysis is to teach students about the smallest meaningful unit of a written language (Fang et al., 2010). She modeled to students the word, *trace,* and how it is a root word that can become *retrace* if a prefix is added to it.

In the semantic analysis portion of the instruction, the students were struggling with finding other similar words or sharing any background knowledge for *trace fossil*. Because they were struggling, there was very little engagement among students or with the teacher. The Treatment Teacher shared a couple of words related to the key vocabulary, such as *petrified fossil*, but the students did not make any connection. The classroom was very quiet and there was almost no interaction.

During paraphrasing and sentence generation, the Treatment Teacher used several effective instructional strategies that led to a significant increase in the engagement among students and with the teacher. The Treatment Teacher wrote the key vocabulary word definition on the board, and said to students: “Now, how would be make this definition easier to understand? Like if we were using it in a T.V. show?”

This question provoked increased participation among students, several of whom raised their hands and offered suggestions. This section of the chart was completed very quickly, because many students participated. They changed words, i.e., *ancient-old*; *evidence-proof*; *provide-give.* Engagement among the teacher and students was noticeable, because most students raised their hands to participate or simply yelled out answers.

The next level of the chart also elicited a significant level of participation among students. As a class, they generated a new sentence using the key vocabulary word. Given that students were just being exposed to the chart, the Treatment Teacher used a scaffolding technique. First, she said that students had to begin the sentence with the word, *paleontologist.* She later explained to the researcher that she selected this word because students are familiar with its meaning, and used it quite often in classroom discussions. As students gave suggestions for the sentence, the Treatment Teacher wrote them on the board. The sentence designed by the students was: "The paleontologist found a trace fossil of a Dodo bird in a dig site in India." Although they had used the word correctly in the sentence, the Treatment Teacher wanted to insure students knew the meaning of the word. Thus, she asked them to add a comma in the sentence and a definition of the key vocabulary word. Because students were participating so well, she asked them: "Why should we use the example of the Dodo birds in this sentence?" The students explained to her that Dodo birds were funny, old, and silly. She kept prompting students, asking for more reasons, until one student said, "Because they are extinct." That was the answer she was expecting, so she congratulated students and she further explained that, "Since they are extinct, we can only find fossils of them."

To answer the question of a larger scientific concept in the VTC, the Treatment Teacher used practices very different from the ones discussed during training. She began by asking, "What words can we relate to *trace fossil*?" The students began shouting words that they considered connected to the key word. Some of the words included: *paleontologist*, *carbon mold*, and *Earth Science.* The Treatment Teacher wrote all the words on the board and began constructing a concept web with the students. This was not discussed during the training sessions; however, it motivated students to participate by offering words as suggestions to the web.

The observations conducted by the impartial observers were quite similar to the observations conducted by the researcher. Both observers were concerned about the sporadic participation of the students, mostly present during paraphrasing, and sentence generation. Both of them agreed that the instruction of these two layers of the chart were more successful simply because of the increased interaction between students and the teacher. However, the two observers had different concerns about the layers dealing with morphemic analysis and semantic analysis.

Observer A was concerned about the vocabulary used by the Treatment Teacher during instruction of the chart. The Treatment Teacher used words like *prefix, suffix,* and *morphemic analysis* without discussing their meaning. Thus, Observer A wondered if students actually knew the meaning of these terms. Similarly, she was concerned about how the Treatment Teacher taught students about semantic analysis. According to her, the Treatment Teacher did not provide a single meaningful example of a personal vignette, to facilitate to students how to understand this strategy. Overall, Observer A rated the lesson as one that missed student interaction and more meaningful examples, including think-alouds.

In contrast, Observer A noticed several examples of effective instructional practices when the Treatment Teacher was discussing paraphrasing and sentence generation. According to her, the teacher provided meaningful examples, and a step-by-step approach which might facilitate student learning. For example, during sentence generation, students participated by yelling words to add to the main sentence; however, all these words were science words.

Observer B was also concerned with student motivation and engagement. However, she noticed that students were somewhat aware of morphemic analysis because a student asked the teacher if *trace fossil* had a suffix. The Treatment Teacher's reply was "No, these are root words." Although this exchange provided the opportunity to further develop a discussion on morphemic analysis, the Treatment Teacher moved on to Latin origins. The discussion about Latin origins only created engagement for two girls seated in the front of the class, as the rest of the class remained quiet.

Similar to Observer A, Observer B noticed that the portion of the lesson on semantic analysis was very weak. The Treatment Teacher did not provide any meaningful examples and did not try to promote more engagement among students. Because students did not have an example of what semantic analysis was supposed to look like, they could not contribute to the discussion, and their schemas were not activated.

Observer B was especially interested in the strategies used by the Treatment Teacher to teach paraphrasing and sentence generation. During paraphrasing, she wrote the sentence on the board and asked students to substitute three words. She helped them with examples and welcomed all the contributions from students. Engagement was high. Sentence generation was also well taught, according to Observer B, because of the engagement students showed. During instruction, the Treatment Teacher told students where to place the key vocabulary word and how to begin the new sentence. Students participated by offering many ideas, and engagement was high.

Classroom Artifacts - Phase I of the Study

Participants first had access to the VTC chart during Phase I of the study. As discussed previously, Phase I included modeling and guided practice led by the Treatment Teacher. An analysis of the artifacts, samples of which have been included for both Phases I and II in Appendix O, revealed that all students had the same answer for the morphemic analysis and the semantic analysis layers. In the case of the word, *paleontologist*, for example, all students wrote that *paleo* meant old, and that *logist* meant someone who studies. The similarity in all the answers implied that students and teachers were working together. Similarly, when students were completing the chart for the word, *cast*, all of them had the same information (that it was a root word and that it meant hallow).

As the week progressed, students began to add information to the morphemic analysis layer that did not coincide with the instructions the Treatment Teacher received during the training sessions. For example, for the word, *trace fossil* (see Appendix P), students included the information that *trace fodere* means, in Latin, to dig a trace, a copy, or an outline. Further, for the words, *carbon film* (see Appendix Q), students added the information that *carbo* meant coal in Latin. These changes might be a reflection of the Treatment Teacher's intervention during instruction through the use of the dictionary.

In the semantic analysis layer, students also had similar answers. For example, for the vocabulary word, *cast*, students wrote broken bones, and melting crayon to put on a mold. For the words, *carbon film*, students wrote carbohydrates and carbon dioxide. The most alarming instance occurred as an entire group of students associated the words, *trace fossil*, to find a fossil. This is a reflection of the teacher not exposing the students to enough meaningful examples of semantic analysis. In addition, students' schemas were not activated before they began discussing this word.

Another example of the semantic analysis layer included the word, *mold*. Although many students had written many words, very few of them had any scientific context, such as *fungus*, *blue cheese,* and *jello*. Similarly, in the case of the word, *paleontologist* (see Appendix R), most students made connections with the word pale, as in lacking without light. Although making connection to non-scientific words might be an effective beginning for students, it does not reflect the training sessions given to the Treatment Teacher. Ideally, students would make connections with scientific words. For example, in the case of the word, *paleontologist*, students could make connections to archeologists, biologists, and paleontology. These connections might aid students in identifying the meaning of similar words, when encountered in scientific texts.

The clearest evidence of student learning was found in the sentence generation layer. There is a twofold reason for the complexity of this layer: (a) students have to have a deep word knowledge; (b) students have to use the word in the scientific manner;

and (c) because the key word must be used in the scientific sense, other science-related words must be presented. For example, in the first week, students created the following three sentences:

1. Paleontologists created a <u>cast</u> of the fossil that is too fragile from the rock.
2. The paleontologists at the dig site found a <u>carbon film</u> fossil means this area was covered in water in the past.
3. The paleontogist discovered a <u>mold</u> of the claw of a t-rex at the site.

Although these three examples presume that students understand the meaning of the word, *paleontologist*, and are capable of using it in connection with other science-related words, a FKERT yielded different results. The first example scored 56, which according to the FKERT chart refers to fairly difficult, and it is estimated that students who read and comprehend this sentence have completed some high school grades (Flesch, 1952). Similarly, the second example scores a 58 in the same test. The third example also showed a high reading score of 53. All examples showed a strong involvement of the Treatment Teacher and reliance on peers, since most of the sentences were the same.

The larger science concept layer in the chart was the same for all the key vocabulary words for the first phase of the study. Thus, during Phase I, students wrote that all the words were part of the following larger concept, *earth's history* and *fossil.* Both words were located in the book, in the same section as the key vocabulary words. Relying entirely on the science textbook to point out the larger scientific concept is not a true reflection of the instruction sessions. Students should not select a term as a larger science concept simply because it is a textbook heading. According to Fang et al. (2010), the purpose of this activity should be to help students recognize common properties among core concepts.

Field Notes and Impartial Observations during Phase II

Following the first phase of the study, in which students were instructed on how to use the chart, they began using the chart independently. Phase I of the study lasted one week and Phase II lasted five weeks. The observations on the second phase of the program aimed to find any improvements in the engagement among students, more understanding of their scientific vocabulary, and more independent use of the chart.

Week 1. During the first week of independent use of the chart, the Treatment Teacher allowed students to sit in groups. Thus, some students sat in groups of four to five, two students sat as a pair, and three students decided to work independently. There was a lot of engagement between students who sat in pairs or in groups; however, there was no observed engagement from the students who worked independently.

The Treatment Teacher offered support by walking around the classroom and answering the few questions students had. Most of her corrections were made because she identified certain areas that needed to be corrected in their work, and she pointed out to them. Very few students asked questions, and most of them seemed proficient in the practical use of the chart, i.e., writing appropriately in each layer. There was very little interaction or engagement during the first two layers of the chart; however, students were very excited to share their new sentences for the sentence generation layer. Although students shared many sentences, the Treatment Teacher only wrote one sentence on the board: Pandas are almost <u>extinct</u>.

In response to this sentence, the Treatment Teacher called it a “kindergarten” sentence because it was too short, and it did not include a definition of what the key vocabulary word meant. To improve this sentence, the Treatment Teacher asked the student how pandas became extinct, and she offered some suggestions, e.g., lack of food.

