IMPROVING THE ACQUISTION AND RETENTION OF SCIENCE MATERIAL BY FIFTH GRADE STUDENTS THROUGH THE USE OF IMAGERY INTERVENTIONS

by

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Abstract

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A strong base of knowledge in vocabulary is imperative for all students as they are exposed to a great deal of novel words throughout their academic careers, especially in content areas such as science. By devising effective interventions to teach science vocabulary, literacy and science can be integrated and students' mastery of novel words will improve.

This study examined the effect of imagery interventions for the presentation of novel science vocabulary to fifth grade learners. Eighty-nine students from two schools in Long Island participated in this study and were randomly assigned to four different instructional interventions: a Picture Presentation method, in which a word was paired with a picture; an Image Creation- No Picture method, in which the participants were told to create an image of the word and draw it on paper; an Image Creation- Picture method, in which the students were presented with the picture and then told to draw it; and a Word Only method, which involved the simple verbal presentation of the word. These interventions were developed taking into account the ability of images to facilitate vocabulary learning, the theory of dual coding, and depth of processing. Participants' acquisition of the words was measured one day after instruction and retention was

examined two weeks later. The students were given word fill-in and definition word match tasks at both time points.

Results demonstrated that students in the imagery intervention groups (Picture Presentation, Image Creation- No Picture, and Image Creation- Picture) scored higher on the outcome measures at both immediate and delayed recall. It was also shown that the deeper the students processed the “to be learned” vocabulary words, the higher they scored on the outcome measures. Based on the mean outcome measure scores at both time points, students in the Image Creation- Picture intervention scored the highest, followed by the students in the Image Creation- No Picture intervention, those in the Picture Presentation intervention, and finally the Word Only intervention students. Such a study has implications as to the most effective way to integrate science and literacy and successfully present novel concepts in the classroom.

If we teach today as we taught yesterday, we rob our children of tomorrow

- John Dewey

Dedication

This work is dedicated to my wonderful family and friends. I am so fortunate to have all of you in my life! Your patience and support have made all the difference in helping me reach the finish line. Thank you for your words of encouragement and for always believing in me.

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To my mom, thank you for always encouraging me to go after my dreams and inspiring me to teach. If I am half the teacher or wonderful woman you are, I know that I have achieved great success.

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CHAPTER 1

Introduction

This chapter begins with an overview of the integration of science education and literacy, including the benefits of this approach to instruction. This is followed by descriptions of the importance of vocabulary for learning, imagery and imagery inducement, Paivio's dual coding theory, and depth of processing. Presentation of these constructs is followed by a discussion of how they are related and why they are critical for academic success. Finally, an intervention which focuses on imagery interventions for the presentation of vocabulary words in the science content area is described, with the goal of improving elementary students' ability to successfully acquire "to be learned" material.

Literacy in the Science Classroom: Current Practices

The pressure of high stakes testing in the areas of reading and math in elementary school has reduced the amount of time teachers have to spend on content area subjects such as science. Also, with an increasing emphasis placed on holding teachers accountable for the literacy skills of their students, many have minimized science instruction in the classroom (Thier & Daviss, 2002). However, as of 2007, the No Child Left Behind Act has required that students be tested in science twice in the elementary grades and at least once in grades 10 to 12 (Wenning, Herdman, Smith, McMahon, & Washington, 2003; U.S. Department of Education, 2003). By integrating literacy with science education, teachers are able to strengthen learning in both subjects and reduce the problem of time constraints during the school year. Through an examination of the 1994 Maryland National Assessment of Educational Progress (NAEP) data, Guthrie, Schafer, and Huang (2001) showed that when students have more chances to read because teachers integrated literacy in the content areas, it led to increased reading comprehension, better conceptual knowledge and problem-solving skills in science, and an overall increased motivation to read.

Science and Literacy: Integration

While science instruction emphasizes hands-on experimentation and active participation, one should not minimize the importance of language and reading comprehension, as current science education reforms promote literacy for all students (Yore, Hand, & Prain, 2002). Science education and literacy are inextricably linked. The National Science Education Standards present a vision of science education in which "…all students have the opportunity to become scientifically literate" (National Research Council, 1996, p. 55). A complete understanding of the texts students read, as well as the concepts commonly taught is imperative, as only those who fully grasp the basics can move on to more complicated material and experimentation. Science literacy is extremely important as it offers students a sense of understanding and fulfillment about the world that surrounds them.

Science literacy involves the abilities to construct understandings of science and to apply these meanings to problems and issues, as well as to inform and persuade others to take action based on these ideas (Hand, Prain, & Yore, 2001). In this way, science literacy involves skills which marry the knowledge of scientific concepts with the ability to use language for communication purposes (Thier & Daviss, 2002). In order to be able to understand and communicate scientific knowledge to others, one must first be capable of comprehending the material taught.

Science and Literacy: A Relationship

Science and literacy are reciprocally related to one another. The study of science content material enables children to develop their thinking and reading abilities. Reading and writing in science also helps to reinforce science concepts (Yore, Bisanz, & Hand, 2003). Thier (2002) states, “Good science- and effective teaching and learning in science- is dependent upon strong language skills” (p.8). Yore, Craig, and Maguire (1998) posit that reading is similar to the process of scientific inquiry in that both require the following skills: setting purposes, predicting, questioning, analyzing evidence, and drawing conclusions. During both activities students must also be capable of communicating to others what they take from the learning experience.

By integrating science and literacy, teachers can improve students’ abilities in both areas at once. Thier and Daviss (2002) state:

> Science strengthens literacy skills by infusing them with meanings and purpose. Setting language in an engaging context such as science inspires students to reach for the tools of language in order to uncover and internalize the secrets about the world that science can reveal to them. Literacy skills strengthen science learning by giving students the lens of language through which to focus and clarify their ideas, conclusions, inferences, and procedures (p. 6).

The skills needed for literacy and science complement one another. Students are often able to communicate their ideas and understandings better after combining the disciplines. Therefore, a strong literacy base will serve to strengthen an individual’s science foundation.

Vocabulary and Comprehension in the Sciences

A major component of literacy is vocabulary, which is the knowledge of word meanings (Biemiller & Boote, 2006) in both oral and print form (Lehr, Osborn, & Hiebert, 2004). Understanding novel words and concepts is important for young students as they are confronted with a great deal of new terminology in the passages they read, especially in content areas such as science. Snow, Burns, and Griffin (1998) explain that productive comprehension can be considered in terms of three factors: concept and vocabulary development, ability to understand the linguistic structures of the text, and metacognitive control of comprehension. Vocabulary knowledge enables young students to read proficiently and comprehend the material. There are many different methods for enhancing comprehension, one of which is through vocabulary development.

Elementary school students are exposed to a great deal of content area information from the time they enter the classroom and throughout their education. By learning how to comprehend the terminology and vocabulary they are presented with, they are better able to grasp the underlying concepts, "...as understanding is largely based on background knowledge and vocabulary" (Fisher, Grant, & Frey, 2009, p.183). A command of vocabulary, especially in science, is imperative because many terms presented in this content area represent concepts that are entirely new to students (Groves, 1995). Without a command of the meaning of the words, the underlying concepts they label will never fully be mastered.

Vocabulary knowledge is "…not an all-or-nothing proposition" (Beck & McKeown, 1991, p. 791). A child does not simply know or not know a word, but can vary in the depth at which he/she processes words (Beck & McKeown, 1991). This completeness or precision of word knowledge is one aspect of vocabulary which can differentiate high and low ability students. Students who process new scientific terminology at a "deeper" level will acquire and retain a better grasp of the material. Effective presentation for successful learning of vocabulary words and techniques may help to bridge the comprehension gap between students.

Many science classrooms currently incorporate literacy and vocabulary development into the lessons through the use of "Word Walls" or "Word of the Day" activities (McKee & Ogle, 2005). In common practice, teachers write the word on the board and present students with a sentence and definition of the word. Such an approach highlights the meaning of the word and the visual representation of its written form. Often no attempt is made to link the word with a visual representation of its meaning, which might enable the students to process the vocabulary term at a deeper level. Interventions that focus on connecting content area words to their meanings through the use of imagery are needed. Such strategies would scaffold vocabulary learning in science.

Imagery

Whereas the idea that vocabulary instruction is essential to young learners is commonly accepted, methods of vocabulary instruction vary. There are a variety of techniques that can aid students in their development of word knowledge and comprehension. These techniques are based on different theoretical accounts, one of which involves the use of imagery.

There is a close relationship between imagery and comprehension, as the understanding of sentences, paragraphs, and passages is increased when mental images are formed (Anderson & Kulhavy, 1972; Pressley, 1976; Sadoski, 2005; Sadoski, Goetz,

& Fritz, 1993). Imagery can aid readers in making inferences and organizing information. It has also been shown to be related to the perceptual, affective, and experiential components of prior knowledge that affect the readers' responses to text (Long, Winograd, & Bridge, 1989).

Visual imagery has a large impact on vocabulary acquisition and comprehension. Hibbing and Rankin-Erickson (2003) have found that students who lack the ability to create images when reading experience comprehension difficulties. Since vocabulary is such an integral part of the science content area, it is important to incorporate images when instructing students on new meanings and concepts.

Mental imagery, or creating images in one's mind, is a quasi-perceptual occurrence that closely resembles the actual experience of perceiving some object, event, or scene, but which occurs in the absence of relevant external stimuli (Thomas, 2003). Images play an important role in memory and cognition, and can also facilitate comprehension of text (Sadoski, 2005). Whether imagery occurs spontaneously while reading, or if it is induced via presented pictures, it is important to understand its influence on the development and implementation of effective vocabulary interventions.

Imagery training or inducement can influence performance on literacy tasks (Sadoski, 1998). It has been shown that students who are induced via pre learning instructions to generate either verbal or imaginal schemas outperform subjects who are not (Levin, Davidson, Wolff, & Citron, 1973). Teaching children to construct mental images as they read has also been shown to enhance their abilities to make inferences, predictions, and to remember what has been read (Gambrell, 1983; Pressley, 1976). This study examined different formats for using imagery to support vocabulary learning. In one condition, students were instructed to create images on their own to help them remember vocabulary words. In another imagery condition, students were provided with the pictures by the researcher. The third imagery condition employed both image presentation and image creation.

Dual Coding

Imagery can be incorporated into vocabulary interventions in a variety of ways. One of the most comprehensive theories which accounts for vocabulary, imagery, and cognitive processing is dual coding. Paivio's dual coding theory posits that cognition consists of two separate, but interconnected and interacting mental systems: a verbal system for language and a nonverbal system for imagery. These systems are only partially connected and can function independently or in an integrated fashion. Processing, according to this theory, occurs at the representational level or dimension, meaning that representation in one code does not necessarily imply activation in the other. Therefore, "…one code can be active without the other, or both can be active in a parallel fashion" (Sadoski & Paivio, 1994, p. 548).

Dual coding theory assumes that information stored in two codes is better comprehended and remembered than that which is stored in one code. This is because when information is encoded both verbally and nonverbally "...the information is elaborated, promoting increased comprehension and a strengthened memory trace" (Sadoski et al., 1993, p. 291). There is an additive effect of dually coded information, in that knowledge stored this way potentially is remembered twice as well. The ratio, however, is modified by factors such as readability, context effects, and/or context familiarity (Sadoski et al., 1993).

Another element of dual coding is the “conceptual peg” hypothesis in which imagery serves as a natural mnemonic or peg, on which information is hung (Sadoski & Paivio, 1994). This suggests that mental images can serve to organize and unify information, as well as facilitate the recall of this information (Sadoski et al., 1993). Being that concrete words evoke more imagery, these words tend to facilitate the recall of information associated with them better than abstract words. Concrete cues, however, can be provided to help facilitate the recall of abstract information, which is typical of the recall tasks students receive in educational settings (Sadoski et al., 1993).

It is easier to access the definitions of concrete, as compared to abstract words, as abstract language has less connection to imagery. Words that are concrete have direct sensory referents and evoke a web of language and meaning. Concrete words are also translated faster and more accurately than abstract words, and are better retained (van Hell & de Groot, 1998).

Recently, this theory of cognition has been advanced as a general theory of literacy (Sadoski, 2005). The verbal code is specialized for representing and processing language, which includes speech and writing. The nonverbal code deals with the representation and processing of nonverbal objects and situations. Complete knowledge of words and their meanings is explained by the interactions within and between these two codes (Sadoksi, 2005). For example, processing by both codes facilitates the understanding of the word “tree.” In the verbal pathway, words such as “trunk,” “roots,” and “leaves” can be associated with the word. In the nonverbal pathway, images of trees and past experiences with them are evoked. By combining both types of knowledge, a comprehensive understanding of the word is created.

Depth of Processing

The interventions used for this research also aimed to increase the depth at which students processed the “to be learned” information. A wealth of research based upon the theory originally put forth by Craik and Lockhart has shown that “depth of processing” is positively related to the amount of information that is stored in memory (Weiss, Robinson, & Hastie, 1977). Depth of processing refers to the degree of semantic involvement with a particular task. Deep encodings are associated with higher levels of performance (Craik & Tulving, 1975). Thus, the more effort a student puts forth when encoding information, the better able he/she will be to retain and later retrieve it from memory. It was anticipated that the students in the imagery interventions in this study would encode the meaning of the vocabulary terms at a deeper level, as stimuli that are “…enriched by associations or images yield a deeper encoding of the event, and a long lasting trace” (Craik & Tulving, 1975, p. 270).

Synthesis

Science is a discipline which relies heavily on students’ ability to understand new terms and concepts. In order to comprehend material, students must have a strong literacy background, especially with regards to vocabulary knowledge. Research, often based on the dual coding theory, has shown that words and text which enable the formation of images facilitate recall (Anderson & Kulhavy, 1972; Pressley, 1976; Sadoski, 2005). Also, words which are elaborated through the use of images are processed at a deeper level, further assisting in the process of encoding the information. Given that images are so useful for learning they should be employed in content areas such as science to help students understand and learn the material presented to them.