This input switched the classroom topic from the chart to pandas, and for next seven minutes students and teacher interacted heavily. The students shared stories about pandas; they asked scientific questions about them; and they seemed very interested.

Although students shared many stories and some degree of background scientific knowledge about pandas, when they completed the larger scientific concept, they only related the word, *extinct*, to *fossil*. The Treatment Teacher did not re-direct or try to add more words to the last part of the chart.

During another observation opportunity, the researcher continued to witness some inconsistencies between the observed classroom practices and the training sessions. For example, when competing the chart for the word, *extrusion*, students quickly shared that *ex* means outside. The Treatment Teacher asked the students to add more information, that *trudere* is a Latin word that means to thrust or to push. The Treatment Teacher did not further explain the possible connection between this information and the meaning of the word, *extrusion*. As students continued to complete the chart, more differences from the training sessions continued to occur.

Because students did not know any similar words to the key vocabulary word, or any vignettes from everyday life, the Treatment Teacher encouraged them to use the dictionary. With the help of the dictionary, most students selected the words, *exit* and *exclude*, neither of which is scientific. Similarly, the paraphrasing layer was very challenging to students. Only some students seated in the front of the class were able to come up with new words. The rest of the class only changed the position of the words in the sentence. Even though the researcher modeled different ways to paraphrase, and the Treatment Teacher was given resources to facilitate instruction in the training session, she utilized only changing the word positions.

The sentence generation layer was very exciting to students. This was evident in the impartial observers and researcher's notes. When she asked for feedback on what sentences they created, many hands were raised. Before students began yelling out sentences, the Treatment Teacher said she did not want any "kindergarten" sentences, which mean sentences without other scientific words or without definitions. A group of students, working collaboratively came up with the following sentence: "The geologist found extrusion works laying outside the dormant volcano." The Treatment Teacher was very encouraging, and students came up with similar sentences that included scientific words, but no definitions. Most students selected the word, *fossil*, as a larger scientific concept.

Week 2. During this observation it became clear that students were struggling with morphemic analysis, and they said it was the most complex layer of the chart. For example, the key vocabulary word was *fault*, and neither students, nor the Treatment Teacher identified it as a root word. Instead, she encouraged students to use the dictionary and find Greek or Latin words related to the key vocabulary word. One student's question led to the following exchange:

Student: "I don't know what to do" [in reference to morphemic analysis]

Teacher: "Look at the word and find a prefix and a suffix."

Student: "I don't even know what that means."

Teacher: "If you came to class every day, you would know."

Similar to this question, another student asked: "Is *index* a prefix or suffix [in reference to the word *index*]?" The Treatment Teacher responded, "Read the questions and figure it out."

This was not a representative reflection of the instructional sessions, but the lack of further guidance allowed more students to continue being confused and rely more on the dictionary for assistance.

In the semantic layer portion of the chart, students asked the Treatment Teacher for more support, as it is shown in the following conversation:

Teacher: "Well, you do know what fossils are, right?"

Student: "Yes."

Teacher: "Well, where do you find fossils?"

Student: "At an archeological dig."

Teacher: "So that could be a word you can relate to."

In the paraphrasing portion of the chart, the Treatment Teacher closely followed the chart's training. For example, the impartial observers took notes on the Treatment Teacher's use of several examples, and encouraging words for students. As a replay, about 16 of the 25 students in the classroom participated by sharing answers and asking questions.

In the sentence generation portion of the chart, the participants were very anxious. They had questions about how to begin a new sentence, and how to use the new word. The Treatment Teacher used the training she received, and told the students what the first word should be. She explained to them, that this measure might help them, as they are just getting used to the VTC, but that the following week, they would complete each layer independently.

In the larger concept portion of the chart, the Treatment Teacher did not use the training she received. She relied on her own views on how this layer should be taught, and told students to use the textbook to find the answer. This practice was not in alignment with the researcher's training, or with a strategy that would allow for conceptual understanding of the new word.

During the remaining class period, it was clear that many students turned in incomplete work. Only a few continued to be engaged with the work or asked questions. At the end of this observation, the researcher had the opportunity to speak privately with the Treatment Teacher. She asked her about the students who worked in a group of four that had succeeded in finishing the chart. The Treatment Teacher responded that although the group had succeeded with the chart, they were "slow readers." The researcher did not have enough time to ask her what she meant by "slow readers."

Week 3. This week included the visit of the two impartial observers. At the beginning of this observation, it was clear that the dynamics of the classroom has changed significantly. One half of the students were seated individually to work on the chart, and the other half of the class was seated in a single large group. When the researcher asked the Treatment Teacher the reason for this change, she stated that the seating was according to their preference. Before the beginning of the chart activity, the Treatment Teacher asked students to have their textbooks and dictionaries available.

At the beginning of the activity, it became clear to both observers that students still struggled with the morphemic analysis layer. The key vocabulary word for the observation was *period.* A conversation about this word followed:

Student: "How about the word, *period*?"

Teacher: "In this case, the word part, *per* is a prefix."

Students continued struggling with the word, asking each other questions about how to find that information in the dictionary. One student, in particular, was sitting alone and had not completed any layers of the chart.

According to both observers, only some students struggled with the semantic analysis layer. Observer A said that many students just used the textbook's index to find the new word and some other words that related to them. Other students, whom the observers assumed had larger vocabulary, did not use the index.

According to Observer A, more students continued to struggle with paraphrasing, and received little support. However, more engagement occurred when students were completing the sentence generation layer, and they had several questions and words to add to the sentence. According to Observer A, the chart had become a skill rather than a strategy.

Both observers were in agreement about the sentence generation and larger science concept layer. According to them, the Treatment Teacher should have played a larger role in helping students complete these layers. For example, Observer A said that the Treatment Teacher should have shared examples of different sentences, and taught students about word families. In this context, word families would have been an effective scaffolding strategy for students to learn about larger science term.

During the same observation, Observer A raised several questions about classroom management. These concerns included time spent completing the chart, dealing with students who were off-task, and minimizing distractions.

Observer B had similar notes; however, she also raised the question of preparation time; in her view, students did not receive enough instruction on the chart before they were asked to work individually on it. This is the reason, according to her, that students were struggling with morphemic analysis and semantic analysis. Additionally, she believed that the lack of teacher mentoring, content knowledge, and morphemic analysis had become an obstacle to student learning. Observer B arrived at this conclusion because of her observations and brief experience with the chart. During the observation, she commented, “This chart is complex, and it requires the teacher to really know her stuff” [content knowledge].

Observer B raised questions about classroom management and the teacher’s ability to deal with student distractions. For example, during one of the researcher’s observation sessions, she noted that a student asked about the word, *period*, in reference to a woman's menstrual cycle. Although this question could have had a learning intent, the student posed it to distract the Treatment Teacher and students. Instead of quickly answering the question and moving on, the Treatment Teacher allowed the student to continue with this distraction for several minutes. Observer B also raised issues about the teacher's knowledge in a different sense. She questioned the timing by the Treatment Teacher in releasing responsibility. She wondered if, after releasing the learning responsibility to the students, she should have revisited the topic, re-directed, re-explained, and helped. Additionally, she believed that students who were struggling should receive more guided practice while others could study independently.

At the end of this observation, the Treatment Teacher had a few minutes between classes. The researcher used this time to mention to her that there was no need to add information to the morphemic analysis layer (referring to Latin and Greek words she had asked students to add to the chart). In replying to this comment, the Treatment Teacher was adamant about the need for Latin and Greek words, indicating that this type of information was valuable to students because they could use it to understand the meaning of other words. Although the Treatment Teacher said that this type of information would aid in students learning scientific words, she did not discuss it with students, and she made no explicit connections between the Greek/Latin words and the key vocabulary words.

Week 4. At the beginning of this observation, the researcher observed the same classroom layout as was in place in Week 4. The same students were seated together in the back of the classroom, and the students who worked individually continued to do so. This means that the Treatment Teacher did very little to promote collaboration among students. To truly promote learning a reading strategy with struggling students, the content area teacher must have a commitment to collaboration (Israel, Maynard, & Williamson, 2013). To contribute to this type of collaboration, the Treatment Teacher could have better communicated to students the benefits of reading and science learning and planned one or two authentic learning experiences that integrated new key vocabulary words and the chart (Williams et al., 2009).

Students worked on the following key vocabulary word, *divergent boundaries.* During this last week of classroom observations many students struggled with morphemic analysis. It was evident that students had difficulties because they asked questions and made comments such as "How do I break down this word?" "I cannot find the prefix and suffix," and "I don't know where to begin." Most of these questions came from the same students who had been struggling from the beginning of the study and were seated alone. The students who were seated in a small group struggled less, possibly because they asked each other questions or directed these questions to the Treatment Teacher and shared the information with the group.

When the teacher noticed that most students were struggling with the first layer of the chart, the teacher wrote the following information on the board in reference to the word, *divergent*: "The word part *di* means twice, and *apart* means not opposite."

She also wrote that *vert* means turn and that *div* means to split in parts. All the students recorded the information, and the teacher asked them to continue completing the chart. This classroom practice was not in accordance with the training sessions in which the researcher asked the Treatment Teacher to use the resources available to make connections on how this information can help students understand the key vocabulary words.

In the paraphrasing layer, many students used the dictionary to find similar words. One of the students, who was a second language speaker, struggled particularly with this part of the chart and was using a dictionary. However, the Treatment Teacher and the student did not notice that she was using an English-Spanish dictionary, and, therefore, could not find any synonyms to paraphrase. After a couple of minutes, the student moved on to the next layer of the VTC.

The students who were seated in the large group, i.e., they joined classroom desks and formed a pod of four students, quickly completed their VTC. Though some students who worked individually were also successful, others struggled with the task and were given additional time to finish the chart. After this observation, the researcher shared a few comments with the Treatment Teacher. She suggested timing the chart activity to minimize student distractions and because students were now familiar with the chart. The Treatment Teacher agreed.

Week 5. On this observation day, the class was extremely distracted by a hurricane drill. As expected, students seated in a group quickly directed their attention to the task and began working on the chart. Other students who were working independently struggled with finding their charts and dictionaries.

During this classroom visit, the researcher heard several questions directed to the Treatment Teacher about the purpose of this chart, how long they would be using it, and why. The Treatment Teacher did not take time to explain to students how the chart might benefit their understanding of new science-related words, or for how long the study would last. Her response was that the chart would be used until the study was complete. This response was not a reflection of the emphasis discussed in the training sessions. In those sessions, there were discussions about the purpose of the VTC, how to use it, how to establish the connections between reading and science learning and vocabulary instruction, and the role vocabulary plays in scientific understanding.

After this brief session of questions, students did focus on the task. The large group of students who usually worked together (group of four students) continued to work on the chart and write extra information in the morphemic analysis layer. Extra information was sought at the Treatment Teacher's behest, i.e, the Latin or Greek word origin found in the dictionary related to the key vocabulary word. In the other layers, students worked quietly, as usual, on the chart with one exception. In the sentence generation layer, students were excited to share their sentences and how they were able to use the key vocabulary words.

After approximately 20 minutes, the group of four students had completed the chart, but students who worked individually were still struggling to complete it. Much like the other weeks, the Treatment Teacher allowed students who continued to work on the chart although they were struggling to stay on task. The students who had already finished had quiet side conversations as they waited for the rest of their peers to complete the chart.

Classroom Artifacts: Phase II of the Study

Week 1. In the first week after students began working in the chart independently, there were few differences in Phase II classroom artifacts from those reviewed in Phase I. For example, in the case of the word, *extinct* (see Appendix S), students had only two different sentences:

1. "Dinosaurs are extinct but their fossils show proof of their existence."
2. "Paleontologists have studies fossils of ancient organisms."

A brief analysis of these two sentences show a great interference of the Treatment Teacher because of their high reading level. Sentence 1 has a FKRE score of 50 which means that it is fairly difficult, and that students with some high school experience would understand it well. Sentence 2 has a score of 8 which means that it is very difficult and that students with a college degree would understand it well.

Much the same, in the case of the key vocabulary word, *evolution* (see Appendix T), students wrote the following sentence: "The paleontologist discovered a fossil that showed evidence of the evolution of today's whale from a land animal." According to the FLRE score chart, a score of 8 indicated the sentence to be very difficult, and that readers who have a college degree would understand it well. Such high reading scores implies that in Phase II of the study students continued to rely on the Treatment Teacher to avoid “kindergarten” sentences.

In terms of the larger scientific concept, students continued to rely on the textbook as evidenced by the fact that all students used the textbook’s heading where they found the key vocabulary word. This implied that students did not take the opportunity to analyze similarities among different science-related words. Rather, they simply relied on the textbook.

Week 2. Analysis of artifacts from this week showed major differences in students’ development, understanding of the chart, and ownership of their work. For the first time, the researcher noticed several different answers and more input from students.

In the case of the key vocabulary word, *index fossil* (see Appendix U), it continued to be clear that the Treatment Teacher was influencing the outcome of the morphemic analysis layer. All students wrote that the word part, *in*, means inside. However, there were major differences in the sentence generation layer. All the different sentences were much simpler and easier to read. For example:

1. “Certain fossils, call index fossil, help geologists match rock layers.”
2. “The index fossil was very old.”

According to the FKRE analysis, sentence 1 received a score of 61, which means that it is fairly standard, and that most seventh- and eighth-grade students could understand it well. Similarly, sentence two scored 73 in the same assessment, which also means that seventh- and eighth-grade students should be able to understand it well.

Although these sentences did not reflect a deep understanding of the vocabulary words, as in the prior examples, they did show more ownership and less interaction with the Treatment Teacher. Another example was: "We went through a long era of time from the wheel to the car." This sentence scored a 93 in the FKRE. According to the FKRE score chart, 93 stood for very easy and students with a fifth-grade level would understand it well. This is another example where students appeared to have been more likely to have written the sentence without assistance from the Treatment Teacher.

Week 3. Analysis of the classroom artifacts from this week showed a certain level of improvement in students' sentences and very little interference from the Treatment Teacher. For example, the first sentence was clearly written by students without the help of the Treatment Teacher because it does not include a definition (as she has recommended many times).

1. "The period of time the dinosaurs lived was very old."
2. "The geologist had to divide Earth's history into periods."
3. "In Antarctica the ice falls from mountains into the water to make icebergs, which is a continental drift."

All three sentences, according to the FKRE score, are classified as difficult and very difficult sentences. Interestingly enough, these sentences do not include definitions, and, seemingly, students did not receive help on them from the Treatment Teacher. Although students succeeded in showing some understanding of these key vocabulary words, others still seemed unclear about them, as was evident in the case of the key vocabulary word, *uniformitarianism.* This term was already used in phase I of the study, but the Treatment Teacher chose to use it a second time because of the significance of the word, to students' understanding of the chapters. Although apparently complex sentences (FKRE score of 24), the following examples do not clearly show students' understanding of the word:

1. "The paleontologist was trying to find a new way to define uniformitarianism."
2. "Scientists make inferences about Earth's past as the principle of uniformitarianism."

Further analysis of the chart showed that most students continued to rely on the science textbook to select the larger science concept. Only a few students began selecting terms that were not directly used as a textbook heading. For example, in the case of the key vocabulary words, *continental drift* (see Appendix V), some students began to write down different words such as *movement* and *change* besides *earth's surface* (as usual) and *plate tectonics.*

Week 4. Much like the prior week, students continued to follow the Treatment Teacher's mentoring to complete the morphemic analysis layer. For example, in the case of the key words, *divergent boundary* (see Appendix W), students wrote the following information:

"*di*- two, twice, apart, not to the opposite; and *vert*- to turn."

This performance was not a reflection of the training sessions, and it was not discussed by the researcher with the Treatment Teacher. Although the researcher briefly discussed these differences with the Treatment Teacher, she resisted changing her instruction practices where vocabulary instruction was concerned, and she struggled with embracing the VTC. According to her, this information helped students understand the meaning of the key vocabulary word(s).

Analysis of data showed that in the semantic analysis layer of the VTC students made several connections to the key vocabulary words. This was different from their work in the prior weeks when they made few connections and their work was similar. For example, some students wrote that *divergent boundary* reminded them of: driver, dive, or dry. Other students made a connection to *detergent*, *boundary*, or *divorce.* Although more students made connections, none of the connections were of a scientific nature.

However, the sentence generation layer continued to show progress. Students' progress in understanding was clear because they created more complex sentences that showed some level of the key vocabulary understanding:

1. "The plates were moving which caused divergent boundaries to form mid-ocean ridges."
2. "Plates move apart, or divergent from each other, forming divergent boundaries."
3. "A divergent boundary made an earthquake appear."

All three sentences should be considered complex according to the FKER test scores. Sentences one, two, and three were considered difficult and very difficult (scores of 43, 33, and 6 respectively). This type of improvement implies that students continued to take ownership of their work, improved their knowledge of scientific word knowledge, and relied less on each other for answering this layer. By having progressively less reliance on each other, students spent less time copying what others wrote and more time on creating their own sentences.

Analysis of the last layer of the VTCs showed very little difference across student artifacts. Students continued to rely on the science textbook to come up with the larger scientific concept. For instance, in the case of divergent boundaries, students continued to write: *earth's history, earth's science,* and *fossil*. These were all textbook headings.

Weeks 5 and 6. These two weeks were combined for reporting purposes because Week 6 was incomplete due to posttesting of students. Furthermore, the posttest was administered immediately after the end of the school's weeklong spring break.

The results, at the conclusion of the study, continued to be very promising. The key vocabulary word, *transform boundary* (see Appendix X), provides a good example. In the first layer of the chart, students maintained their common behavior of adding information to the morphemic analysis. This procedure was promoted by the Treatment Teacher and maintained based on her pedagogical beliefs.

Sentence generation continued to show some improvement. Students continued to produce different sentences that showed some understanding of the key vocabulary word and very little influence of the teacher. Two examples of sentences created by students follow:

1. "The geologists are always studying different types of boundaries."
2. "The idea that the continents slowly moved over Earth's surface became known as the continental drift."

However, analysis of student artifacts showed that students went a step further in this week. They began using more than one vocabulary word in a single sentence. This showed a greater understanding of scientific words, and was suggestive of students making a connection between words. Following are four examples:

1. "The continental drift caused Pangea to split apart and made mid-ocean ridges to form."
2. "Plates shift aside, or diverge from each other at a divergent boundary."
3. "A paleontologist looked in the Mesozoic era for t-rexes."
4. "Before the continental drift the Earth was called pangea."

Although these sentences showed a certain level of vocabulary understanding and complexity, they were also indicative of students' ability to connect a key word to other words discussed during the study.

Summary

The results of this study indicated that the use of the Vocabulary Think Chart did not improve the participating students' understanding of scientific vocabulary. There was only a small difference between the pre- and posttests of students in this regard. In order to evaluate students' progress during the study, the researcher collected two different kinds of qualitative data. The researcher collected classroom observations conducted by two literacy experts, analyzed her personal observations, and analyzed student artifacts, i.e., VTCs.

The lack of significant difference between the pre- and posttest scores in the study led to several questions that could only be answered through an analysis of the qualitative data. The qualitative analysis showed that students (a) needed more time to learn how to use the VTC, (b) needed more direct instruction and modeling, and (c) needed more interactions with their peers. Table 11 contains a summary of the analysis of qualitative data including themes which emerged related to observations, field notes, and classroom artifacts.

The analysis of the qualitative data suggested that students' understanding of the chart was impacted by the implementation of the chart. Teachers need to have a deep knowledge of content as well as knowledge about effective vocabulary instruction in science. Further, the teacher's pedagogical view of vocabulary learning in science classes must be in alignment with the Vocabulary Think Chart. Additionally, instructional tools and practices such as the VTC need to be embraced and practiced over time before they become part of a teacher's pedagogical framework. These results are discussed in detail in chapter 5. Implications for future research, study limitations and recommendations for future research are also presented.