Present Study

Images play an important role in memory and cognition, and can also facilitate comprehension of text (Sadoski, 2005). The study used imagery as a way to manipulate the depth at which information is processed. In order to test the utility of imagery in vocabulary learning, a 1-between-subjects, 1-within-subjects repeated measures design was employed.

The study examined four interventions which aimed to better enable fifth grade students to acquire and retain the science information presented to them in their elementary school classrooms. These interventions were created as a result of variations in the way in which the vocabulary was presented to the students: specifically with regards to the presentation of pictures and instructions to create mental images. Whether the images were presented, or if the students were induced via instructions to create mental images, it is important to understand their potential contribution to the development of effective instructional interventions.

This study focused on an elementary school sample, because having a strong understanding of scientific terminology is imperative for young students. As students progress through school, they are exposed to an increasing number of vocabulary items as well as more complex reading material, especially in the area of science. By intervening early on, we are better able to prepare students for what lies ahead. At this point in a student's educational endeavors, it is imperative to lay the foundations in science skills and understanding to allow for future learning.

The content on which the students were instructed was information from the middle school biology curriculum, specifically the key words needed for complete understanding. These supplemental science vocabulary lessons were presented as an enhancement program for fifth grade elementary school students, and as such focused on vocabulary typically presented to middle school learners. Biology was chosen as it is a challenging part of the science curriculum presented during middle school. According to the New York City Department of Education's *K-8 Science Scope and Sequence* (2008), the life sciences are introduced in the sixth grade, with specific attention being paid to diversity of life and the structure and organization of living things, whereas the specific components of cells and how they function is instructed in the seventh grade.

If fifth grade elementary school students were able to learn the novel content area words as a result of the use of the interventions, it would demonstrate that students can be taught to master complex material at an early age and that images facilitate vocabulary learning. Furthermore, by getting a handle on these concepts before they are formally presented in middle school, students would be able to approach their biology unit with a stronger base of knowledge and less anxiety; an added educational benefit. If the interventions were successful, the students would also enter middle school with a complete ownership of these terms rather than just mere recognition of them.

Specifically, the study examined the presentation of biology concepts and vocabulary using a 1-between-subjects, 1-within-subjects repeated measures design. The between-subjects factor, the intervention assigned, had four "levels" corresponding to the four different conditions employed. The within- subjects factor, outcome measures, had two "levels," the immediate and delayed recall time points.

The key vocabulary items needed to understand the concepts were instructed using: a) a Word Only intervention, which involved the simple verbal presentation of the scientific terms and concepts; b) a Picture Presentation intervention, in which pictures were paired with the vocabulary; c) an Image Creation- No Picture intervention, in which students were told to create mental pictures in their mind and draw them on paper; and d) an Image Creation- Picture intervention, in which students were presented with pictures and then told to draw them on paper. The Picture Presentation and Image Creation- No Picture interventions were directly compared with the Word Only intervention to examine the relative utility of presenting images versus creating them. The final intervention, Image Creation- Picture, employed both presentation and image creation, and as such should have demonstrated an additive effect for facilitating vocabulary learning. The effectiveness of the interventions was studied in terms of how well the benefits conferred transferred to improvements on comprehension of complex scientific ideas and concepts through the use of researcher-generated vocabulary measures.

Such a study has implications regarding the way to organize instruction in the elementary science classroom. With a clear understanding of how students best learn, we can develop ways to enhance comprehension. Teachers will have options when designing instruction with the goal of enabling students to learn new and complex vocabulary and concepts. They will also be able to assist their students in generalizing this knowledge to improvement in their overall comprehension. There is hope that if students become more aware of these interventions and their benefits for learning, they will utilize these strategies on their own when exposed to new terminology. Finally, creating interventions that enable students to learn vocabulary and concepts within the science classroom, allow literacy and science instruction to be integrated, and as such is beneficial to student learning. By providing students with effective interventions early on, we are putting them on the correct path to be skilled lifelong learners.

Based on the above discussion, the specific research questions investigated by this study regarding the acquisition and retention of the science vocabulary terms were as follows:

Acquisition

1. Does the use of imagery enable students to score higher on the researcher-generated immediate recall outcome tests, demonstrating increased comprehension? In other words, is a picture worth a thousand words?
2. Does the depth at which the students process the vocabulary influence students' acquisition of the "to be learned" information? In other words, would processing the information "deeper" produce better learning as measured by the number of items scored correct on immediate recall vocabulary outcome measures? Specifically, it was predicted that:
    a. The Image Creation- No Picture intervention, which employs image creation and requires the deepest level of processing as a mental image must be created relying on the student's understanding of the word alone, would be be more effective than the other three interventions in terms of the number of vocabulary words the students acquire.
    b. The Image Creation- Picture intervention, which employs both image presentation and image creation, would be more effective than the Picture Presentation and Word Only interventions in terms of the number of

vocabulary words the students acquire, as Image Creation- Picture requires a deeper level of processing.

c. The Picture Presentation intervention would be more effective than the Word Only intervention in terms of the number of vocabulary words the students acquire, as Picture Presentation requires a deeper level of processing being that the picture is provided.

3. In contrast to the prediction addressed in 2a, would the Image Creation- Picture intervention be more beneficial to students in terms of vocabulary acquisition compared to the Image Creation- No Picture intervention? In other words, is there an additive effect of image presentation and image creation? The Image Creation- Picture intervention may also help clarify the meanings of the words as pictures are provided before the students are instructed to draw them. This prevents students from developing inaccurate mental images and drawing pictures which do not represent the meaning of the word.

Retention

1. Will students who are instructed via the imagery interventions, those which involve image presentation, image creation, or a combination of the two, display increased ability to remember the vocabulary words on delayed outcome measures compared to the students in the Word Only intervention?
2. Will the differences between each of the imagery interventions in terms of the number of vocabulary words retained follow the same pattern at delayed recall as outlined in the acquisition hypotheses? Or, will the differences between the imagery interventions diminish due to the loss of information over time?

Participants' Perceptions of the Interventions

1. Will student responses obtained from the vocabulary learning evaluations and student discussions display the same trends as the vocabulary outcome measures?
2. Will student responses garnered from the discussions support the quantitative results?

CHAPTER 2

Literature Review

This chapter is comprised of three major subdivisions. The first subdivision consists of a discussion of science education and its integration with literacy. It also includes information regarding literacy and two of its components: reading comprehension and vocabulary development. Second is a section on imagery, how it is used in both science and literacy, as well as how it facilitates the acquisition of “to be learned” information. The dual coding theory and its relation to the presentation and learning of vocabulary using imagery are also described. The third and final subdivision synthesizes the research in this chapter on science education, literacy instruction, vocabulary, imagery, and dual coding, and provides a rationale for the study.

Science Education, Literacy, Vocabulary Instruction, and their Importance for the Effective Instruction of Students

Science Education

In the era of No Child Left Behind, it is often a wonder that objectives for science instruction such as those described in the National Science Education Standards (National Research Council, 1996) can even be considered. Schools have adopted policies across the nation in which they are rewarded or sanctioned based upon their students’ scores on standardized tests. Many share the concern that students will improve in tested areas such as math and reading due to the emphasis on these subjects in school, while other content areas such as science will fall to the wayside (Winters, Greene, & Trivitt, 2008). Studies have shown that as a result of high stakes testing, teachers have adjusted their behaviors accordingly, focusing more on the tested subjects and less on other content areas (New

York State Education Department, 2004). On a more positive note, there is evidence which suggests that student science proficiency does increase as a result of their increases in reading and math. Basically this means that learning in reading and math contributes to learning in science (Winters et al., 2008). Integrating subjects, such as literacy and science, will also lead to such a benefit (McKee & Ogle, 2005).

Literacy

McKee and Ogle (2005) use a broad definition of literacy which includes "…the ability to use reading and writing, speaking and listening sufficiently well to engage in thinking and to communicate ideas clearly. [It also incorporates]…the ability to critically analyze and evaluate information…" (p. 2). McKee and Ogle stress the importance of vocabulary knowledge, a key component of literacy, which is the ability to think about and understand the meanings of words. In order to think about the material one is attempting to master, it is important that he/she is able to understand the content specific terminology that identifies the ideas or phenomena presented. With reference to science instruction, without comprehension of specific biology vocabulary words, students will not be able to relate them to one another or to the information presented and grasp the "bigger picture" the words are used to convey. One must master the basics before moving on to more complex material.

Science and Literacy

The role attached to literacy in science education has changed a great deal in the past thirty years based on the models of the applied cognitive sciences. Before this time, science education was dominated by a behaviorist or logical-mathematical perspective in which reading and writing were largely ignored. When these components were incorporated into the curriculum, it was in the form of a unidirectional process; text to reader or speaker to listener (Yore et al., 2003). As a result of developments in the literacy and science disciplines, as well as insights into human cognition and the application of communication technologies, the two fields have incorporated elements from one another. Science education has incorporated literacy into its models of teaching and learning. This integration of science and literacy has in turn influenced a variety of educational reforms, curricula, and classroom practices (Yore et al., 2003).

Whereas studies in the late 70s and early 80s focused on issues of science textbooks' content and style, a much more interactive view of the student as a learner is now the focus. In reading a text, readers must process information by switching back and forth between perceptions of text-based information and personal experiences stored in memory that are related to the ideas being read (Yore et al., 2003). Therefore a connection between the words presented and the concepts they represent is of utmost importance.

The National Science Education Standards have emphasized the importance of connecting science with other school subjects (National Research Council, 1996). At the same time, the need to incorporate literacy into science content, providing students with opportunities to read, write, and present has been emphasized (Douville, Pugalee, & Wallace, 2003). Douville et al. (2003) note that integrating the curriculum across disciplines has benefits for both teachers and students. Teachers are able to develop professionally through the construction of connections between material, and students are able to make use of academic skills and materials in real-world learning activities (Douville et al., 2003).

McKee and Ogle (2005), in discussing the integration of literacy and science content, note that the two work together to strengthen and clarify learning in each respective domain. These disciplines also help motivate students to understand what is going on around them. They state that one goal in every classroom should be to help students develop a desire to learn the meanings of new words and understand their uses. The stronger a student's literacy skills, the better his/her grasp of science material. Language becomes the pathway by which scientific understanding is accessed (Thier & Daviss, 2002).

Thier and Daviss (2002) state that effective science teaching and learning are dependent on strong language skills in that science and language are joined in the "…pursuit, determination, and communication of meaning in the context of the physical world" (p. 8). The marriage of literacy and science also enables individuals to confront questions that require the use of scientific thinking and understanding of scientific information. Yore (2003) notes that language is a *means* for "doing" science and constructing understandings. It is also an *end* in that information regarding procedures and scientific understandings is relayed to others, so they in turn can make informed decisions. Language is useful for both creating and conveying information. Language, both oral and written, is an important component of science instruction and learning.

Integrating literacy and science can also lead to benefits in reading and conceptual thinking. In their study examining Concept-Oriented Reading Instruction (CORI), Guthrie, Anderson, Alao, and Rinehart (1999) implemented a yearlong integration of reading/language arts and science instruction. CORI involves conceptual themes, real world science interactions, strategy instruction, peer collaborations, construction of portfolios, as well as other interactive approaches to learning. CORI includes four phases: observe and personalize, search and retrieve, comprehend and integrate, and communicate to others. For example, in the first phase, students go into the field and explore a subject using hands-on activities. The students generate questions based on their observations. In the second phase, the students work to retrieve information related to their questions. Then they attempt to integrate their findings and share them with others through discussions, presentations, and written exchanges.

In this specific study, 53 fifth grade and 67 third grade students were taught life science and earth science concepts using CORI, while an additional 53 fifth graders and 66 third graders received traditional instruction. Students were given performance assessments in reading/language arts designed to measure aspects of literary engagement. Half of the students were randomly selected to take an assessment based on ponds and desserts, and the other half on volcanoes and rivers. Participants were given pictures, instructed to write everything they already knew and what they wanted to find out based on the pictures, and were told to log their search for information. They drew pictures representing the differences between the two items they were given and provided written explanations. Students were also given expository and narrative texts relating to the pair they received and answered questions based on the passages.

Results demonstrated that the students instructed with CORI showed academic benefits. In terms of conceptual learning, the CORI students did better than the traditional students ($p < .02$). The fifth graders also did better with regards to conceptual learning than the third graders under both instructional conditions ($p < .001$). The CORI students also scored higher than the traditional students in terms of motivated strategy use when seeking information ($p < .05$), but no main effects for grade level were shown. Finally, the CORI students scored higher on text comprehension, as compared with the traditional students ($p < .03$). Overall, the higher level of reading engagement which is attributed to the principles of CORI, led to increases in students' literacy abilities and conceptual learning. Linking disciplines within the curriculum affords students many advantages.

Components of Literacy: Reading Comprehension and Vocabulary

The integration of science and literacy is beneficial for students (McKee & Ogle, 2005). However, one cannot understand the full impact and importance of literacy without a discussion of two of its major components: reading comprehension and vocabulary. Without a strong command of vocabulary and the ability to take meaning from written text, understanding new concepts would be nearly impossible.

Word recognition, comprehension, vocabulary, and rapid access to meanings are essential skills for young students. Biemiller and Slonim (2001) report that children learn approximately 800 to 900 root words a year through the age of twelve. The acquisition of these words is essential for reading comprehension and reading development (Rupley, 2005). There are many causes of reading difficulties; however, poor vocabulary knowledge is a significant contributing factor for many poor readers (Fisher & Blachowicz, 2005).