Table 12

Summary of Analysis of Qualitative Data: Impartial Observers, Researcher's Field Notes, and Classroom Artifacts

Source/Week	Impartial Observers	Researcher's Field Notes	Classroom Artifacts
Phase I	• The Treatment Teacher used a vocabulary students might be unfamiliar with, during instruction of the VTC. • Treatment Teacher did not provide enough meaningful examples during instruction of the VTC. • There was sporadic collaboration between students and the Treatment Teacher.	• Inconsistencies were observed between training sessions and classroom practices. • There was some collaboration among students and the Treatment Teacher.	• Students' answers all had strong similarities.
Phase II Week 1	• Only two different sentences were generated. Strong reliance on each others' work and Treatment Teacher support.	• There was more student collaboration during sentence generation. • Inconsistencies were observed between training sessions and classroom practices.	
Phase II Week 2	• Students showed ownership and understanding of the chart. • Many different sentences were generated without a significant reliance on the Treatment Teacher. • Students continued to follow the Treatment Teacher's misunderstanding of morphemic analysis.	• Difficulties with morphemic analysis were related to inconsistencies between training sessions and classroom practices. • Students turned in incomplete charts. • Only a few students collaborated during the classroom discussions by asking questions.	

Source/Week	Impartial Observers	Researcher's Field Notes	Classroom Artifacts
Phase II Week 3	• Students built more complex sentences by adding other science-related words. • Students continued to rely on the textbook for finding the larger scientific concept. • Treatment Teacher continued to struggle with the idea of implementing the chart into her pedagogical framework. • Students began to make connections between the key vocabulary word and other words in the semantic analysis layer of the chart.	• A change in the classroom layout was noted. Some students chose to seat alone and other students seat in groups of four. • The Treatment Teacher faced problems in dealing with distractions.	• Students struggled with morphemic analysis due to some incoherent instruction. • There was not enough support from the Treatment Teacher to students who were still learning the chart. • There was a concern about the amount of time to complete the chart, and classroom distractions. • There was a concern that students did not receive enough instruction on the VTC before Phase II began. • Treatment Teacher was resistant to changes in her classroom practices. • Lack of teacher mentoring could have aided the Treatment Teacher in the task of teaching the chart.

Source/Week	Impartial Observers	Researcher's Field Notes	Classroom Artifacts
Phase II Week 4		• No changes were observed in classroom layout; some students still sat in groups of four, and other students sat alone. • Treatment Teacher did not promote collaboration with and between students. • There was continued concern with morphemic analysis caused by the Treatment Teacher. • There were classroom management problems caused by students finishing the chart at different times.	
Phase II Week 5	• Students created several different and complex sentences. • Some students used more than two science-related words in their sentences. • Other layers of the VTC remained the same.	• Students were very distracted by a hurricane drill. • Students still did not know enough about the significance of the chart. • Students who worked in a pod of four finished the chart in about 20 minutes. Students who worked individually struggled for much longer.	

CHAPTER 5
SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Introduction

This chapter of the dissertation includes a brief restatement of the problem, a review of the study's methodology, and a summary and discussion of the study results. Implications for theory, practice, and research are also discussed, and limitations of the research are recognized.

Statement of the Problem

Although reading has been considered key to academic success, very few gains have been made in improving achievement of students in this area of learning. This is especially true among secondary students who have continued to score poorly in standardized reading assessments (NAEP, 2007). More specifically, only 34% of eight graders and 20 % of twelfth graders fell below the proficient level in their ability to comprehend the meaning of text at their ability level (Lee et al., 2007). Not much has changed in terms of low reading scores, in more recent data. The average reading score of eighth graders in 2011 was only one point higher than in 2009, and only five points higher than in 1992 (NAEP, 2011). The percentage of eighth graders who performed at or above the Basic level has not substantially changed since 2009. Eighth graders also performed poorly in the vocabulary section of the NAEP (2011) reading assessment. The lower performing of fourth and eighth graders who were at or below the 25th percentile in reading comprehension, performed lowest in the vocabulary section. The difficulties with literacy in the 21st century have led about 3,000 students to drop out of high school every year (Alliance for Excellent Education, 2003), and the low performance of U.S. adolescent students has not only been reflected in the high number of students who drop out of high school. Reading scores in the SAT [Stanford Assessment Test] (2012) reached a four-decade low (*Washington Post*, 2013). This implied that gradual decline of college bound students' ability to read passages, answer questions about sentence structure, vocabulary and meaning on college entrance exams.

Because of the need for secondary students' literacy improvement, this study explored a significant need in the field of literacy and science instruction in secondary grades, that of improving students' scientific vocabulary and learning. In a more recent NAEP (2011) reading assessment showed that 45% of twelfth graders do not know the meaning of complex words such as *desolution* and *urbane*. Because of the significant need for more content-related vocabulary instruction for adolescent students, there is a need for more strategies that have the potential to help students transfer shallow word knowledge to deep word knowledge. One such strategy is the Vocabulary Think Chart.

Review of Methodology

The purpose of this mixed-method study was to measure the effect of the use of the VTC in seventh-grade science students' understanding of scientific vocabulary. There were 89 participants involved in the study: 36 students in the treatment group and 53 in the comparison group. Because of student absenteeism on the pre- and posttest days, only 27 students' scores were used in the treatment group, and 37 in the comparison group.

Questions in the pre-and posttests attempted to measure students' understanding of scientific vocabulary through matching key vocabulary terms with textbook definitions. In addition to the pre-and posttests, the researcher collected qualitative data to further understand the quantitative results of the study. The qualitative results shed some light to the Treatment Teacher's adherence to the chart, and participants and the Treatment Teacher's understanding of the chart. There were three different kinds of qualitative results collected: (a) the researcher's field notes, (b) two literacy experts' field notes, and (c) student artifacts, i.e., VTCs completed by participants in the study.

The two different groups received the similar type of instruction and content. The only difference was that the comparison group did not receive any instruction on the VTC, and used different vocabulary instructional strategies selected by the Comparison Teacher. Prior to the beginning of the study, the researcher met with the Treatment Teacher for three one-hour training sessions on how to use the VTC. After this training period, the Treatment Teacher provided the treatment group with a one-week training on how to use the chart. This training included modeling and guided practice. After the first week, students were required to use the VTC as a post-reading activity, individually or in groups, for five weeks. The comparison group followed the same science curriculum, without the use of the VTC.

During the experimental phase of the study, the researcher conducted weekly observations of the treatment group and one observation of the comparison group. The literacy coaches (independent observers) conducted two observations of the treatment group. At the end of each week, the researcher collected the completed charts. The Treatment Teacher used the chart at least three times a week as a post reading activity and as the only vocabulary instructional activity.

Summary of the Results

This study used the pre- and posttest scores of the 64 seventh grade science students, to measure any improvements in their understanding of scientific vocabulary. To measure this possible difference, the pre- and posttests were analyzed using an ANOVA that indicated two results:

1. Based on the pre- and posttest analysis, there was no impact on the learning of scientific vocabulary after the use of the VTC;
2. Based on the analysis of quantitative data, there was some improvement in students' use and understanding of the science-related words.

In addition to the quantitative results, the researcher and two impartial observers collected observation notes and student artifacts for the purpose of examining the implementation of the VTC and the students' experiences with it. According to the recommendations given by the impartial observers, the Treatment Teacher should have: (a) invested more time in modeling the use of the VTC; (b) prioritized engagement among students with science-related word learning; (c) followed the researcher's recommendations on how to complete each of the VTC's layers. Based on an analysis of classroom artifacts, (a) students relied strongly in engagement among themselves to complete each layer of the VTC; (b) students improved their sentence generation skills throughout the study, as their sentences became more complex and students became more independent from the Treatment Teacher support; and (c) students made very little progress in terms of morphemic analysis, and larger science concepts because of the Treatment Teacher's lack of focus on these layers.

Discussion and Interpretation of the Findings

Although this study did not yield particularly significant quantitative results, it unearthed additional information as to how teachers can facilitate vocabulary learning in secondary science classes. Thus, interpretations of these results are included in this section. Particular attention is placed on the population served in this study, teacher implementation of the strategy, and the type of vocabulary instruction needed in middle school science classes.

Pre- and Posttest Vocabulary Assessment Scores

There was a small increase in the posttest scores of the treatment group, but not enough to be considered significant, in this study. There are several factors that may have contributed to this result: (a) Treatment Teacher support during the study; (b) Treatment Teacher's attitude towards disciplinary literacy or the VTC vocabulary instruction; (c) VTC instruction: length of the study and as a result of the Treatment Teacher instruction; and (e) student motivation.

Support for the Treatment Teacher During the Study

This study's findings showed unequivocally that the Treatment Teacher needed support during the study. Based on classroom observations of the VTC instruction the Treatment Teacher provided, it was obvious that the training sessions were insufficient in preparing her to implement the VTC in her class. The Treatment Teacher needed more support from a reading coach and/or more instructional materials. The support from a reading coach could have come in the form of more modeling, answering questions that the Treatment Teacher might have, and mentoring to simply share successes and difficulties. Some instructional materials that might have been useful include practical books on vocabulary instruction for secondary students and academic articles with steps on how to teach secondary vocabulary instruction. This finding is consistent with many studies (Bryk & Schneider, 2002; Elmore, 2004; Guskey, 1989; 2002; Lesaux et al., 2010; Marsh et al., 2008). In these studies, secondary teachers claimed that instructional materials are pivotal when initiating a new instructional strategy. According to these researchers, instructional materials are necessary because of their realization that instructional strategies are not one-size fits all. As seen in this study, some students might quickly understand the VTC and others might struggle. Thus, having more supportive materials on the topic of reading strategy instruction, might aid with possibly scaffolding or making the strategy more challenging. For example, in Lesaux et al., (2010), teachers claimed that all the support they needed during the treatment was scripted lessons.

Researchers also showed that teacher support in the form of having department co-plans, professional development geared toward vocabulary instruction, and discussions with their peers during the study can also play a significant role in a teacher's transition to a new instructional strategy. Informal collaboration could have played an important role for the Treatment Teacher in the sense that she could have asked other teachers how to deal with questions students might have or in the sharing of ideas. Support from a literacy coach could also have provided her with the opportunity to discuss how to fit the VTC into her science instruction, more opportunities to practice and receive feedback before instruction, and develop ownership in the use of the chart. Other teachers claimed they received more support from a program specialist, someone designated to provide formal aid during the process of implementing a new instructional strategy. The need for teacher mentoring when first introducing literacy practices in content area classes, was further supported by Hall and Piazza (2008) who suggested that it is difficult for teachers to implement literacy practices with students if they do not receive mentoring.

Treatment Teacher's Attitudes Toward VTC Instruction

Although theorists and researchers have modified their views to recognize that science is not only a mathematical process but also a discipline that involves reading and writing (Gee, 2004; Hapgood & Palincsar, 2007; Saul, 2004), many science teachers have little knowledge on how to implement this disciplinary infusion (O'Brien et al., 1995; Wellington & Osborne, 2001).

Most researchers agree that content area teachers chose not to incorporate literacy in instruction for different reasons: (a) not enough time; (b) not their responsibility to teach reading skills (Alger, 2007; D'Arcangelo, 2002; Hall, 2005). Alger's 2002 study illustrates this issue. Her research indicated that because students could not be expected to complete reading assignments independently, content area teachers could use strategies to decrease and ameliorate the necessity of reading (Reidel & Draper, 2011). In other words, content area teachers often use reading strategies as "workarounds" and to "decrease the amount of reading" (Alger, 2002; Reidel & Draper, 2011).

The efforts to prepare content area teachers to infuse literacy in the content areas are focused in pre-service content area literacy courses (Hall, 2005). Although these courses can change preservice teachers' attitudes toward literacy and content area learning, they do not transfer to classroom practices. Thus, Hall (2005) posited that the focus of content area reading courses should progress from a general perspective to a more specific. The need for more focused literacy courses for content area teachers has been further supported by the work of Shanahan and Shanahan (2008), Applegate and Applegate (2004), and Draper (2008). They posited that teachers' beliefs toward literacy and content area instruction can significantly impact the motivation and level of engagement among students. These authors' findings resonate with the findings in the present study, because the Treatment Teacher was very resistant to the use of the VTC. This resistance may have negatively impacted student engagement and motivation about the VTC.

Because the VTC did not seem to fit into the Treatment Teacher's pedagogical framework for science learning, the use of the chart did not become part of her classroom practices. Instead, the Treatment Teacher conducted a "staged delivery" of the use of the VTC, rather than allowing the chart to become part of everyday science learning. The term "staged delivery" means that the Treatment Teacher was only using the chart because of the study, and not because of her own desire to add the VTC to her classroom practices. The same lack of the Treatment Teacher's interest in the VTC was evident when the she asked the researcher to prepare the teacher model charts due to lack of time.

Vocabulary Think Chart Instruction

The kinds of instructional practices used by the Treatment Teacher to teach the VTC may not have been in alignment with the most effective research practices when teaching new vocabulary. These differences may have occurred because of the short amount of time for training on the VTC prior to the study and the Treatment Teacher's resistance to the intervention. In reality there are specific practices teachers should conduct when trying to improve literacy in adolescent students (Kamil, 2008). Kamil made four recommendations for teachers who are conducting explicit vocabulary instruction: (a) dedicate a portion of regular classroom lessons to explicit vocabulary instruction; (b) provide repeated exposure to new words in multiple contexts, and allow enough practice sessions; (c) give sufficient opportunities to the use of new vocabulary in a variety of contexts, including discussions, writing and extended reading; and, (d) provide students with strategies for becoming independent vocabulary learners.

The components of effective reading instruction should have the following components: (a) teacher modeling the strategy into action, (b) collaborative use of the instruction, (c) guided practice with gradual release of responsibility, and (d) independent use of the instruction (Baumann & Kame'enui, 2010; Duke & Pearson, 2002). As discussed by the impartial observers involved in the present study, and as shown in the researcher's field notes, the Treatment Teacher did not provide enough meaningful examples during the VTC instruction and did not promote collaboration among students and with her during the treatment phase of the study. Furthermore, according to the impartial observers, one week of training prior to use of the chart by students was not enough time. Thus, the lack of these components may have negatively impacted the results of this study.

Student Motivation

Student motivation plays a significant role in reading among adolescent students (Guthrie, McRae & Klauda, 2007; Mol & Bus, 2011; Wigfield & Guthrie, 2007). In these studies, it was ascertained that reading motivation plays a significant role in the amount or breadth of students' reading comprehension. When discussing reading motivation, it is noteworthy to mention the difference between intrinsic and extrinsic reading motivation. Intrinsic motivation deals with a desire to read due to an individual interest in a particular topic; while extrinsic reading motivation deals with reasons that are external (Schunck et al., 2008). Extrinsically motivated readers are usually energized by strategies such as trying to get positive outcomes or trying to avoid negative ones

(Wigfield & Guthrie, 1997). Similarly, extrinsic motivation might include the desire to get good grades, receive praise from the teacher, or outperform classroom peers.

The Treatment Teacher did not implement any classroom practices to motivate and engage students with the VTC. These activities include: (a) relevance, to foster intrinsic motivation; (b) student choice, to foster intrinsic motivation; (c) success, to build self-efficacy, and (d) collaborative structures (Guthrie, McRae, & Klauda, 2007; Schiefele, Schaffner, Moller, Wigfield, 2012). Although students decided to work in small groups and collaborate with each other, their engagement was not in word learning. This lack of engagement in word learning allowed students to focus on side conversations rather than focus on the chart. Collaboration between students in word learning could have helped in students' learning new science-related words, as discussed previously. Peer conversations, which occurred while students were completing the chart, would make these words more useful (Frey & Fisher, 2010). Authentic conversations among peers, or authentic conversations that include the teacher, could provide peers with alternative models for understanding the text as well as authentic examples of using key vocabulary words in the content area context (Oster, 2001; Wilhelm, 2001).

Connection of the Current Study to its Theoretical Framework

The present study was supported by three different theoretical frameworks: (a) schema theory; (b) depth of level theory; and (c) zone of proximal development theory. Each of these theories guided the interpretations of this study's results.

According to Anderson and Pearson (1984), schema theory asserts that readers need to bring something to the reading process to achieve comprehension. Schemas, as explained by cognitive psychologists, are representations of experiences and knowledge one carries (Harris & Hodges, 1985). In this study, low background knowledge on the VTC played a significant role in the vocabulary learning process for students. Students' low amount of experience with the VTC, in combination with the Treatment Teacher's instruction of the chart, made it difficult for them to develop new schemas.

Students' experience with the VTC increased throughout the study, as they were exposed to the use of the VTC with several different science-related words. Students' increasing experience with the VTC became clear through the analysis of classroom artifacts. As the study progressed, students were able to create more complex sentences that included other science-related words, and did not rely entirely on word definitions. Thus, the VTC provided students with the opportunity to make connections with what they already knew and just learned, thereby improving their science-related vocabulary. Improvement in students' knowledge of science-related words can be helpful for students, since knowing more words might facilitate the understanding of scientific-texts (Guzzetti & Bang, 2011).

The depth of level of theory (Craik & Lockhart, 1972) was also strongly represented in the current study. This theory asserts that the more cognitive energy a person exerts in learning vocabulary, the more likely they will be to remember it and use it later. This theory related to the current study in the sense that the VTC required students to have a deep engagement with each new science-related word. Once students worked in all the layers of the VTC they were more likely to use these words again. Students' engagement with the chart could have been more advantageous; however, their engagement was negatively impacted by the Treatment Teacher's presentation and support for the use of the VTC. This was represented in the analysis of observations during the treatment phase of the study. As discussed previously, the Treatment Teacher did not provide students with enough meaningful examples of the use of the chart. Neither did she promote collaboration among students. Finally, the period of time for learning how to use the chart independently was insufficient for students to master the intervention.

Even though the Treatment Teacher impacted somewhat negatively students' engagement with the chart, some student progress was noticeable in students' classroom artifacts. As the study progressed, students were able to show a higher number of connections among the key vocabulary word(s) and other science-related words. The classroom artifacts showed that throughout the study students were capable of creating more complex sentences that also incorporated other science-related vocabulary words.

Although some progress was made towards students' scientific vocabulary comprehension, more could have been accomplished based on the depth of level theory. In this regard, students may have been able to make more connections among words if they had spent more time on the layer that involved the larger scientific concept. Furthermore, the Treatment Teacher could have provided more modeling of the use of the VTC, providing support and feedback to students during the treatment phase. For example, the Treatment Teacher did not follow the researcher's training recommendations for the larger science concept layer instruction. Instead, the Treatment Teacher relied on the science textbook to locate other science-related vocabulary words in the same chapter of the key vocabulary word. According to her, using a science textbook heading was a larger science concept. Consequently, students relied heavily on the textbook to complete this layer in the chart.

Another theoretical framework that helped explain the results of this study was the zone of proximal development. This framework originated from Vygotsky's (1978) work on the socio-cultural theory and has been used to interpret students' developmental and potential levels. To facilitate this process, teachers often use scaffolding (Vygotsky, 1978). This theory is useful in explaining the analysis of students' reactions to the use of the VTC at the beginning of the treatment phase and towards the end of the study.

In the first phase of the study, the Treatment Teacher should have used more modeling, guided practice, and more examples to scaffold students' understanding of the VTC and prepare them to use the chart to learn scientific vocabulary. Although these practices did occur during Phase I of the study, the analysis of the observations conducted by the literacy experts and the researcher, showed that these practices should have continued for a longer time. Students needed reviews during the study on how to complete specific sections of the VTC. In the second phase of the study, because students still lacked more scaffolding practices before working independently, they relied on each other for feedback. Classroom observations showed that students who sat in a pod of four students used this opportunity to exchange ideas with each other and were able to complete the chart.

The zone of proximal development was also useful in understanding and interpreting the Treatment Teacher's Practice during this study. Because students were new to the use of the VTC, the Treatment Teacher should have provided help for students to reach their full potential. The Treatment Teacher could have given students verbal praise for their progress, given them personal feedback to their questions, and provided an example of a completed chart for students during the treatment phase of the study.

The Treatment Teacher could also have given more support to students who were struggling with the chart. During Weeks 4 and 5 of the study, some students successfully completed the VTC in about 20 minutes, but others struggled during the entire class period (45 minutes). These students often struggled with the morphemic and semantic analysis of the layers. Because the Treatment Teacher's classroom practice differed from that which was recommended in her own training, more students struggled with these layers. Overall, the Treatment Teacher should have provided them with more modeling, and guided practice, and collaboration among students, to instruct them on these specific layers.