Reading comprehension is the process of constructing and reconstructing meaning from printed material (Miller, 1993). This meaning emerges from the interactions that occur between reader and text, and between the knowledge, skill, and motivation of the reader (Aarnoutse & Schellings, 2003). Reading comprehension is an interactive process, which requires an individual to access his/her prior knowledge. It is also a process which involves complex organizational strategies on the part of the reader (Levin, 1973). Through this active process, readers try to understand the written message of the writer at the lexical, syntactic, semantic, and pragmatic levels (Aarnoutse, van Leeuwe, & Verhoeven, 2005).

Reading comprehension not only requires the skills associated with reading such as accurate and fluent word recognition, but it also requires the knowledge of syntax and vocabulary (Goldenberg, 2008). According to Paul (1989), good readers are those who know several meanings of numerous words, and poor readers are the individuals who know few words or only one meaning of common words. A large vocabulary base helps readers further their learning and their formation of concepts and ideas. Snow et al. (1998) state that people’s ability to infer and retain words is dependent upon their background knowledge of other words and concepts.

Vocabulary is the knowledge of the lexical meanings of words and the concepts connected to these meanings (Aarnoutse, Van Leeuwe, Voeten, & Oud, 2001). Differences in vocabulary size affect word recognition skills as well as reading comprehension (Beck & McKeown, 1991). Beck, Perfetti, and McKeown (1982) state that the best situation for comprehension occurs when all of the words in the text are highly accessible, and as such are well understood. In such an instance, processing can be directed towards the meanings of sentences and passages, and is not interrupted by individual word searches. If there are too many unknown words, gaps in comprehension are created, and the student will have difficulty constructing meaning. This difficulty will divert attention to the search for specific word meanings, and will interfere with the processing of text. Not knowing the meaning of words in a text is an impediment to understanding it (Braze, Tabor, Shankweiler, & Mencl, 2007).

Vocabulary and Comprehension: The Relationship

Vocabulary instruction and reading comprehension are intertwined. Enhancing the development and growth of the vocabularies of children enables them to better comprehend what they read, as struggling readers' comprehension improves with vocabulary instruction (Rupley, 2005). Furthermore, Cunningham and Stanovich (1997) have shown that knowledge of vocabulary assessed in the first grade predicts over 30% of reading comprehension variance in the eleventh grade.

Not only are these two constructs related, but there is a unique reciprocal relationship between reading comprehension and vocabulary. Vocabulary knowledge is a significant predictor of comprehension, as knowing the meaning of the words in a text is necessary for understanding it (Braze et al., 2007). While a good vocabulary base is needed to comprehend the text one reads, the more reading an individual does, the better his/her vocabulary becomes. Vocabulary and reading comprehension "…share a nurturing relationship, each supporting the growth and development of the other" (Rupley, 2005, p. 203). It has also been found that vocabulary growth and development of reading comprehension are mutually reinforcing between the second and sixth grade (Aarnoutse & van Leeuwe, 1998).

Vocabulary also facilitates the relationship between decoding and comprehension. Many students with learning disabilities, especially in the area of reading, possess much less vocabulary knowledge when compared with their typically achieving peers. This is detrimental, not only to their reading comprehension, but for their ability to decode texts.

Braze et al. (2007) conducted research on young adults between the ages of 16 and 24 with reading difficulties and found that weakness in word knowledge may compound weaknesses in the ability to decode words. Based upon their research, readers who have poorly developed lexical representations will have a disproportionately harder time with word identification as well. Given that word identification is a skill influential in reading comprehension, the findings of Braze et al. suggest that efforts directed at vocabulary development would be helpful in reading instruction.

A large vocabulary base facilitates education in that it is strongly related to reading comprehension and overall school achievement (Beck, McKeown, & Kucan, 2002). If reading skills are acquired efficiently, the abilities mastered lead to growth in other cognitive skills and overall understanding of information taught as well (Stanovich, 1986). This applies to all domains of knowledge, especially in content areas such as science. If a student cannot read and understand the words in the text, he/she will not be able to learn the concepts the words are used to describe. This may explain the widening achievement gaps between those who read well and those who read poorly (Levin, 1973).

Insufficient vocabulary knowledge can be a cause of reading difficulties for a large percentage of students whose progress appears normal during the first two or three years of instruction, but who fall behind between the third and seventh grade. This is because reading changes from a process of learning to identify words that are already in the child’s spoken vocabulary, to becoming a vehicle for acquiring knowledge. The tendency for students to fall behind during this time is serious, as remediation programs are not as effective at this point (Shand, 1993). As the level of difficulty of assigned texts increases, reading problems will worsen, as it becomes harder for a student to comprehend the words used (Shand, 1993). Early intervention is important, as putting children on the right path of reading and vocabulary development enables them to be efficient lifelong readers.

A number of empirical studies have demonstrated the importance of vocabulary for comprehension. Marks, Doctorow, and Wittrock (1974) examined sixth grade students, who were assigned to two different groups and given reading passages. One group was presented with a passage containing high frequency words, and the other with a passage containing low frequency words. Those who read the high frequency word version scored 25% higher than the low frequency words group on comprehension questions. This finding was replicated in a subsequent study by the same researchers (Wittrock, Marks, & Doctorow, 1975).

Stahl and Fairbanks (1986) also found a large effect size (.97) of vocabulary instruction on reading comprehension in their meta-analysis of 52 vocabulary studies. In the studies they reviewed, students who were given vocabulary instruction showed improvement on reading tests to the extent that they scored comparably to their peers who were not in need of vocabulary remediation. Specifically, their results showed that "…on the average, children at the 50th percentile of groups receiving vocabulary instruction scored as well as children at the 83rd percentile of the control groups on passage comprehension measures [after various interventions]…"(p. 245). Vocabulary instruction was also shown to have a small significant effect (.30) on reading comprehension of passages in standardized tests that did not contain the taught words. The methods that produced the highest effects on comprehension and vocabulary measures in their review were those that involved both definitional and contextual information about the to-be-learned words, a finding of particular significance for the study presented.

It is important to note that while the relationship between vocabulary knowledge and reading comprehension seems logical, it fails to find consistent strong support in terms of research. While some studies have found that instruction in vocabulary increases reading comprehension (Beck et al., 1982), others have failed to find an effect (Pany & Jenkins, 1978). Due to disparate findings, and often weak relationships, researchers have been cautious in claiming a causal effect of vocabulary knowledge on reading (Shand, 1993).

Individual Differences in Vocabulary

Children display a wide variety of individual differences when it comes to vocabulary knowledge, which undoubtedly influences learning and instruction in school. Some children enter the classroom with a great deal of exposure to books and a wealth of literacy experiences; however for others, these experiences may be quite limited. Children from lower income homes are usually at a disadvantage, because there are not as many literacy resources, and/or their parents may not engage in linguistically rich interactions with them (Apthorp, 2006). Furthermore, low income pre-schoolers may have been exposed to 50% fewer words than their more advantaged peers upon school entry (Fisher & Blachowicz, 2005).

In examining the developmental component of vocabulary learning and acquisition, Biemiller and Slonim (2001) have shown that clear differences between children in terms of the vocabulary they have acquired are apparent before second grade. This is because by Grade 2, most, if not all children have begun to read to some degree.

Those who are able to read more proficiently are exposed to more words, which increases their level of vocabulary. The researchers also cited Case's cognitive-developmental theory, which emphasizes working memory capacity. At around age 7, children become capable of asking questions about vocabulary they do not know. This allows many students to further elaborate on words they are unsure of and store them in memory. This corroborates Biemiller and Slonim's observation that by around second grade, most children are aware of what words they know and do not know, and are capable of seeking help. During this developmental period, differences in vocabulary size may be noticed by teachers and caregivers. These differences become more apparent in grades three and above, when the comprehension of written material exceeds the abilities of children with low levels of vocabulary knowledge, preventing them from achieving a sufficient understanding of the text (Becker, 1977; Biemiller, 2003). Coyne, McCoach, and Kapp (2007) note that young children who fall behind in their vocabulary knowledge are at greater risk of being identified as having a reading or language disability. In order to reduce or prevent achievement gaps, teachers must get children on to the right trajectory of vocabulary growth and reading development and help them maintain that growth (Apthorp, 2006). Therefore, as with reading, educators' chances of successfully addressing vocabulary differences and potential achievement gaps are greatest in the preschool and early primary years (Biemiller & Boote, 2006).

While vocabulary interventions do generally target poor readers, they often offer detailed instruction focusing solely on the vocabulary words presented. However, it is the below-average readers who need early and varied types of interventions the most. This would help to build up their literacy skills and overall cognitive development (Stanovich, 1986). It is imperative for teachers to intervene early on in a student's educational career, to prevent him/her from falling behind to such an extent that his/her educational progress is seriously delayed. The longer we wait, the longer the student fails to learn from written content area materials, and the greater the increase in negative attitude toward schooling. This is likely to discourage the student (Shand, 1993). It is advisable to not only intensify vocabulary instruction for those students who are most at risk for academic difficulties, but to instruct them with multiple methods in order to find one that creates the perfect "fit" between the learner and learning intervention. This would serve to engage the learner and prevent further problems.

Good and poor readers differ not only in the amount of vocabulary learned, but also in their vocabulary knowledge perceptions. Able readers are accurate about half of the time in estimating what vocabulary they know and over-estimate the words they think they do not know. Less able readers are accurate in estimating what they do not know, but over-estimate what they know (Drum, 1983). In order to assess their ability level accurately, it is important to objectively test students to determine their actual knowledge of vocabulary.

Teachers must also identify their students' vocabulary abilities in the science content area, as this domain relies on novel and technical terminology. Students must be capable of learning the specific words needed for understanding the material presented. Teachers should tailor their instruction in such a way as to identify students who are having difficulties with the content area vocabulary early. While the study presented looked at older students, who for the most part have a mastery of general vocabulary, these students are embarking on learning novel information in a new content area, thus making their ability to comprehend the terms of utmost importance.

Vocabulary and Its Importance for Science Instruction

While a good command of vocabulary is necessary for all subjects, its effects on learning are all the more apparent in content areas such as science. Science has its own language, in which students are introduced to either completely new words or novel uses of familiar words. Wilson (1998) states that a particular scientific word should be taught to students at the appropriate time, such as when it will fill a gap in the children's knowledge and when they have a clear need to use appropriate vocabulary to describe something that has been experienced. Wilson claims that if executed correctly, word learning can enhance science learning. This in turn will facilitate the command of more complex language skills such as speaking, reading, and writing.

Yager (1983) notes that terminology is a central feature of most science textbooks, and as such is a major focus in K-12 science instruction. This is because many science teachers use textbooks to determine what students must learn, and rely on the terminology they contain to guide their instruction. Even in classrooms today, teachers assign large portions of text for students to read to supplement their classroom learning. Therefore, "...science requires a disproportionate percent of time for vocabulary mastery" (p. 586).

Yager (1983) found that more attention to vocabulary is necessary in science classrooms than for mastery of a foreign language. Through an analysis of two fifth grade textbooks, he determined that the total number of new science vocabulary presented during the school year was around 2,720 words. Yager claimed that the research was weak regarding the agreement among foreign language scholars concerning vocabulary, however 1,250 words instructed during any one of the middle school years was the generally accepted amount. This was far fewer than the number of science words elementary school students were expected to master. In Yager's research no attempt was made to avoid counting words more than once; however, an analysis by Groves (1995) found that while there were not as many new vocabulary terms in science texts as previously reported, the vocabulary load was still very high. Even though instruction has changed throughout the years, the amount of words presented in the science content area is still extremely high, and consequently interventions to facilitate the efficiency with which students learn and retain vocabulary should remain a priority.

A good command of vocabulary influences science achievement. Yore (1987) found through his pilot study of 54 fifth grade students in British Columbia that general reading vocabulary and reading comprehension were associated with science achievement and the ability to read science text. In order to measure students' reading vocabulary, a 50-item test that required the participants to identify a word of similar meaning to the given word was used. Students were also given the Gates MacGinitie test to assess general reading ability, a measure similar to Cloze tests to examine reading comprehension, and teacher designed tests to determine science achievement and science reading ability. Results showed that the highest correlation was found between reading vocabulary and science achievement ($r = 0.51$). The second highest ($r = 0.35$) was between reading comprehension and science reading ability.

If students cannot comprehend the words they encounter in a new science text, their focus is on decoding terms, rather than thinking about meanings and understanding the material (Allington, 2001). This poses a challenge, not only for the students, but for the teachers as well. Instructors are left with the task of helping students identify the key terms that must be learned, as well as differentiating these terms from their common everyday uses, as many scientific words have more than one meaning. Vocabulary development ensures a sturdy basis for learning, as well as the ability to understand scientific concepts. Referring to the integration of literacy and science instruction, McKee and Ogle (2005) state, “teachers who both encourage students to attend to new words and provide a structured approach to vocabulary development can help students build their interest and knowledge” (p. 57).

Students must also be able to connect the vocabulary word to the underlying concept in a deep and meaningful way. Yore et al. (1998) note that efficient, successful readers of science text material “realize that words are labels for ideas….and text is stored descriptions of ideas…” (p.34). Effective learners do not treat the word as an isolated piece of information, but rather a part that enables them to develop a complete understanding of the content they are learning. In order to acquire this level of knowledge about the word, effective vocabulary interventions must be employed.