Recommendations for Educators

Every year, more researchers report the need for providing adolescent readers with quality effective vocabulary instruction to help them read and understand the various challenging texts they encounter in science classes (Carnegie Council on Advanced Literacy, 2010; McKeown et al., 2009). Effective science instruction must include instruction on expository texts, and the language through which science is constructed and communicated (Fang, 2008) as well as prepare students to meet the learning demands of each discipline or content area (Hand et al., 2003; Norris & Phillips, 2003; Saul, 2004). The lack of significant growth in participating students' understanding of scientific vocabulary warrants more science-related literacy instruction. Many students struggle with academic vocabulary and comprehension of expository texts as they transition from early grades to upper grades (Carrier, 2005).

The participants in this study were seventh-grade students. Providing them with effective vocabulary instruction that will support their comprehension of disciplinary texts will prepare them for high school science learning and will increase their college and career readiness (Yerrick & Ross, 2001). Thus, secondary science teachers need to offer effective vocabulary and comprehension instruction for adolescent students. To do so, they cannot only rely on just one source of instruction, such as the science textbooks. Currently, science textbooks provide students with only a few literacy exercises (Montelongo & Herter, 2010). Because of the lack of literacy instruction in science textbooks, many science teachers have successfully incorporated strategies such as using trade books, providing writing opportunities, or integrating concept-oriented science instruction (Guthrie et al., 2000; Keys, 1999; Morrow et al., 1997) to science learning.

In order to effectively incorporate these strategies, secondary science teachers need to develop their knowledge about effective science instruction that incorporates scientific vocabulary and comprehension learning. They need to model how to analyze words, learn about morphology, peer collaboration, and consolidation of students' word learning through individual authentic activities. Additionally, science teachers need to find ways to motivate students to understand and use science language. Because science teaching and learning are complex processes and many students have unique learning needs, teachers could benefit from support from literacy experts or instructional coaches and from peer support in Professional Learning Communities (PLCs). The instructional coach can play an important role in modeling, supporting, and providing science teachers with guidance and resources on how to integrate science-specific literacy in science classes. Additionally, PLCs can facilitate this process through collaborative teacher support and problem solving about instructional challenges.

Limitations of the Study

There are several limitations associated with the current study. First, the small number of participating students could have influenced the results of this study. Participants in the study were drawn from a convenience sample of existing classrooms in the participating school. The researcher had no comparison over the participant groups (comparison and treatment) or the participant teachers regarding their roles as Treatment Teacher and Comparison Teacher assignment process. All the students in the regular science classes at the study site participated in the study.

Second, the pre- and posttest instrument used in the current study was not in alignment with the VTC. The VCT is a complex chart with several layers that include morphemic analysis, semantic analysis, paraphrasing, sentence generation, and larger scientific concept. The instrument used in the study, however, consisted only of matching the definitions and the key vocabulary words. The Treatment Teacher used this type of instrument because she used a textbook CD with these questions and believed that other types of questions, i.e., sentence completion, and comprehension questions, would be too challenging for students attending regular science classes. Additionally, for fidelity purposes, the science department had decided, as a whole, to use only textbook tests to assess students' science learning.

In regard to the different phases of the study, there was not enough time to prepare the Treatment Teacher for the study. The researcher had access to the Treatment Teacher on three separate days before the beginning of the study. This was not enough time to instruct her in all the independent layers of the chart, and this was evident during the treatment phase of the study. Also, the Treatment Teacher was very hesitant to add constructing the chart into her daily work practices, and she asked the researcher to prepare the chart for her every week. According to the Treatment Teacher, constructing the chart would require her to prepare all of the elements of the vocabulary instruction necessary for using the VTC.

The Treatment Teacher represented a limitation for three different reasons. First, the Treatment Teacher's pedagogical view of vocabulary learning in science classes was not in alignment with the use of the VTC. Because of this disconnect, the Treatment Teacher treated the VTC as a stand-alone activity rather than as an integrated practice to support science learning (Bean & Harpor, 2006; Moje & Wade, 1997; O'Brien, Stewart, & Moje, 1995; Pearson, Moje, & Greenleaf, 2010). Secondly, the Treatment Teacher did not volunteer to participate in the study. She was approached by the researcher, as oppose to expressing interest in learning about vocabulary instruction. If the Treatment

Teacher had been invested in the study, a different outcome might have been possible. Additionally, the Treatment Teacher only received an informal training on the VTC from the researcher. It would have been more consistent with the study's rigorous methodology to develop a more formal and more extensive training on the VTC. This might have interfered on how the Treatment Teacher taught the chart to the participants of the study.

The researcher also represented a limitation to the study when she assumed the role of observer. The researcher may have come into that role with expectations on how the Treatment Teacher should act during the VTC instruction, how she should answer students' questions, and how should she promote peer collaboration. The researcher developed these assumptions based on the training she provided the Treatment Teacher on the VTC. The researcher may have been influenced by her worldviews and pedagogical beliefs about vocabulary instruction in her field notes, and her presence in the classroom may also have caused changes in students' behavior, consequently altering the data collected during observations. Some students could have acted, or asked questions that they thought reflected what the researcher was studying. Similarly, the researcher's pedagogical beliefs about vocabulary instruction may have impacted the qualitative analysis of this study.

The students did not have enough time to learn how to use the VTC independently. This study's methodology allowed one week for training the students that included modeling and guided practice before working independently with the strategy. At the beginning of the treatment phase of the study, students were hesitant about working independently and were heavily dependent on the Treatment Teacher. This was evidenced by the questions students asked at the beginning of the treatment phase such as "What is morphemic analysis?" and comments like "Please don't make us do this by ourselves." More modeling and guided practice would have been beneficial for students. Because the Treatment Teacher was faithfully following the study protocol; however, she did not offer more modeling and guided practice to students.

The length of the study might also have negatively impacted the study results. Students were only exposed to the VTC for six weeks, and this was insufficient for them to learn how to complete each layer. Ideally, students would have used the chart for at least 12 weeks which would have permitted them to learn how to use the chart and incorporate it to their daily classroom practices.

Recommendations for Future Research

Future researchers should consider a larger sample of participants for this type of study. This population, i.e., age group, is unique, and many classroom management problems can arise. Thus, it would be more effective to have several treatment groups. The treatment groups should have fewer students, thus enabling the Treatment Teacher to better individualize the intervention. A larger sample size would also make the study results more generalizable and yield a more accurate picture of adolescent science students and their successes and challenges with science learning.

Future researchers should also collect additional sources of information about the reading levels of participating students. In the current study, the only measurement prior to the beginning of the study used to establish students' reading skills was the students' performance on the FCAT. Future researchers should use consider using additional means of measuring student performance, e.g., the Florida Assessment for Instruction in Reading, Qualitative Reading Inventory, to establish the participants' literacy skills.

Teachers will often need more than three days to learn about the VTC, and how to implement it in accordance to Fang's (Fang et al., 2010) recommendations. Because the chart is fairly complex and multi-layered, science students often need more time to incorporate the use of the VTC to their science learning practices. In addition to modeling the use of the VTC, teachers should receive a written script to guide them in presenting the VTC to their students. The written script might diminish any procedural questions teachers have when first using the chart. This measure would also insure that teachers would use the VTC as prescribed by the researcher. Along the same lines, once the study begins, future researchers should provide some form of support for teachers. This type of support must come from an expert in the VTC who can model adequately how to use the chart, give demonstration lessons, and address questions teachers might have. This support would aid teachers in developing ownership of the strategy and implementing it with fidelity in their classroom practices.

Similar to teachers, students may need more than six weeks to develop sufficient knowledge about how to use the VTC to develop students' scientific vocabulary development. Thus, future researchers should consider a longer period for training, support, and implementation, so that students actually learn how to use the chart. In terms of the VTC's instruction and use, future researchers should also consider student-to-student collaboration. Although there was some level of student collaboration during the current study, it was not structured, promoted, or encouraged by the teacher. Thus, future researchers should include this practice during the study so that students can exchange ideas and learn from each other, and teachers can learn more about the benefits of collaborative learning.

In reference to the quantitative results of this study, future researchers should make some changes. Future researchers should consider using a different instrument than the one used in this study. The instrument used in this study only included a matching activity to measure students' improvement in science-related vocabulary words. However, the VTC chart required students to use a variety of vocabulary learning skills including paraphrasing and generating new sentences. Consequently, future researchers should attempt to use an instrument that includes the same activities students are required to complete in the chart. This process would paint a more accurate picture of the impact the chart had in students' learning of science-related words. Last, the administration of the posttest should be established with care and in consideration of the district's academic calendar. In this study, the posttest was administered immediately after the Spring Break. Future researchers should select a date so as to avoid the possibility of negatively impacting student performance.

Summary

This study was conducted to explore the impact of the VTC on seventh-grade science students' understanding of scientific vocabulary. The goal of this study was to provide students with an intervention that would facilitate the acquisition of science-related vocabulary in middle school classes. Because the VTC is such a complex chart, much care must be given when selecting what instructional practices should be associated with the use of this intervention.

The Treatment Teacher played a significant role in this study. She did not receive enough training before using the chart. Although she was somewhat excited about participating in the study, she did not have a lot of time available for her to develop adequate knowledge of the VTC. Secondly, the Treatment Teacher deviated from the training received from the researcher before the beginning of the study. She did not teach students how to do morphemic analysis and semantic analysis as she was instructed by the researcher. Also, she did not provide students with enough meaningful examples during the VTC instruction, and guided practice while students were working independently.

The instrument used in the study was a teacher-made test that was not in alignment with the VTC. The VTC is a complex chart, composed of several layers of discipline-related vocabulary instructional strategies, and the teacher-made test was not. The Treatment Teacher created a test based on the question bank available in the science textbook, with only matching activities. An instrument that included the different layers of the VTC would more accurately represent students' understanding of the chart. The participants in the study took the posttest when they returned from Spring Break. This could have influenced the results of the study, because students had a week-long span of time when they had not been using the VTC.

The significance of this study stands on the need for consistent, complex and effective science-related vocabulary instruction for middle school students. Although this study did not yield fruitful quantitative results, it brought to light the significant need for change in vocabulary instruction in science classes. The students in this study will be exposed to increasingly more complex science classes and need to be prepared with vocabulary knowledge and skills to help them understand the challenging texts they will be asked to read. Thus, although this study could have invested more in student and teacher preparation for the intervention, it shed some light on the need for more science-related vocabulary instructional interventions. As discussed in the qualitative analysis, students were not familiar with vocabulary learning strategies, and were not used to classroom practices that require collaboration for word learning. Further, the Treatment Teacher was not familiar with the layers in the VTC, and her views on vocabulary learning were disconnected to the most effective word learning strategies.

APPENDIX A
VOCABULARY THINK CHART

Questions	Answers
1. What is the target word?	
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	
4. How is the word defined in the text? Can you paraphrase this definition?	
5. Can you come up with a sentence in which the target word is used in the scientific sense?	
6. This word is part of which larger science concept? What are some other words related to this larger concept?	

APPENDIX B
FIDELITY OBSERVATION PROTOCOL

Observation Fidelity Protocol

Observer Name: ______________________________

Date: ______________________________

Class observed: ______________________________

Direction: Please check where appropriate and add comments where necessary.

Components	1-Not appropriate	2- Fairly appropriate	3- Appropriate	5- Comments
Morphemic analysis				
Semantic analysis				
Paraphrasing				
Sentence Generation				
Larger Science Concept				
Teacher provided meaningful examples for each part of the chart				
Teacher provided an appropriate amount of examples for each part of the chart				

APPENDIX C
CONTENT VALIDITY CHART

Observer Name: ___________________________________ Date: ________________

Assess the following test to insure that each vocabulary word was properly assessed, for seventh-grade science students. .

Direction: Check the appropriate box in reference to each vocabulary word.

Vocabulary	**1- not appropriate**	**2- fairly appropriate**	**3- appropriate**
Fossil			
Mold			
Cast			
Carbon Film			
Paleontologist			
Evolution			
Extinction			
Relative Age			
Absolute Age			
Law of superposition			
Extrusion			
Intrusion			
Radioactive Decay			
Era			
Period			
Continental drift			
Pangaea			
Divergent boundary			
Convergent boundary			
Transform boundary			
Plate tectonics			
Rift valley			
Mid-ocean ridge			
subduction			

APPENDIX D
IRB APPROVAL

University of Central Florida

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

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Paloma Ferreira** and Co-PIs if applicable:

Date: **January 15, 2013**

Dear Researcher:

On 1/15/2013, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Quasi-experimental study on the efficacy of the Vocabulary Think Chart as a vocabulary intervention to improve seventh-grade science students on their conceptual understanding of scientific vocabulary.
Investigator:	Paloma Ferreira
IRB Number:	SBE-12-09000
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 01/15/2013 03:06:15 PM EST

Joanne Muratori

IRB Coordinator

Page 1 of 1

APPENDIX E
SCHOOL DISTRICT APPROVAL

School Board of Brevard County
2700 Judge Fran Jamieson Way Viera, FL 32940-6699
Dr. Brian Binggeli, Superintendent

School Board

January 22, 2013

Dear Ms. Ferreira,

Thank you for your application to conduct research in the Brevard Public Schools. This letter is official verification that your application has been accepted and approved through the Office of Accountability, Testing, & Evaluation. However, approval from this office does not obligate the principal of the schools you have selected to participate in the proposed research. Please contact the principals of the impacted schools in order to obtain their approval. Upon the completion of your research, submit your findings to our office. If we can be of further assistance, do not hesitate to contact our office.

This letter serves as approval for your additional research at Kennedy Middle School.

Sincerely,

Vickie B. Hickey

Vickie B. Hickey, Resource Teacher
Office of Accountability, Testing, and Evaluation

Office of Accountability, Testing & Evaluation
Phone: (321) 633-1000 FAX: (321) 633-3465

APPENDIX F
SCHOOL SITE APPROVAL

[redacted]

Brevard Public Schools
THE FUTURE OF FLORIDA'S SPACE COAST

January 24, 2013

This letter is to inform that the researcher, Paloma Ferreira, has been authorized to conduct the study on the Vocabulary Think Chart, in [redacted]

Sincerely,

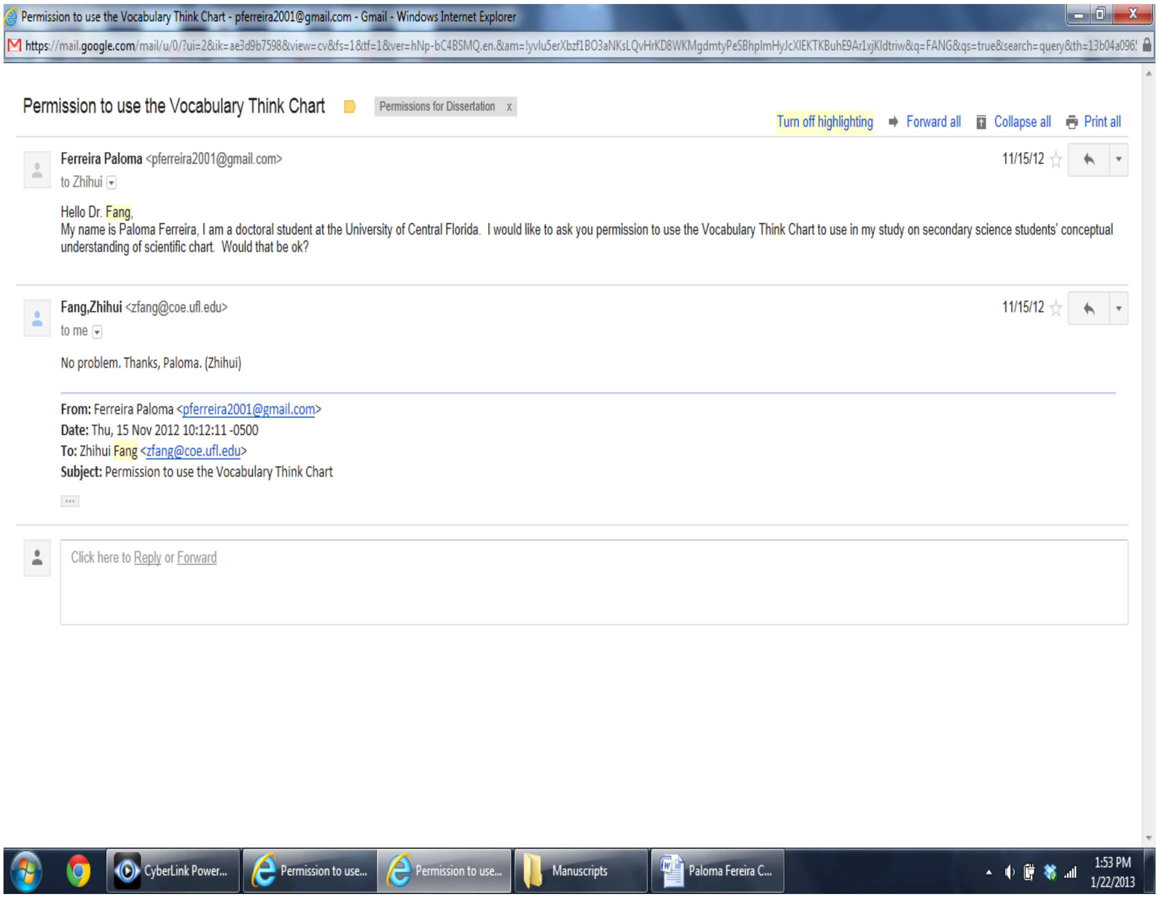
Richard C Myers

[redacted]

[redacted]

Brian T. Binggeli, Ed.D., Superintendent
Phone: (321) 633-3500 • FAX: (321) 633-3509

APPENDIX G
APPROVAL FORM TO USE THE VTC


Permission to use the Vocabulary Think Chart - pferreira2001@gmail.com - Gmail - Windows Internet Explorer

Permission to use the Vocabulary Think Chart

Permissions for Dissertation x

Turn off highlighting Forward all Collapse all Print all

Ferreira Paloma <pferreira2001@gmail.com> 11/15/12

to Zhihui

Hello Dr. Fang,
My name is Paloma Ferreira, I am a doctoral student at the University of Central Florida. I would like to ask you permission to use the Vocabulary Think Chart to use in my study on secondary science students' conceptual understanding of scientific chart. Would that be ok?

Fang,Zhihui <zfang@coe.ufl.edu> 11/15/12

to me

No problem. Thanks, Paloma. (Zhihui)

From: Ferreira Paloma <pferreira2001@gmail.com>
Date: Thu, 15 Nov 2012 10:12:11 -0500
To: Zhihui Fang <zfang@coe.ufl.edu>
Subject: Permission to use the Vocabulary Think Chart

Click here to Reply or Forward

CyberLink Power... Permission to use... Permission to use... Manuscripts Paloma Fereira C...

1:53 PM 1/22/2013

APPENDIX H
TREATMENT FIDELITY CHART

Treatment Fidelity Chart

Date	Words Completed

APPENDIX I

TEACHER MODEL CHART--LITHOSPHERE

Student Name: Teacher Sample

Date: Day 1 – Phase I

Period:

Chapter:

Questions	Answers
1. What is the target word?	lithosphere
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	litho = prefix means rock or stone sphere = suffix means circle.
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	sphere stratosphere.
4. How is the word defined in the text? Can you paraphrase this definition?	- The uppermost mantle of the Earth. - The biggest layer of the Earth.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	There is no evidence for subconduc Oceanic lithosphere in the eastern alps.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Earth's enterior, Earth's core.