In current practice many elementary school teachers have “Word Walls” where the words students learn during instruction are listed in alphabetical order, with new words inserted every time the students are presented with them. Upper-level teachers also often introduce a “Word of the Day” to help students expand their vocabularies and encourage students to keep vocabulary journals which they can review on their own time (McKee & Ogle, 2005). While this does serve as a way to connect a visual component with the verbal presentation of the word, which will be the subject of the next section, the focus is on the visual presentation of the word’s spelling, rather than on a connection to its meaning. This may assist the students in remembering the order of the letters when they write the word, however, it will not help them connect the meaning to the word or master it. The same problem arises when considering the use of concept maps. These pictorial representations can be used to display the relationships between many words, but do not connect the meaning of each word to the word itself. There is a need for imagery interventions that focus more specifically on connecting words to meaning. When images of words are presented or are created by the students themselves, these pictures serve as a way to master the concept underlying the words, and as such will help the students acquire the vocabulary and retain it in memory. This is the main focus of this study. Even if the word instructed is simple and concrete, newly acquired vocabulary can help students create and comprehend broader abstract concepts. Pictures help build concepts and should be incorporated into science learning.

Vocabulary Instruction and Interventions

Memorization of definitions is not an effective way to learn science vocabulary. With the amount of words students are expected to comprehend, they may forget which words correspond to which definitions. If this happens, many vocabulary terms will not be fully understood, and as such the students will only have a shallow grasp of the material. Dale (1962) has cautioned that excessive emphasis on words apart from their meaning results in memorizing subject matter with mere verbalisms. Instead, teachers should emphasize meanings, and not just the words. While this was in reference to reading teachers, it certainly applies to the sciences.

There is also an important distinction between knowing the meaning of a word well enough to pass a vocabulary test and knowing it well enough to comprehend it in text and use it appropriately (Beck et al., 1982). Shand (1993) states that the most important accomplishment of education is to "…assure that all students, by the time they reach the point at which reading becomes a principle vehicle for the expansion of both vocabulary/concept and world knowledge, have developed a vocabulary of sufficient breadth and depth to enable them to comprehend the materials that they will encounter in school" (p. 11). The goal of vocabulary instruction is to facilitate students' ability to handle language, specifically with comprehending text (Beck & McKeown, 1991). Snow et al. (1998) note that vocabulary instruction results in an increase in students' specific word knowledge, and also leads to better performance on global vocabulary measures, such as standardized tests. Instruction also facilitates an increase in children's reading comprehension abilities (Snow et al., 1998).

Many teachers supply their students with definitions of unfamiliar words during the reading process, under the impression that simple exposure to the meanings will help children acquire the new vocabulary. Research has failed to support this assumption and shows that supplying meanings has little impact on acquisition, and fails to affect comprehension (Pany & Jenkins, 1978; Pany, Jenkins, & Schreck, 1982). McKeown (1991) contends that definitions can serve as a source of independent word learning, but should be viewed as an initiation event in learning about a word instead of the primary vehicle for learning the word. He notes that younger students encounter a great deal of difficulty understanding formal academic definitions when compared to older students. These problems may be due to issues such as vague language, or that younger children find it hard to relate the components of definitions and use them to form a clear concept of the word and its use.

In the classroom, children are exposed to a great deal of vocabulary words. While many students are able to pick up the meanings of new words through incidental exposure, those who are at risk for reading disabilities and who start off with a lower initial vocabulary cannot do this as effectively (Stahl, 1991). Also, when it comes to complex and more abstract vocabulary words, mere exposure and context clues in naturally occurring prose may not lend themselves to inferring the correct meaning of the words (Beck & McKeown, 1991). These findings indicate that for many students, explicit and direct instruction of vocabulary words is necessary (Biemiller, 2001).

Penno, Wilkinson, and Moore (2002) state that a combined approach to vocabulary instruction, which includes both incidental learning and contextually relevant instruction, is ideal. Their study set out to determine if exposure to new vocabulary items within the context of a story would result in vocabulary learning. They also examined the effects of frequency of exposure and teacher explanation of target words on learning. Forty-seven children from two classes between the ages of five and eight from Auckland, New Zealand were used for the purpose of this study.

Participants were given two vocabulary pretests to measure their initial vocabulary knowledge and were then randomly assigned to two groups. Students in the explanation treatment group heard a story and the reader explained the meanings of 10 target vocabulary items in context. Those in the no explanation group heard the story, but the reader gave no explanation of the vocabulary items. The stories and outcome measures were repeated an additional two times. After the treatments, the participants were given multiple choice vocabulary tests to assess their familiarity with the target vocabulary words and a retelling task, designed to measure their use of the target words. Results showed that while vocabulary learning occurred incidentally while listening to a story, as evidenced by a change from $M = 3.16$ questions correct on the pretest to $M = 3.69$ posttest ($p < .01$), greater gains were made when the teacher provided explanations of the vocabulary words. Students who heard explanations went from $M = 2.76$ pretest to $M = 5.33$ posttest ($p < .01$). While gains can be made from incidental exposure, explanation is beneficial.

Not only is the type of instruction important, but the style and organization the teacher uses to disseminate information is necessary to consider. Paul (1989) states that teachers must provide direct, systematic vocabulary instruction, and be sure that attention is given to the entire conceptual framework elicited by the word. Instruction should also build upon prior knowledge. Furthermore, students should have multiple exposures to the words they are being instructed on across time, to promote understanding (Bryant, Goodwin, Bryant, & Higgins, 2003). In the study presented, students were provided with multiple exposures to the words utilizing different modalities.

Researchers have found that the more direct the instruction of vocabulary, the better the students' acquisition of word knowledge (Pany & Jenkins, 1978; Pany et al., 1982). Pany et al. (1982) evaluated teaching procedures frequently employed to improve vocabulary, determined the applicability of these procedures across learner type, and examined the relationship between methods of vocabulary instruction and reading comprehension in a series of three experiments. For the first experiment, 12 fourth grade students were examined, and were given a 65-item multiple-choice vocabulary test which consisted of words judged to be unfamiliar to them. These words all had shorter, more familiar synonyms. Four different treatments were used to present the words: Meanings from Context, in which a sentence was given, but no direct instruction was provided on word meanings; Meanings Given, in which a sentence and the meaning were given; Meanings Practiced, in which the students were given the word, a synonym, and a sentence containing the synonym; and No-Meanings Control, in which just the word was presented. Two vocabulary and two comprehension measures were implemented after the interventions. The comprehension measures consisted of a Sentence Paraphrase Test and a Sentence Anomaly Test.

Results of the first experiment demonstrated a significant test by treatment interaction. The students in the Meanings Practiced condition scored the highest on the outcome measures, followed by the Meanings Given condition, Meanings from Context, and then No-Meanings Control. The more direct the instruction, the better the students learned the vocabulary words. Students comprehended the meaning of sentences best when taught under the Meanings Practiced condition, and comprehended sentences least well when taught in the Meanings from Context condition.

In the second study by the aforementioned researchers, the same procedure was carried out; this time using six learning disabled (LD) students from the fourth through sixth grades. There was again an overall significant test by treatment interaction. The Meanings Practiced means differed significantly from all other treatment means, showing that for these reading disabled students, the Meanings Practiced condition was the most effective instructional procedure. While the Meanings Given condition had an effect, it was much weaker, and Meanings from Context produced no effect with this sample of learners. When compared to the students in the first experiment, this sample acquired fewer synonyms under each treatment condition. This demonstrates that vocabulary instruction and interventions are especially important for learning disabled students who have a greater difficulty learning new vocabulary words. While students with learning disabilities were not included in the sample for the present study, their abilities and learning characteristics are important to consider. Those interventions proven to be beneficial for the participants used in this study should be presented to and used with learning disabled individuals as well.

While understanding the vocabulary words in a text enables an individual to grasp the meanings of isolated words and sentences, vocabulary instruction does not always generalize to story comprehension. The third and final experiment in the aforementioned study, which used only the Meanings Practiced condition, set out to determine if vocabulary training would improve passage comprehension using ten fourth grade LD students and outcome measures consisting of Cloze, story retell, and comprehension tests. Results indicated significant differences between the control and experimental groups on all of the vocabulary and comprehension measures when it came to sentence comprehension. However, when it came to story recall, differences were not significant. This may be because comprehending a story requires more vocabulary instruction than was presented with this methodology. Despite the inability of word meaning instruction to generalize to story comprehension, this does not indicate that vocabulary is unimportant for comprehension. The small sample size used in all three studies must be noted as a limitation and may affect the ability of the results to generalize to other samples and settings.

Unlike Pany et al. (1982), Beck et al. (1982) found an effect of vocabulary instruction on comprehension. Beck et al. observed the effects of vocabulary knowledge on lexical access and reading comprehension by studying 23 fourth grade students. They compared an extensive vocabulary program in which teachers instructed students on 104 vocabulary words presented through approximately 75 daily lessons, each lasting 30 minutes, to a control group which received no instruction. Within the instructional group, students were subgrouped into “some,” “many,” and “none.” In the “some” group new words were taught and reinforced through daily vocabulary lessons. For participants in the “many” group, the subset of words from the “some” condition were maintained over time, reappearing in the instruction of new words in the form of a review, and as such received approximately twice the exposure. For those in the “none” group, words corresponding to pairs of words from the “some” and “many” groups in difficulty, semantic similarity, and length, were used in the pre and posttests but not during the course of instruction. This group was included to allow within-subjects comparisons. All students were measured with a semantic decision latency task, aimed at tapping comprehension at the word level by requiring each student to decide whether each word could be a person; a semantic verification latency task to examine comprehension at the sentence level by requiring subjects to decide whether each sentence presented was true or false; and a story recall task aimed at tapping comprehension at the discourse level.

Results showed a difference between the control and experimental conditions, and differences within the experimental condition between the “many,” “some,” and “none” subgroups in terms of the outcome measures. Participants in the “many” group showed a small but significant advantage compared to those in the “some” group. However, even within the experimental group, performance on the vocabulary knowledge test was well below perfect, with average results of 77.6% for the “some” group and 86.5% for the “many” group, indicating that acquiring word meanings is not an easy task even with extensive instruction. These findings shed light on why many studies which provide shorter and less intensive training periods do not find results.

Results also showed that experimental group subjects were faster in terms of speed of processing in the semantic decision and sentence verification tasks. These subjects also exhibited greater recall of texts, and in their recollections used the instructional words more than nine times as often as did the control subjects, demonstrating gains in productive control over the taught words. Overall, the program was effective; students learned the meanings of words, had faster access to the words, and a better comprehension of text that used the words.

The type of instructional format used for vocabulary learning has also been studied in science classrooms. Depending on the way instruction is disseminated, science lessons can impact immediate and delayed vocabulary knowledge. Upadhyay and DeFranco (2008) examined 108 third grade elementary students’ learning and retention of science vocabulary in connected science instruction classrooms and direct instruction classrooms using environmental science units. The researchers defined connected classrooms as those in which teachers design and implement instruction that connects students’ prior knowledge and outside experiences with the science content of their lessons. Direct instruction classrooms follow traditional approaches in which the teacher delivers the information to the students without much interaction. The researchers hypothesized that more learning would occur in the connected classrooms, as this type of instruction enables the students to bridge their classroom knowledge with community knowledge and helps them to integrate new information with what they already know. Students were given pre and post-instruction surveys, as well as a survey three months after the completion of the units to measure the retention of science knowledge.

Results demonstrated that the increases in pre and post-instruction environmental science vocabulary scores were greater for the direct instruction classes. However, the growth curve indicated that the rate of the loss of vocabulary in the direct instruction group was higher than the connected instruction group between the post-intervention survey and the delayed survey given three months after instruction. This means that students remember new information best over the long term when it is linked to relevant prior knowledge. It was concluded that in order to support immediate gains in science knowledge that can be retained over time, teachers must balance direct and connected science instruction.

Focus groups were conducted with four students from each type of instruction classroom following the study. Students from both groups reported the benefits of the intervention they underwent. Students from the connected instruction classes reported that they enjoyed the activities. They appeared to be more engaged because they felt that their ideas were valued. However, many students from the direct instruction classroom reported that they preferred this type of learning style, because they were never confused about what to study. The information they needed to focus on was explicitly presented to them and was very clear and easy to follow.

A word of caution when discussing interventions for vocabulary in content area classrooms- teachers must be careful not to emphasize rote memorization and the study of vocabulary as an end in itself. This leads to the misconception that science is a finished body of knowledge and is not continually growing and changing (Groves, 1995). Instead, teachers should organize instruction in such a way that the focus is on "...the use of vocabulary as simply a means of guiding students towards the attainment of science concepts" (Groves, 1995, p. 234).

Vocabulary and Depth of Processing

The discussion of vocabulary interventions touches on the theory of depth of processing. The interventions noted in this section appear to differ in terms of the cognitive effort which is employed. For example, there is a stark contrast between incidental exposure and contextually relevant instruction, as described in the Penno et al. (2002) study. Incidental exposure does not require the learner to mentally manipulate or work with the words. This relates to depth of processing which, as previously mentioned, refers to the level at which information is encoded. The more an individual works with a specific task or type of knowledge, the more meaningful it becomes, and the better it is remembered (Craik & Tulving, 1975). This is important to consider when discussing vocabulary interventions, as the depth of processing model predicts that tasks or methods which require students to work with the words and impose their own organization and meaning will enable more efficient learning and comprehension.

Craik and Tulving (1975) conducted a study to examine this theory by manipulating the levels of processing students used through instructions regarding memorization of the words presented. Those who were assigned to the shallow processing group were told to answer structural questions about the word, such as if the word was written in capital letters or what the first letter was. Those who were placed in the moderate level of processing group were told to focus on the phonemic properties of the word, such as what it rhymed with. Those told to engage in deep processing were instructed to focus on the semantic features of the word such as whether or not it could be used complete a sentence. Their study, which is seminal in memory research, showed that those who employed a deep level of processing were the most skilled in recalling the words.

Weiss et al. (1977) examined the depth of processing theory and the idea that the nature of an encoding task determines the amount of processing a stimulus receives. The researchers tested 20 second graders and 20 fourth graders from a suburban Boston elementary school on their memory of vocabulary words. They presented a list of 39 words to the students, each followed by a question which was used to experimentally manipulate the levels of processing the students used when encoding. The researchers hypothesized that a shallow or superficial level of encoding would be produced by questions about the presence of a particular letter in the word. A deeper level of encoding would be used in answering questions such as, “Do you like this word?” Finally, the deepest level of encoding would be employed in questions about the category membership of the word. The researchers then asked the students to orally recall as many words as possible from the list.

Results demonstrated no reliable statistical difference between the levels of encoding. However, there appeared to be a trend that showed that the highest proportion of words was recalled after the category type question. There were also significant differences between the two age groups ($p < .05$) with regards to the category encoding questions, with the older participants recalling more words. There were smaller non significant differences between the age groups for the other two categories of questions. In the study presented, students at an older elementary school grade were used, and the encoding of the words was experimentally manipulated, this time using imagery.

Two more contemporary researchers, Shapiro and Waters (2005) provide a clear explanation of this theory in which processing ranges from shallow to deep. They note that shallow processing focuses on characteristics rather than meaning, as a person will pay more attention to surface attributes such as sound or the physical features of the word. A deeper level of processing is met through a focus on meaning. They state, "[t]he richer the meaning attached to an item to be remembered, the deeper the processing and the more likely it will be recalled" (p. 134).

Also focusing on meaningful encoding, Schmitt and McCarthy (1997) note that simply repeating a word by using a maintenance rehearsal strategy will enable a person to learn a vocabulary item, however "better" learning takes place when a deep level of semantic processing is used. When words are processed "deeply" they are encoded with elaboration, which improves learning. Students who can relate words to other vocabulary, connect the words to their own experiences, or mentally manipulate an aspect of the word or its meaning, are able to reinforce the word association and store it more efficiently (Schmitt & McCarthy, 1997) The more cognitive effort employed when learning a word, the more efficient the acquisition of its meaning.

Imagery can facilitate the ease with which students relate the meanings of words to their own experiences, and as such can be used to increase the depth at which the vocabulary is processed (Schmitt & McCarthy, 1997). Students who picture the words they are trying to learn are mentally manipulating the vocabulary item, and thereby elaborating its memory trace.

Summary

With the pressures of high stakes testing and teacher accountability, little if any time is left in the classroom for anything but test preparation. It is often a challenge to tailor the curriculum to the students' needs and to foster skills across the disciplines. Despite these obstacles, research has shown that integrating literacy across the curriculum and including it in content area disciplines such as science not only saves time, but improves learning (Guthrie et al., 2001; Thier & Daviss, 2002; Yore et al., 2003). Goals have been set in the hope of creating a scientifically literate society, in which students can construct their own understandings of science material, apply it to their everyday lives, and use their newfound knowledge to inform their actions (Hand, Prain, & Yore, 2001; National Research Council, 1996)

There are many approaches a teacher might take to improve the literacy skills of his/her students, but one of the most basic, yet important, is strengthening a student's vocabulary base. Elementary school students are exposed to a great deal of content area vocabulary, especially in science. A thorough understanding of the meanings of words not only improves vocabulary, but also enhances reading comprehension and reading development (Rupley, 2005).

The only way a student can grasp complex constructs and understand the material he/she reads, is through knowledge of the necessary terminology. One must have a thorough understanding of the meanings of the words in their lessons before mastering the material. If a student understands the vocabulary, processing can be directed towards comprehension of sentences and passages, rather than of the specific words (Beck et al., 1982).

Vocabulary instruction should be integrated into science lessons and across the curriculum to give students a great deal of exposure to the desired words. Incorporating vocabulary in the science classroom will not only improve the students' word learning ability, but will also boost their overall science achievement (McKee & Ogle, 2005; Thier & Daviss, 2002).

There are a variety of methods for improving vocabulary, one of which is through the use of imagery. The following sections will discuss the relationship between imagery, vocabulary, and comprehension, as well as discuss the importance of the dual coding theory. Imagery interventions for enhancing the acquisition and retention of science vocabulary are also described.

Imagery and its Relation to Vocabulary, Comprehension, and Science Instruction

Imagery

When examining vocabulary interventions and techniques to facilitate comprehension, it is important to discuss the formation of images, or mental representations, by students. The creation of images while one reads text serves as an aid to understanding and remembering (Sadoski, Goetz, & Kangiser, 1988). Individuals asked to create mental images of events described in sentences learn two to three times as much as those who just read the sentences aloud (Anderson, 1971). Imagery is a major component of cognitive processing, and as such warrants it own detailed discussion.

Imagery Inducement

Students told to create images have been shown to learn new material more efficiently. In a study by Anderson and Kulhavy (1972) using high school seniors, comprehension increased with the amount of imagery the students reported. In this study, 63 seniors were instructed to form mental images while reading a textbook passage. Students were assessed as to their comprehension abilities by a combined short answer and multiple choice test. A follow-up questionnaire indicated that more than half of the control group employed imagery on their own while studying the passage, which confounded the results. Also, one third of the group instructed to form images did not do so. Possibly due to the lack of fidelity to treatment, results failed to show a difference between the group instructed to form images and the one just instructed to read the text. However, the students from both groups who formed images outperformed those who did not. The study demonstrated that students will learn more from a passage if images are formed, as those who created images scored higher.

Levin (1973) also conducted research to examine the effect of imagery strategies on comprehension, focusing on an elementary school sample. In his study, 54 fourth-grade children were given stories to study in either printed or pictorial form. The printed stories consisted of 12 sentences, each printed on an index card. The stories in pictorial form consisted of 12 cartoons corresponding to each sentence. Half of the subjects who were given the text version were taught a visual imagery strategy prior to reading the passage. It was hypothesized that there would be a reading ability by mode of text representation interaction. Questions about both the content and sequence of the stories were asked, and the number of correct student responses was recorded.

Results demonstrated that imagery facilitated comprehension, as those who were given imagery instructions answered more questions correctly. However, the pictorial representations were not facilitative. This could have been because the pictorial sequences were not ideal representations of the stories or because of the need for some type of linguistic accompaniment which may have been required for formal comprehension. Those subjects with adequate vocabulary skills benefited more from the imagery instructions than those with inadequate vocabulary skills. Finally, instructional strategies were more helpful to “difference” poor readers, who are not able to use organizational strategies spontaneously than to “deficit” poor readers, who lack the necessary prerequisite skills for reading such as decoding. This demonstrates that visual imagery may not necessarily be a useful strategy for everyone. The study also shows that fourth-grade children who are able to decode and possess a good deal of vocabulary may still perform poorly on reading tasks because they cannot integrate text by pairing the words they see on paper with the images they describe. As such, they may benefit from instruction to construct mental images corresponding to segments of text.

The developmental course of verbal and imaginal strategy production is also worth examining. A study by Levin et al. (1973) used both fifth and second grade students, as these two groups were considered to be better and less well developed in terms of their imagery-production capabilities. Participants were divided into four groups: control, imagery, in which the subjects were told to make up pictures in their heads; sentence, in which the subjects were instructed to make up one sentence stories relating the words; and imagery and sentences, in which both were employed. All subjects were then presented with picture and word pairs during a study period, and later given the same pairs with a card missing. In some testing conditions, the participants had to recognize the missing card from a sheet presented with choices, and in other conditions, the participants had to recall what the missing item was. It was hypothesized that a sentence-over imagery-strategy would be more effective for second grade students, as their image generation ability is just beginning to develop.

According to the results, the control group was statistically different from each of the strategy groups; however, no significant differences were found among the various instructional strategies in either grade. Additional results demonstrated that picture pairs were easier to learn than word pairs in both grades, and recognition was easier than recall, which is typically seen in research. Surprisingly, the sentence-over-imagery-strategy was not significantly better in enabling the students to remember word pairs when compared to the other strategies. This is contrary to the finding that combining mental imagery and textual illustrations further enhances learning (Gambrell & Jawitz, 1993). Another important finding of this study was that children as young as seven were able to employ an induced visual-imagery strategy to facilitate learning, demonstrating how early imagery instructions can effectively be implemented.

Images also facilitate the recall of entire passages. In a study by Pressley (1976), 86 third-grade children were taught mental imagery strategies to help them remember stories. Stories were presented to the participants in booklets which alternated between blank and printed pages. Those in the experimental group were instructed to construct mental pictures while looking at the blank pages. They were also presented with slides depicting the meaning of the sentences and were told that this was an example of what their mental images might look like. The experimental group participants were also told that their mental images did not have to be exactly the same as the slides, but should include all of the same elements. Students in the control group were instructed to do whatever they could to remember the story.

On a 24-item short-answer test, the imagery group significantly outperformed the control group. This study suggests that mental imagery can be taught in the classroom and can improve children's memory of the passages they read. Also, a nonsignificant trend toward a reader ability by strategy interaction suggests that poor readers can be aided comparatively more by inducing images, a finding in contrast to that found by Levin et al. (1973). However, just because students can remember what was read does not necessarily mean they comprehend the meaning behind it. The short-answer test asked specific questions about events in the story, which only required good recall and no interpretation. All questions referred to concrete material presented in the story. The study presented went more in depth as comprehension was also assessed.

Gambrell (1982) conducted a similar study in which first and third graders were given segments of short stories. Children in the experimental group were instructed to make pictures in their heads before each segment, whereas the control participants were told to think about what they had read in order to remember the text. After each segment, experimenters asked the participants, "What do you think is going to happen next?" Children in the third grade imagery group were able to make twice as many accurate predictions when compared to the control. First graders in the experimental condition also outperformed those in the control; however, differences were not statistically significant. According to Gambrell, teaching children to create images as they read enables them to construct inferences, make predictions, and remember what it is they have read. In this way, imagery enhances remembering, and is associated with comprehension.

Finally, Gambrell and Jawitz (1993) studied 120 fourth grade readers to investigate the effect of instructions to induce mental imagery and attend to illustrations on story comprehension. The participants were split into four groups: those instructed to form mental images while reading an unillustrated version of a story, those instructed to form mental images while reading an illustrated version, those not instructed to form mental images while reading an illustrated version and those not instructed to form mental images while reading an unillustrated version. Reading comprehension was assessed by a prompt to elicit free recall and 16 cued recall questions. It was hypothesized that mental imagery and illustrations play similar roles, and the two strategies, when used in combination, would interact in a positive way.

Results demonstrated that children in the group instructed to form images on their own, as well as to attend to illustrations in the story, outperformed all other groups on comprehension and recall. The students in this group were able to generate complete stories during recall, were able to recall more story structure elements, and answered more questions correctly when compared to the other groups. This favors the notion that the combined mental imagery and illustrations strategy was more potent than either strategy alone, which is opposite of the findings of the aforementioned Levin et al. (1973) study. The idea here is that the imagery and illustrations interact in a way which improves comprehension of text. The imagery plus illustration group was followed by the imagery-only group that read the unillustrated version, then the group that was not instructed to create images but exposed to the illustrated version, finally followed by the control group. Post-hoc analysis demonstrated that all three groups were significantly different from the control group. It is important to note that the control group was the only group in this study that was explicitly told to read to remember. However, without imagery, they still performed the worst.

Also noteworthy is that there was some evidence that mental imagery was more effective than the illustrations in terms of reading comprehension performance. When analyzing the types of questions the students answered, those in the imagery-only group recalled more story structure elements than those in the control group, but there was no statistically significant difference between the illustrations-only group and the control. Also, while 58% of the students in the imagery-only group wrote complete stories, only 40% of those in the illustrations group were able to. This suggests that induced mental imagery may be more effective than illustrations, a finding which was examined in the study presented. Finally, the results of the study support an imagery-illustration interaction theory, in which readers use mental imagery and illustrations in dynamic and interconnected ways, leading to enhanced comprehension. This was also investigated in the study described, through the use of an intervention that combined a picture and the instruction to create a mental image. Overall, the Gambrell and Jawitz study, like the others discussed, suggests that instructions to create mental images and attend to illustrations enhance the quality of children's story comprehension. These findings highlight the need for researchers to examine induced mental imagery as it is applicable to the classroom (Gambrell & Jawitz, 1993).

Imagery in the Sciences

Imagery plays a major role in facilitating learning. McKee and Ogle (2005) note that young students profit from illustrations of words. This is because an illustration can act as a visual clue when the students need to read the word or must use it for written work. The authors also describe the utility of pictures in reference to young elementary students and English Language Learners (ELLs). While the use of pictures in preschool and early elementary school lessons was discussed in great depth in their book, no mention was made of the utility of this approach in content area lessons and with older elementary school children. The present study examined a fifth grade sample and the students' ability to master information that would otherwise be presented to them in middle school. If the interventions prove to be useful, not only can it be claimed that lessons typically taught to older students can be presented earlier if the vocabulary has been effectively acquired, but that imagery should remain a focus of vocabulary interventions in the late elementary school years and during science instruction.

Thier and Daviss (2002) also discuss the use of imagery in relation to the integration of science and literacy. They explain guided imagery, which is an approach that allows students to capitalize on their imaginations when reading from a textbook. The students picture what is described in their text and also try to visualize images associated with the headings and subheadings of the chapter they are reading. This enables the students to find meaning when reading about a complex or abstract subject. It is also helpful, because "…the mental images sparked by guided imagery can be vivid enough to lure them into the text and to more readily retain the information in the reading" (Thier & Daviss, 2002, p. 104).