APPENDIX J
TEACHER MODEL CHART – RADIATION

Student Name: Teacher Sample

Date: Day II – Phase I

Period:

Chapter:

Questions	Answers
1. What is the target word?	radiation
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	-tion - process (suffix)
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Creation Conduction
4. How is the word defined in the text? Can you paraphrase this definition?	The transfer of energy that is carri in rays like light is called rays. - The exchange of energy that is taken ray like.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- X-ray pictures are taken using electronic radiation.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Heat transfer

APPENDIX K
TEACHER MODEL CHART -- CONVECTION

Student Name: Teacher Sample

Date: Day 2- Phase I

Period:

Chapter:

Questions	Answers
1. What is the target word?	convection
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	-tion (suffix) - process -con (prefix) - together
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	radiation conduction
4. How is the word defined in the text? Can you paraphrase this definition?	Heat transfer by the movement of a fluid is called convection. - Heat exchange by the transfer of a fluid is called convection.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Forced convection is a function of the prevailing fluid flow vector.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Heat transfer.

APPENDIX L
TEACHER MODEL CHART -- CONDUCTION

Student Name: Teacher Sample

Date: Day 3 - Phase I

Period:

Chapter:

Questions	Answers
1. What is the target word?	Conduction
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	con (prefix) - together tion (suffix) - process.
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	construction preparation energy
4. How is the word defined in the text? Can you paraphrase this definition?	Heat transfer between materials that are touching is called conduction. - Heat exchange between substances that are close is called conduction.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Material contact allows for Conduction.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Heat tranfer Earth mantle.

APPENDIX M
TEACHER MODEL CHART -- CEMENTATION

Student Name: Teacher Sample
Date: Day 4 - Phase I
Period:
Chapter:

Questions	Answers
1. What is the target word?	cementation
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	cement -> to dry hard -tion -> the process
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	cement compact
4. How is the word defined in the text? Can you paraphrase this definition?	Cementation is the process in which dissol minerals crystallize and glue parts together. - Cementation is the process in which mate harden together.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Oil filled the crest of the reservoir fi and prevented extensive quatz cementation
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Sedimentary rocks Rock Rock formation

APPENDIX N
EXAMPLES OF CLASSROOM ARTIFACTS

Student Name: [redacted]
Date: 2/14/13.
Period: 6
Chapter: 4.1

Questions	Answers
1. What is the target word?	Carbon Film
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	Carbon - Carbo - Latin means coal
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Carbon dioxide camera - films take movie-film macerator Picture, copy
4. How is the word defined in the text? Can you paraphrase this definition? A type of fossil consisting of an extremely thin coating of carbon on rock	A kind of fossil containing an extremely thin layer of cabon on rock
5. Can you come up with a sentence in which the target word is used in the scientific sense?	The paleontologist at the dig site found a carbon film fossil means this area was covered in water in the past
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Earth's History

Student Name: [redacted]
Date: 2-12-13
Period: 5
Chapter:

Questions	Answers
1. What is the target word?	Cast
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	a copy of an organism Material in mold
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Broken bone fossil mold To make things happen
4. How is the word defined in the text? Can you paraphrase this definition?	a ~~solid~~ hard copy of the outside shape of an organism ~~formed~~ created when minerals seep into a mold.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	the Paleontologist created a cast of the fossil that is too fragile from the rock
6. This word is part of which larger science concept? What are some other words related to this larger concept?	fossils

change word to parap

Student Name: [redacted]

Date: 2/27/13

Period: 6

Chapter: Chapter 4 section 2

Questions	Answers
1. What is the target word?	Index Fossil
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	Index - something that shows or indicates. fossil - the remains or traces of an animal of plant that lived long ago
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Index - index finger or the index of a book fossil - something old, or something not living.
4. How is the word defined in the text? a fossil must Can you paraphrase this definition? be widely distribuated and represent an organisum that existed for a geologically.	A fossil must be widely spreaded & presented represented a living thing that use to be alive for a geologically.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	The paleontologist fossil & was using an index fossil
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Earths Science & history

Student Name [redacted]
Date: 3-8-13
Period: 6
Chapter:

Questions	Answers
1. What is the target word?	Uniformatarianism
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	Un - Not form - Shape or petition. ism - a concept of.
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Uniforms ? like something you have to wear at certain schools.
4. How is the word defined in the text? Can you paraphrase this definition?	The geolic Principal that the same geologic processes that operate today operated a long time ago.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	cars are a uniformatarianism to the world, so are words.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Change.

APPENDIX O

TEACHER SAMPLE CHART -- UNIFORMITARIANISM

Student Name: Teacher Sample
Date: Day 5 – Phase I
Period:
Chapter:

Questions	Answers
1. What is the target word?	uniformitarianism.
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	uniform – the same. uni – form ism – process.
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	uniform the same
4. How is the word defined in the text? Can you paraphrase this definition?	The principle of uniformitarianism arg that the geologic processes today are the same as the one in the past.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	– this principle states that the geologica processes stay the same. – Uniformitarianism allows scientist to make inferences about the Earth's pa
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Geologic time Geology History.

APPENDIX P

TEACHER SAMPLE CHART -- TRACE FOSSIL

Student Name: Teacher Sample
Date: Day 1 - Phase I
Period:
Chapter:

Questions	Answers
1. What is the target word?	trace fossil
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	trace - a foot print or trail Fossil - remains.
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Dinosaurs Zoo Jurasic Park
4. How is the word defined in the text? Can you paraphrase this definition?	Trace fossil provided evidence of the activities of ancient Organism - Trace fossil give proof of what old animals used to do.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- I have seen trace fossils at the Zoo.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	- Fossils Remains

APPENDIX Q
TEACHER SAMPLE CHART -- CARBON FILM

Student Name: Teacher Sample
Date: Day 3 - Phase I
Period:
Chapter:

Questions	Answers
1. What is the target word?	Carbon Film
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	carbon film -> root words
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Carbon copy
4. How is the word defined in the text? Can you paraphrase this definition?	Carbon film is a type of fossil, consisting of a thin layer of carb on rock.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Carbon film is a kind of fossil that has a coating of carbon on rock. - Carbon films help preserve delica leaves.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Fossils, remains

APPENDIX R
TEACHER SAMPLE CHART -- PALEONTOLOGIST

Student Name: Teacher Sample

Date: Day 4 - Phase I

Period:

Chapter:

Questions	Answers
1. What is the target word?	Paleontologist
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	Paleo – prefix means old gist – suffix means student
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	dinosaur Jurassic Park.
4. How is the word defined in the text? Can you paraphrase this definition?	a student of physical remain of ancient cultures. – an expert on remains of old cultures.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	– a paleontogist can conduct excavations in Egypt.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Science experts Fossils.

APPENDIX S

TEACHER SAMPLE CHART -- EXTINCT

Student Name: Teacher Sample

Date: Day 3 – Week 1 – Phase #

Period:

Chapter:

Questions	Answers
1. What is the target word?	extinct.
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	ex – outside (prefix)
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	dinosaurs extermination
4. How is the word defined in the text? Can you paraphrase this definition?	a type of organism that no longer exists. - An animal that no longer exists.
5. Can you come up with a sentence in which the target word is used in the scientific sense? →	- Dinosaurs have been extinct for many years
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Fossils Evolution

APPENDIX T
TEACHER SAMPLE CHART -- EVOLUTION

Student Name: Teacher Sample
Date: Day 1 - Week 1 - Phase II
Period:
Chapter:

Questions	Answers
1. What is the target word?	Evolution
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	evolve - root word means change tion - process.
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Change.
4. How is the word defined in the text? Can you paraphrase this definition?	Evolution is the change of animals through time. - Evolution is the modification of living things in time.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Fossils show that living things have evolved.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Fossils

APPENDIX U
TEACHER SAMPLE CHART -- INDEX FOSSIL

Student Name: Teacher Sample
Date: Day 1 – Week 2 – phase II
Period:
Chapter:

Questions	Answers
1. What is the target word?	index Fossil
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	index fossils – root words
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Fossils index reading chapters
4. How is the word defined in the text? Can you paraphrase this definition?	Index fossils can be helpful when paleontologist match rock layers - Index fossils can be useful to matc rock layers
5. Can you come up with a sentence in which the target word is used in the scientific sense?	Index fossils tell the relative ac of rock layers
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Fossils dinosaurs

APPENDIX V
TEACHER SAMPLE CHART -- CONTINENTAL

Student Name: Student Sample
Date: Day 4 - Week 3 - phase II
Period:
Chapter:

Questions	Answers
1. What is the target word?	Continental drift
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	Continental – drift – Means a movement of Earth's contine
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	Continental drift - movie Paleontology movement
4. How is the word defined in the text? Can you paraphrase this definition?	Wegner's idea that continents move over Earth's surface is known as continental drift.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Wegner's concept that continents moved is known as continental drift. → The idea that all the continents were once joined together in a single land mass and then separated through continental drift.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	→ Continents Wegner's Hypothesis

APPENDIX W

TEACHER SAMPLE CHART -- DIVERGENT BOUNDARY

Student Name: Teacher Sample
Date: Day 3 - Week 4 - Phase II
Period:
Chapter:

Questions	Answers
1. What is the target word?	divergent boundary
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	di - prefix means two -ary (sufix) pertaining to
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	different movement plates
4. How is the word defined in the text? Can you paraphrase this definition?	Divergent boundary deals with plate movement away from eac other.
5. Can you come up with a sentence in which the target word is used in the scientific sense?	- Divergent boundary accounts for plate movement away from each other. → Divergent boundary is one of the plate movement.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Plate tectonics.

APPENDIX X
TEACHER SAMPLE CHART -- TRANSFORM BOUNDARY

Student Name: Teacher Sample
Date: Day 4 - Week 4 - phase II
Period:
Chapter:

Questions	Answers
1. What is the target word?	transform boundary
2. Do you recognize any part of the word, such as prefix, suffix, or root (based word)? What does each part mean?	trans - prefix means accross. form - root word, shape. ary - suffix pertaining to
3. What does the word remind you of? Can you give a semantically related word, an orthographically similar word, or a real-life vignette triggered by the word?	change transference
4. How is the word defined in the text? Can you paraphrase this definition?	Transform boundaries are places where two plates slip past each othe - Transform boundaries are locations where plates move in opposite direc
5. Can you come up with a sentence in which the target word is used in the scientific sense?	Transform boundaries, underneat the Earth's surface can be rocky ar jagged.
6. This word is part of which larger science concept? What are some other words related to this larger concept?	Changing crust Plates

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