Imagery has also been shown to lead to improvements on science exams. McIntosh (1986) conducted a study to investigate the effects of imagery on a rule recall and transfer task with 104 ninth grade male students in Philadelphia. Each of the four participating classes was assigned to either an imagery encouragement or imagery discouragement group and was presented with the following gas laws in their physical science class: Boyles' Law, Charles' Law, and Gay-Lussacs' law. Students in the imagery encouragement group were instructed to create an image of a typical gas as it responded to changes in pressure, temperature, or volume and to draw the image in their notebook. Participants in the imagery discouragement group were told to write the rule and repeat it aloud during the lesson. After instruction, students took a gas law criterion test to measure recall and transfer of the information presented. During the test, using the Marks Vividness of Visual Imagery Questionnaire (Marks, 1973, as cited in McIntosh, 1986), students were required to rate on a five-point scale, the degree of imagery they used when answering each test question.

Encouraging the formation of an image in this study did not facilitate recall (p = .52). Imagery utilization, as shown by those who reported a high use of images, aided in rule recall (p = .02). One reason why the intervention may not have had an effect is that even when they are not encouraged to form images, students may do so on their own, confounding the results, as occurred in the Anderson and Kulhavy study. The study does provide evidence that imagery use can be an effective way to recall science rules.

Dual Coding: Theoretical Underpinnings

One theory which examines the use of imagery in the processing of information, and has been empirically tested by numerous studies is dual coding. Paivio's dual coding theory states that information is processed along two distinct channels: verbal and visual. Research has shown that memory for verbal information is enhanced when the information is accompanied by a visual presentation, either real or imagined (Anderson & Bower, 1973). The dual coding theory links vocabulary to comprehension through the use of images in improving understanding and enabling deeper processing. As such, this theory was used to frame the design of the vocabulary interventions in the present study.

Information is organized very differently in the two systems. The verbal system is organized sequentially, as it is constrained by the linear nature of speech or print. The imagery system, on the other hand, is more holistic. Units are stored in an integrated way and cannot be separated into their discrete parts. This is because individuals encounter perceptual objects as clusters of information. Visual objects are embedded in their surroundings and context, and as such are difficult to separate.

The two systems are linked by the referential connections which involve the activation of representations in one code by previously activated representations in the other code. For example, the sentence “The diver plunged into the pool” can evoke a set of mental images (Sadoski & Paivio, 1994, p. 586). Conversely, an image can evoke language that is typically associated with it. These connections are formed by life experiences. Within each respective system, there are associative structures which operate via associative connections, in which a word can evoke another word, or an image may naturally lead to another image (Sadoski & Paivio, 1994). Experience is responsible for determining the number and strengths of interconnections, with concreteness being relevant to the development of referential connections, and verbal context relevant to the development of associative connections (Paivio, Clark, & Lambert, 1988).

Information that is concrete readily evokes mental images as compared with abstract language, making it easier to remember. This is because two forms of mental representation, language and imagery, are available for processing the information. Dual coding theory assumes that both abstract and concrete words are represented within the verbal system; however, it is the concrete words that are more likely to have a strong connection to the image system. Abstract language has a relatively weaker capacity in enabling an individual to form images. Concrete language has also been found to be more comprehensible, interesting, and memorable (Sadoski, Goetz, Stricker, & Burdenski, 2003).

Dual Coding: Implications for Comprehension

Dual coding provides an explanation of the ability to master and understand words, phrases, and sentences in different contexts. The self-generated images a reader forms may "…constrain and specify the set of subsequent probable wordings by nonverbal means, and also expands the episode inferentially" (Sadoski & Paivio, 1994, p.587). Imagery helps reduce the uncertainty when shaping meaning from reading a text. The images evoked depend upon a particular individual's past experiences and the situation that is described to him/her. This model also allows for flexibility in responses to novel situations, as meaning is determined by both the term and its connections to nonverbal world knowledge (Sadoski & Paivio, 2001). Sadoski and Paivio (1994) offer an eloquent explanation in that "…for language to make sense, it is necessary for it to be both semantically and syntactically systematic and to conform to the nonverbal world in some imaginable way" (p. 590).

This theory also offers an explanation of how individuals derive meanings from words, which can be accurately decoded but not understood without prior processing of contextual meaning. The meaning of a word is dependent on contextual and imaginal knowledge. For example, ring can refer to the ring of a telephone, a boxing ring, or wedding ring. Comprehension of a term also relies on knowledge of what a wedding ring is, or what a boxing ring looks like, as well as other context features (Sadoski, 2005).

Finally, dual coding is a theory that "…draws a complex set of empirical research findings about interest, comprehensibility, memorability, and importance together under a set of general principles that are both explanatory and applicable to a variety of text types" (Sadoski, 2001 p. 264). Affective responses, which include interest, are nonverbal and associated with the nonverbal code, and as such are expected to accompany mental imagery and concrete language (Sadoski & Paivio, 1994). These findings suggest that in order to make texts more interesting and understandable, they should be altered in ways to make them more concrete and imageable.

A study by Sadoski et al. (1993) set out to extend the predictors of dual coding theory in the recall of sentences and longer texts by Texas A&M students through a series of four experiments. This study also examined the conceptual peg hypothesis by looking at whether or not mental images serve to promote the recall of what otherwise would be considered abstract information, by using concrete, image evoking sentences. This study was both ecologically valid and instructionally relevant in that the materials used were adapted from actual history articles and books. Ten historical figures were selected, and four sentences were created about each: two concrete and two abstract. In the first experiment, participants rated the sentences for four qualities on 7-point bipolar scales examining content familiarity, concreteness, interestingness, and comprehensibility. Relationships were shown between concreteness and interestingness (r = .72), concreteness and familiarity (r = .36), and concreteness and comprehensibility (r = .91). These results show that in the study, concreteness and comprehensibility were almost completely overlapping constructs, and concreteness was the best predictor, accounting for approximately 80% of the variability in comprehensibility. Overall, students rated the concrete language as easier to understand, which supports the dual coding theory. Concrete language, which can be coded verbally and nonverbally, is perceived of as more comprehensible than abstract language.

The second experiment by the aforementioned researchers investigated the effects of concreteness and abstractness on immediate and delayed recall, this time using sentence pairs rather than word pairs. Undergraduates were randomly assigned to one of four groups of sentence pairs: concrete-concrete, concrete-abstract, abstract-concrete, or abstract-abstract. They read passages and immediately after finishing were told to recall everything they remembered. There was also a delayed recall task which occurred five days after the initial experiment. Results showed that those in the abstract-abstract group recalled significantly less than the participants from the other groups, who did not significantly differ from one another when measured immediately and after a 5 day interval. Also, immediate recall exceeded the delayed recall.

The third and fourth experiments, using students from Texas A&M who had not participated in the first two experiments, extended the findings to the paragraph level.

The results of the third experiment closely replicated the results of Experiment 1 with sentences. Concrete paragraphs were rated as more concrete, interesting, and comprehensible than abstract paragraphs, while rated familiarity did not differ. Results of Experiment 4 closely resembled Experiment 2, as concrete paragraphs were recalled significantly more than abstract paragraphs. Content from the concrete paragraphs was recalled almost three times as much as content from the abstract paragraphs.

Overall, the results of the four experiments are supportive of the dual coding theory. From the studies, it was shown that concreteness was the best predictor of comprehensibility, and that immediate and delayed recall of sentences and paragraphs occurred more efficiently with the concrete samples. Also, concrete text was rated as more comprehensible and interesting than abstract text, but not necessarily more familiar. Efforts to alter texts to make them more concrete should be implemented accordingly.

Dual Coding: Implications for Vocabulary Instruction

As stated in the previous section, dual coding theory suggests that concrete words are learned more readily and recalled more easily than abstract words. The more concrete a word is, the greater the ability for it to evoke a web of images. Therefore the study described looked at both providing images for students and priming students to create images when presenting them with science vocabulary, in order to facilitate learning.

It is important to note that pictures do not always show positive results in facilitating the learning of words. Some find that using pictures detracts from attention to the details of print (Samuels, 1970). Samuels (1970) discussed the focal attention hypothesis, which is based on the principle of least effort. This hypothesis suggests that when pictures and printed words are presented together, readers will only attend to the mode that helps them produce the response with the least effort. If the reader attends to the easily available picture, it will interfere with his/her attention to the details of the print form. The pictures distract the readers and draw attention away from the printed stimulus, which prevents them from learning the word and being able to analyze it. Upon testing, after the pictures are removed, those who learned with pictures will not perform as well as those who learned with the words alone.

Arlin, Scott, and Webster (1978-1979), tested the focal attention hypothesis, and contend that the work of researchers such as Samuels (1970) was flawed. They assert the usefulness of pictures when learning words. These researchers note that in Samuels' study, the temporal order of cueing was confounded with the picture/no-picture dimension. The picture was presented simultaneously with the "to be learned" word, but the verbal cue was provided as feedback after the presentation of the word, causing a distracting effect of the picture on word learning. Also, a greater amount of verbal feedback was given in the no picture condition, which could have influenced the results of the interventions. This is because in the picture condition the image prompted the correct response, whereas in the no-picture condition much more verbal feedback was necessary. Thus the superiority of the no-picture condition may have been due to the disproportionately large amount of feedback rather than to the benefits of this intervention approach.

In their study, kindergarteners were placed in one of three conditions. They were presented with either a word and its picture together, a word and its oral pronunciation, or a control in which the word was presented alone. Results showed that sight word learning occurred 80% faster in the word with picture condition. This is because the picture establishes a connection between the word and the image. These findings suggest that the presentation of pictures with words facilitates rather than hinders learning.

Dual coding theory not only explains the acquisition of sight words, but can be used in meaningful vocabulary instruction, both when learned incidentally from context, and when taught explicitly using direct instruction. According to dual coding theory, encountering and using words in various contexts helps children establish a rich set of verbal and nonverbal connections, which facilitates their learning, and makes the vocabulary meaningful (Sadoski, 2005).

Smith, Stahl, and Neil (1987) used a variety of different methods for meaningful vocabulary instruction. The researchers separated 142 undergraduates into three conditions to learn 50 words. There was a definition only group; a definition and a sentence using the word in context group; and definition, sentence using the word in context, and a simple picture illustrating the meaning of the word group. The group receiving all three treatments scored the highest (as cited in Sadoksi, 2005). A delayed test, administered after two weeks, revealed that the scores increased in each treatment, and that there was now a significant difference between the definition only and definition, sentence, and picture group. This lends support for dual coding in vocabulary instruction.

More recent studies have been conducted with the hopes of settling the dispute regarding pictures and the textual presentation of words. Amrheim, McDaniel, and Waddill (2002) conducted a series of four experiments which were designed to test whether or not pictures are superior to words in a variety of different tasks. The first experiment involved 48 college students from Purdue University, who were instructed to pick which animal out of a pair best fit the adjective given by the experimenter. Pairs presented to the participants were either pictures, or the written names of the animals. According to the dual coding theory, pictures should produce faster responses than words for concrete information, as concrete features are represented in the nonverbal imaginal code, which is accessed readily by pictures. Conversely, words would confer an advantage over pictures for abstract semantic information, as these are stored in the linguistic system. However, no influence of modality on the symbolic-comparison task was shown. Results of the experiment indicated that picture and word stimuli evoked statistically equivalent response speeds in selection of adjectives, and that there were no significant differences between the stimulus modalities. These results are in contrast to the theoretical assumptions regarding the role of pictures relative to words in how knowledge is represented and accessed. The other experiments included in this study varied in terms of the participants, focusing on other undergraduate students, and design to allow more power; however all demonstrated the same results. Their study brings the dual coding theory into question, as these experiments provided no statistical support of its assumptions.

Sadoski (2005) contends that despite claims to the contrary, using pictures to help build vocabulary is effective, as the images make the words more concrete and understandable. He notes that in current classroom practice, target words are first accompanied by pictures and then presented on charts without pictures, to direct attention to the word form, facilitating the child’s complete learning of the word (Sadoski, 2005). Samuels (1970) suggests that when including illustrations, books should be organized in such a manner that the pages with printed text are free of pictures, allowing the student to focus on the task of learning to read.

Dual Coding, Depth of Processing, and Vocabulary

Imagery and depth of processing are both employed in the use of the keyword method. This memory strategy, often used in foreign language learning, is one of the most thoroughly researched methods of direct instruction of vocabulary, and is also based on the dual coding theory. For this method, the learner forms an interactive mental image of the definition of the new vocabulary word and a familiar word that shares some similar element (Sadoski, 2005). For example, *carta*, which means letter in Spanish, can be remembered by using the keyword *cart* and picturing someone placing a letter in a cart. The definition is linked to the word by an image, facilitating its recall.

Shapiro and Waters (2005) investigated the cognitive processes underlying the keyword method. They posited that the benefits witnessed as a result of the use of this method are due to the use of images and cognitive effort. With regards to imagery, the strategy requires a person to create an image that is associated with the "to be learned" word. Evidence supporting the keyword method corroborates the findings of the dual coding theory, in that concrete words are learned more efficiently than abstract words. Individuals using this method must also expend a greater level of cognitive effort. As per Craik and Lockhart's aforementioned theory, processing can range from shallow to deep. Shallow processing typically relies on attributes and surface features, whereas deep processing focuses on the semantic features of a word. In creating a keyword, a person must first think about the meaning of the word in both languages and come up with a plausible way to connect them, which relies heavily on meaning.

Shapiro and Waters (2005) empirically tested the underlying cognitive processes of the keyword method using a 2 (processing task) X 2 (imagery value) mixed design with 104 introductory psychology students from the University of Massachusetts. Being that visual imagery is the foundation of the strategy, the researchers hypothesized that the keyword method would not assist with abstract words or low-imagery words. Based on the role of cognitive effort in the keyword method, they hypothesized that if effort was reduced, by providing the students with the keyword instead of having them create their own, this would mitigate the effectiveness of the strategy. Finally, they hypothesized that memory would be best when both imagery and effort were high.

Fifteen high-imagery and 15 low-imagery Latin words were used for the purpose of this study. All students were told to imagine the meaning of each word interacting with a keyword. In the Given condition, the subjects were provided with both the keywords and the interactions, and in the Self-Generated condition, the students were instructed to generate their own keywords and interactions. After the words were presented, the students were given a distracter task consisting of eight arithmetic problems to prevent rehearsal of the last items and ensure that there was enough time for the items to transfer from short-term to long-term memory. A posttest was given to test the number of English meanings the students remembered and a delayed posttest was administered a week later.

There was a significant main effect of imagery on both the immediate ($p < .001$) and delayed ($p < .001$) posttests. On average, participants were able to recall 79% of the high-imagery words a week later, as compared to only 14% of the low-imagery words. However, there was no significant main effect for processing or an interaction effect on the immediate and delayed posttests. While cognitive effort may not be the basis of the keyword method, imagery clearly serves a major role. Therefore, if words are high in the amount of imagery they elicit they will be more easily remembered. A provided picture will also facilitate acquisition, so a student does not necessarily need to create an image on his/her own. This was tested by the study presented as both image presentation, image creation, and any potential additive effect of the two were explored.

Summary

Imagery is very important to consider in terms of how children learn vocabulary and how to develop effective interventions for them during science instruction. Research indicates that the more imagery produced when reading text and learning new material, the more memorable it is (Anderson, 1971; Anderson & Kulhavy, 1972; Levin, 1973; Sadoski et al., 1988). Imagery may be naturally created by the student during the course of learning, or images may be induced or primed by researchers, either of which is effective in terms of facilitating comprehension. This idea should be taken a step further in terms of vocabulary instruction in the sciences, as creating an image for a vocabulary word naturally, or being presented with a picture or instruction to create an image will most likely help to reinforce the meaning of the word and facilitate learning of the concept presented.

Dual coding, a theory of cognition originally put forth by Allan Paivio, posits that both the visual and verbal codes work together to organize incoming information so it can be processed, stored, and organized in a meaningful manner (Sadoski & Paivio, 1994). It applies to the instruction of vocabulary and literacy in general, in that words which evoke images are remembered more efficiently. Sadoski claims that dual coding is the only theory to effectively integrate different aspects of perception into one overarching theory of cognition (Sadoski, 1998). Finally, Sadoski (2005) notes that dual coding theory is extremely beneficial in that it links classroom practice to theory. As such, the theory helps teachers and researchers alike to understand not only what works for vocabulary instruction, but why it works as well (Sadoski, 2005).

Synthesis

The research findings regarding science instruction, literacy, the integration of the two disciplines, as well as vocabulary, dual coding, and imagery have all been highlighted. This section offers a short summary of what has previously been discussed, as well as draws the components together.

Given that the benefits of integrating science instruction and literacy have been well documented, and the push for developing a scientifically competent society is ever so present (McKee & Ogle, 2005; National Research Council, 1996; Thier & Daviss, 2002; Yore et al., 2002), there is a great need for literacy-based interventions within the science content area. In order for students to learn complex science material, they must understand the terminology required so that they can speak and communicate using the language of science.

Learning new content area material is very difficult without a mastery of certain literacy skills, such as reading comprehension and vocabulary. A student cannot be expected to understand the concepts without a firm grasp of the basic terminology used. Therefore, students must be instructed using effective interventions focused on building and strengthening their vocabularies. This will allow them to further their quest for knowledge in the discipline, anchored by a strong understanding of the integral components needed.

One way to facilitate vocabulary learning is through the use of imagery. Imagery can be generated either spontaneously or with the help of instructions prompting the student to form mental pictures. Either way, the use of images strengthens the ability of the student to learn the meaning of vocabulary and to comprehend text (Levin et al., 1973; Sadoski, 1998). Students, even when not explicitly told to create images to facilitate learning, often take the initiative to do so on their own (Anderson & Kulhavy, 1972; McIntosh, 1986). Imagery also increases the depth at which the meanings of the words are processed (Schmitt & McCarthy, 1997).

According to the dual coding theory, which takes imagery and learning into account, cognitive processing occurs in both the verbal and visual domains (Sadoski, 2005; Sadoski & Paivio, 1994; Sadoski & Paivio, 2001). By linking these two components together, information can be elaborated, and as such is better understood (Anderson & Bower, 1970; Sadoski, et. al., 1993; Sadoski & Paivio, 1994). Connecting imagery to the verbal component also enables a deeper level of processing of the "to be learned" information. Imagery should be employed to assist students in acquiring the vocabulary and understandings necessary to be "scientifically literate" individuals, and proficient lifelong learners.

Rationale for Study

There is currently a focus on strategy instruction within literacy, which has resulted in less attention to background knowledge and vocabulary. While comprehension strategy instruction can be beneficial, it is not much help without a mastery of the vocabulary needed (Fisher et al., 2009). Also, a lot of the work during content area instruction centers on standardized test preparation, rather than on building a strong knowledge and vocabulary base from the bottom up (Thier & Daviss, 2002). Instructional efforts must focus on the basic skills required as "…solid science literacy instruction requires attention to vocabulary" (Fisher et al., p. 184). The present study examined interventions which used imagery to effectively teach content area vocabulary to elementary school students.

Many researchers have identified areas related to vocabulary instruction in which research is currently lacking (Beck & McKeown, 1991; Biemiller & Boote, 2006; Stahl & Fairbanks, 1986). This study attempted to respond to this need, by examining how different imagery interventions affect the learning of science vocabulary by fifth grade students.

While the relationship between vocabulary and comprehension of new material has been widely researched, further studies are needed to bridge the gaps which still remain. Beck and McKeown (1991) have stated:

> The effects of vocabulary instruction on comprehension have tended to be rather small; and most measures of comprehension have relied upon contrived passages, which poorly represent texts students meet in natural reading situations. Thus, the results of instructional studies indicate that vocabulary learning does affect comprehension, but the parameters of that effect have not yet been identified (p. 808).

They also state that while the relationships reported between vocabulary and comprehension may seem small when examined quantitatively, their significance may be more apparent when the quality of understanding is considered. This unresolved issue is addressed by this study through the use of vocabulary learning evaluation forms and student discussions which obtained the participants' opinions of the interventions they experienced, and beliefs as to whether or not they felt these approaches to vocabulary learning provided them with a thorough understanding of the words. This qualitative component allowed the researcher to gain further insight into the utility of the interventions.

Furthermore, while the idea that vocabulary is essential to young learners is commonly accepted, the types of interventions implemented vary. There are a variety of instructional techniques based upon different theoretical accounts, such as Paivio's aforementioned dual coding theory. However, research has often failed to directly establish the relationship between a theory and its implementation in the classroom. A comparison of imagery interventions was made in the present study to compare their effectiveness for classroom use.

According to Biemiller and Boote (2006), there are relatively few recent studies on vocabulary instruction with elementary school children. Most studies involve strategies for reading stories by altering the levels of direct instruction given while reading, thus assessing the students' comprehension of the entire passage. Not many focus on nonstory methods. This study shifts the focus to the instruction of vocabulary words, specifically for science instruction, using a variety of interventions operating at the word level.

This study focused on an elementary school sample, and sought to ascertain whether students could master complex vocabulary aimed above their current knowledge level. The words presented to the participants were those commonly instructed to middle school students. If the imagery interventions were to yield significant results, it would suggest that verbal and imaginal pairing should be implemented early on in school curricula.

Stahl and Fairbanks (1986) have also cited the need for future researchers to examine depth of processing experimentally in relation to vocabulary instruction. The interventions used in this study manipulated the depth at which the vocabulary was processed, by adding an imaginal component, and linking the verbal code to the visual code.

In order to test the assumptions of the dual coding and depth of processing theories, the effects of various manipulations with regard to image presentation and image creation on word learning and retention were examined. Four different interventions which altered the way in which the vocabulary was presented to fifth grade science learners were used. A Word Only method, which involved the simple verbal presentation of the word, was employed to examine students' acquisition and retention of the words when no imagery was employed. Three different imagery interventions were used to determine the effect of imagery on vocabulary learning: Picture Presentation, Image Creation- No Picture, and Image Creation- Picture. Each one of these interventions employed a different level of processing as well.

In the Picture Presentation method, an index card with a picture depicting the word was presented to the participants. In the Image Creation- No Picture method, the participants were told to create an image of the word in their heads and to draw the picture on paper, which enabled the researcher to determine the effects of creating an image on vocabulary acquisition and retention. Finally, in the Image Creation- Picture method, the students were presented with the picture of the word as a frame of reference and then told to draw the word on paper, which would help to determine if there were any additive effects of imagery presentation and imagery creation. The purpose of this study was to investigate the practical significance of these different interventions in facilitating the vocabulary learning of fifth grade science students.

The study also examined the difference between the various manipulations of the imagery interventions. This allowed a comparison between imagery interventions that required varying levels of processing. In the Image Creation- No Picture intervention, the student created an image on his/her own, employing a deep level of processing, which may have increased the benefits conferred by the use of images. In the Image Creation-Picture and Picture Presentation interventions the picture was provided, which did not afford as deep a level of processing. However, the picture may have been useful in that the image formed by the student was based on a concrete example.

Vocabulary should be a priority, especially within the content areas, if students are expected to be able to read to acquire information (Fisher et al., 2009). It is important that the vocabulary words instructed not be treated as a list to be memorized, but rather as integral components that will facilitate a deeper level of understanding of the “to be learned” material. This study assessed interventions for the instruction of new vocabulary in the science content area. Those methods shown to be effective provide a promising way to integrate literacy and science instruction.

Hypotheses

The hypotheses of the study presented draw upon the theories of dual coding and depth of processing. To test the claims put forth by these theories a 1-between-subjects, 1-within-subjects repeated measures design was employed. In this model, the intervention assigned was the between-subjects variable, and the time in which the outcome measures were disseminated (immediate versus delayed) was the within-subject factor. The manner in which the vocabulary words were presented serves as a way to test if imagery, the depth at which the students processed the vocabulary, or if the presentation of an image and the deep level of processing associated with creating an image had an additive effect on the acquisition and retention of the words. Therefore, the study examined the effect of two different theories, both alone, and in conjunction with one another, on student vocabulary learning.

Based on the theory of dual coding, it was hypothesized that when students were instructed via any of the imagery interventions, they would demonstrate better mastery of the vocabulary than when presented with only the word, because adding an imagery component facilitates vocabulary learning (Sadoski, 2005). Therefore, students were predicted to demonstrate higher levels of vocabulary acquisition after the Picture Presentation, Image Creation- No Picture, and Image Creation- Picture interventions compared to the Word Only intervention. According to this theory, both image presentation and/or image creation should facilitate vocabulary learning.

Creating images, especially by drawing them, increases the depth at which students process information and the meanings of words. This is because "…drawing requires careful observation of an object's or phenomenon's distinctive characteristics [which enables] students to attend to details they might otherwise overlook" (Armon & Morris, 2008, p.49). Therefore, according to depth of processing, the Image Creation- No Picture intervention should be the most effective, as it required the students to process the "to be learned" information at the deepest level. This is because the participant must become active in creating an image and drawing it on paper. The Image Creation- Picture intervention also required deep processing, however the picture was provided. The

Picture Presentation intervention should be the third most effective, as imagery was employed; however, the level of processing was not as deep as the aforementioned interventions. This is because the pictures were presented to the students, without their having to create the images on their own. The least effective strategy for vocabulary learning should be the Word Only presentation, as the word was only presented in one code: verbal, and thus only allowed for shallow processing. Therefore, depth of processing predicts specific ordering, rather than simply a benefit from the presence of an image.

Furthermore, it was hypothesized that the imagery interventions would aid the students in remembering the vocabulary words presented to them, acquiring their meaning, as well as retaining this knowledge over time. It was predicted that students in these interventions would show improvements on outcome tasks intended to measure maintenance of vocabulary knowledge. They would also report the relative benefit of these interventions during discussions with the researcher and through their answers on the vocabulary learning evaluations.

One note of caution is that the effectiveness of the Image Creation- No Picture intervention depends on the students' ability to comprehend the meaning of the word sufficiently to be able to form an accurate representation of it in the form of a picture. Hibbing and Rankin-Erickson (2003) note that the reader's images may not always match the words' actual meanings. In such a case, an incorrect image may further detract from comprehension. The researchers state that while a verbal description is sometimes sufficient, at other times an actual picture of the word may be necessary for the student to comprehend the meaning. In this instance, presenting the picture helps the students to a greater extent than just having them draw the picture based on a sentence and definition. Supplying students with a picture prevents them from creating images that have little or nothing to do with the meaning behind the word.

The Image Creation- Picture intervention was included in the study to account for this possibility. Since the pictures were provided in this intervention, the students' images should not stray from the meanings of the words. However, since the students were given the images, their level of processing may not have been as deep as the Image Creation- No Picture presentation. Even though the words presented were concrete and were presented with clear definitions, these terms were complicated and represented novel content area concepts. Taking this into account, it was predicted that the Image Creation- Picture intervention would be more effective than the Image Creation- No Picture intervention for this particular sample, demonstrating an additive effect of image presentation and creation. The students did not necessarily need to copy the picture they observed, but could use it as a springboard for their own mental image and drawing.

Based on the research and theories presented, the following hypotheses were formulated for the acquisition and retention of the science vocabulary words:

Acquisition

Hypothesis 1: Based on the theory of dual coding, students in the imagery interventions (Image Creation- Picture, Image Creation- No Picture, and Picture Presentation) would acquire a significantly greater amount of science vocabulary than those in the Word Only intervention group, as both the verbal and visual components of processing were employed. Therefore, the presentation of pictures and the creation of images would improve vocabulary learning. This difference would be evidenced on the researcher-generated immediate recall outcome measures.

Hypothesis 2: Based on the theory of depth of processing, the deeper the students process the information, the more science vocabulary they would acquire, as measured on the researcher-generated immediate recall outcome measures. Students who created images employed a deeper level of processing, compared to students who were presented with the pictures.

Hypothesis 2a: Students in the Image Creation- Picture group would acquire a significantly greater amount of science vocabulary than those in the other imagery groups, as the meaning of the words was processed at a deep level because an image was created by the student. This particular intervention also included a picture which helped to clarify the word for the participant before he/she created the image. There would be an additive effect of image presentation and image creation, which would be evidenced on the researcher-generated immediate recall outcome measures.

Hypothesis 2b: Students in the Image Creation- No Picture group would acquire a significantly greater amount of science vocabulary than those in the Picture Presentation intervention group, as the meaning of the words was processed at a deeper level, but may not have been as helpful as the Image Creation- Picture group since a picture was not included. The depth at which one processes the words should have more of an effect on learning, compared to presented pictures, as the creation of images has been shown to be more powerful in terms of vocabulary acquisition (Gambrell & Jawitz, 1993). The benefits of this intervention would be evidenced on the researcher-generated immediate recall outcome measures.

Hypothesis 2c: Students in the Picture Presentation group would acquire a significantly greater amount of science vocabulary than those in the Word Only intervention group, as the meaning of the words was processed at a deeper level, which would be evidenced on the researcher-generated immediate recall outcome measures. While image presentation may not afford as deep a level of processing as image creation, it should still be more beneficial than no imagery at all.

Retention

Hypothesis 3: Students in the imagery interventions would answer more questions correctly on the researcher-generated delayed outcome measures, as the benefits conferred by these interventions would enable the students to retain their vocabulary knowledge more efficiently. However, the differences between the students in each imagery intervention would most likely diminish.

Participants' Perceptions of the Interventions

Hypothesis 4: Through an exploration of participants' feelings regarding the utility of the interventions, based on the vocabulary learning evaluation forms and student discussions, responses would reflect the trends displayed by the quantitative results. For example, if the Word Only intervention was not as effective as the imagery interventions, students exposed to Word Only would not report it as having been particularly useful to them.

Hypothesis 5: Through an exploration of the participants' awareness of the components of the interventions, based on the small group discussions, students would have been able to identify the steps of the intervention they were exposed to and why the particular intervention did or did not help them learn the vocabulary.

CHAPTER 3

Methodology

This chapter describes the methodology that was used to examine whether the imagery interventions facilitated the fifth grade students' acquisition and retention of the "to be learned" science vocabulary words. The chapter begins with the selection of participants, followed by a description of the measures and interventions utilized, and ends with the procedures used in conducting the study.

Participants

After receiving approval from the CUNY Graduate Center Institutional Review Board, participants were recruited from public schools in Nassau County, Long Island. A letter was mailed to the schools' principals describing the research and requesting permission to conduct the study at their site (see Appendix A). With their permission, parental/guardian permission forms were distributed (see Appendix B) and students were asked for their assent (see Appendix C).

Data from the mini pilot study, which examined a sample of 18 students, demonstrated moderate effect sizes ranging from .6 to .7. As a result, the decision to have at least 14 to 16 participants per cell was made. A greater amount of participants was still sought, as a sample of 90 students would be sufficient to detect a medium effect size at the $p < .05$ level of significance, after data was collected from each participant twice (Cohen, 1992). The total number of permissions received was 90, which exceeded the sample size of the first pilot by over 500%. Data was collected from 89 students, as one was absent for the majority of the researchers visits. Forty-five males and 44 females participated in the study with a mean age of 10 years and 2.1 months.

To ensure confidentiality, students who participated in the study were assigned an identification number. The list of names and numbers for each class was placed in a sealed envelope and stored separately from the interventions and outcome measure materials. This list was only to be consulted in the event that a student forgot his/her number, which did not occur in this particular study. Neither the teacher nor the researcher had access to this list.

Two elementary schools were used for the purpose of this study. Both were located in Nassau County, Long Island. One is situated in Long Beach and the other in Rockville Centre. The superintendents, principals, and support staff of both schools eagerly welcomed researchers and encouraged the collection of data to help improve teaching methods.

Rockville Centre. The mission statement of the Rockville Centre school notes that it fosters a unique environment in which the focus is on “Celebrating individual growth, mutual respect and cooperation [and] empowering children and adults to become enthusiastic, creative, independent, lifelong learners” (RVC Schools, 2002-2010, p. 1). The school focuses its efforts on “stamping out bullying” as well as the health and well being of every child.

The average class size in grades 1 through 6 in Rockville Centre schools is 21 students. The particular Rockville Centre school the study was conducted in consisted of 314 students in total, with 50 fifth graders. The students in the Rockville Centre schools are predominately White. In the 2010 school year, the breakdown was as follows: 79.3% White, 5.1% Black, 5.7% Asian, and 9.9% Hispanic. Data from 2009 show that 7% of students received free or reduced price lunch and 2% of the students were limited in their

English proficiency. Finally, in 2009, 96.1% of Grade 4 students met standards in Math and 95.3% met standards in English (“Rockville Centre,” 2010).

Class 1 had a total of 25 students: 13 boys and 12 girls. The parent of one girl requested that she not participate in the study, reducing the sample of girls to 11. The mean age of the students in this class was 10 years and 3 months (*SD* = 6.129 months; Range = 9 years to 11 years and 6 months). Twenty students identified themselves as Caucasian, three as Hispanic, and one as Asian. Twenty-one students learned English as their first language; two learned Spanish first; and one student learned Italian first. Twenty students spoke English only at home; two spoke Spanish only; one spoke Spanish, Italian, and English; and one spoke French and English in the home.

Class 2 had a total of 25 students: 12 boys and 13 girls. Two boys declined to participate in this study and one never returned his parental permission slip, making the sample from this class 22. The mean age of the students in the sample was 10 years and 2.2 months (*SD* = 3.934 months; Range = 9 years and 6 months to 11 years). Eighteen students identified themselves as Caucasian; 1 as African American; and 3 as “Other”. Of the three that checked other, one wrote in Indian, one wrote “All of the Above” and one checked Caucasian, African American, Hispanic, and Native American. All students learned English first. Twenty students spoke English in the home; one spoke English and Spanish; and one spoke only Indian.

Long Beach. The elementary school located in Long Beach is one of four elementary schools in the district. According to the school values handbook, the staff believes that “…everyone is entitled to learn in a safe and cooperative environment” (“The Values Handbook and Contract,” n.d., p. 4). The school uses collaborative teaching strategies, as well as hands-on learning to actively engage students with the learning process.

The average class size in grades 1 through 6 in the Long Beach district is 20 students. In the 2009 school year, the ethnic breakdown of the students in the district was 62% White, 13% Black, 4% Asian, and 21% Hispanic. Fifteen percent of students in the district received free or reduced price lunch and 5% of the students were limited in their English proficiency. Finally, in 2009, 96.9% of Grade 4 students met the state standards in Math and 87.7% met standards in English (“Long Beach,” 2010). These were the fourth graders that comprised the fifth grade population from which my sample was drawn.

The particular Long Beach school the researcher conducted the study in was very heterogeneous. There were a total of 63 fifth graders. One of the three classes was an inclusion class. The inclusion students were constantly pulled out of the classroom for various activities and additional instructional help, and consequently were not included in this study. Each class also had several students who participated in the “Learning Activities to Raise Creativity” (LARC) program. These students were high achievers and left the class one day a week for special enrichment lessons for the entire day. The school operates on a six day cycle in which students rotate through several extracurricular activities such as peer mediation, chorus, band, art, speech debate, and remediation classes. The classes were missing a number of students at any given time during the day.

Class 3 had a total of 21 students: 15 boys and 6 girls. Two boys declined to participate and six boys and one girl never returned their parental permission forms, bringing the sample from this class to 12. The mean age of the students in this class was

10 years and 1.5 months (*SD* = 6.332 months; Range = 9 years to 11 years). Eleven students identified themselves as Caucasian and one checked off both African American and Caucasian, and as such was entered in as "Other." Ten students learned English first; one learned Spanish first; and one learned Russian first. Nine students spoke English only at home; two spoke English and Spanish; and one spoke English and Russian in the home.

Class 4 had a total of 21 students: 14 boys and 7 girls. Two boys declined to participate in this study and three boys and one girl never returned their parental permission slips, bringing the sample from this class to 15. The mean age of the students in the sample was 10 years old (*SD* = 3.928 months; Range = 9 years and 6 months to 10 years and 6 months). Twelve students identified themselves as Caucasian; 2 as African American; and 1 as Hispanic. All students learned English first. Thirteen students spoke English in the home; one spoke Spanish; and one spoke only Italian.

Class 5 had a total of 21 students: 11 males and 10 females. One boy declined to participate in this study and the parental permission slips were never received from two boys and one girl. One boy who had permission to participate was absent during the duration of this study, bringing the sample from this class to 16. The mean age of the students in this class was 10 years and 3 months (*SD* = 4.382 months; Range = 9 years and 6 months to 11 years). Eleven students identified themselves as Caucasian; one as African American; one as Hispanic, one as Asian; and two as "Other." One of the students who checked off other wrote in "Don't know" and the other filled in "Indian." Fourteen students learned English first; and two learned Spanish first. Eleven students spoke English in the home; two spoken English and Spanish, one spoke Russian, and two checked “Other” and filled in Bangla.

Thus, the final sample compared a total of 89 students who were randomly assigned to the four intervention groups. A total of 46 participants, 22 boys and 24 girls, were from the two Rockville Centre classrooms and 43 children, 23 boys and 20 girls, were from the three Long Beach classrooms.

Selection of Words

Twenty-five biology terms were selected from the *Glossary of Biology Terms* (Pearson Education, 2009) and from *Parts of the Cell* (San Diego Supercomputer Center, n.d.). The words chosen are all nouns which can easily be visualized. They are all part of the middle school science curriculum (New York Department of Education, 2008).

Definitions

Definitions adapted from Merriam-Webster’s Collegiate Dictionary (1996) and Pearson Education’s *Glossary of Biology Terms* (2009) were given. These definitions were simplified to provide a clear understanding of the words suitable for the fifth grade students. Simple sentences illustrating the use of the words were generated from these definitions. The definitions and sentences were reviewed by two fifth grade teachers independent of the study and unaware of the specific research questions and hypotheses to be certain that they were appropriate for a fifth grade sample. See Appendix D for the definitions and sentences used for each vocabulary word.

Selection of Pictures

The pictures used for the Picture Presentation and Image Creation- Picture interventions were found through a Google image search. Two pictures for each vocabulary word were chosen by the researcher, and the independent fifth grade teachers selected the one for each word that they agreed depicted the definitions clearly and were easy to see. The pictures were printed in color, pasted onto 4” X 6” index cards, and were laminated. See Appendix E for samples of the picture cards used for the interventions.

Pre-Intervention Measures

Demographic information. All consenting students were given a demographic information sheet. This enabled the researcher to collect information on characteristics of the participants that may have been useful in analyzing the results, such as age, gender, and number of languages spoken. Though no specific differences between the students, based on their demographics were hypothesized, the information collected enabled the researcher to examine if there were any unanticipated differences between the students. Each student wrote his/her identification number on the upper left corner of the form and was given 5 minutes to complete the task (see Appendix F).

Vocabulary pretest. A researcher designed vocabulary pretest was given to the students, which contained 25 biology words. The test consisted of the vocabulary words followed by four choices: three definitions and a “Not sure/Do not remember” choice. Students were instructed to select the correct definition of the word. They were told that the words were difficult and above their grade level, and not to worry if they did not know the definitions. Once the tests were completed, they were scored. Fifteen words which 80% or more of the students did not know were selected for the interventions. If there were more than 15, it was decided that the researcher would use her discretion in picking words which she determined facilitate the formation of images more efficiently than the others for the purpose of the interventions. The pretest took approximately 15 minutes. See Appendix G for the biology pretest.

Prior vocabulary knowledge. The *Peabody Picture Vocabulary Test-IV, Form B* (PPVT-IV, Dunn & Dunn, 2007) was used to measure the students' vocabulary knowledge prior to the interventions. This is a norm-referenced measure of receptive vocabulary and a screening measure for verbal ability (Coyne, McCoach, Loftus, Zipoli, & Kapp, 2009). As it is designed to measure an examinee's receptive vocabulary, it serves as an achievement test of the level of a person's vocabulary acquisition. It is an individually administered, norm-referenced, wide-range test (Dunn & Dunn, 2007).

In the test, students are presented with four pictures and are asked to point to the one which best represents the word orally stated by the researcher. There are 228 test items grouped into 19 sets, which are arranged in order of ascending difficulty. Each set contains 12 items (Dunn & Dunn, 2007). The score assigned is based on the number of items the participant gets correct and his/her chronological age. The mean of the test is 100, with a standard deviation of 15 (Pearson, 2007). The test shows a median internal consistency reliability of .94 for both forms A and B, and median test-retest reliability of .93 (Pearson, 2007).

Interventions

This study examined predictions based both on the theories of dual coding and depth of processing. The various manipulations of imagery employed in the interventions created a between-subjects factor with four different levels. Within each class, students who had parental permission and assented to participate in the study were randomly assigned to one of four intervention groups.

Hibbing and Rankin-Erickson (2003) have stated that while verbal descriptions may be sufficient for some students when learning vocabulary, pictures are necessary to assist with comprehension for others. Two out of the three interventions which employed imagery in this study, Picture Presentation and Image Creation- Picture, provided a picture for the students, while the other imagery intervention, Image Creation- No Picture, required students to create an image on their own without the presentation of the picture.

The Word Only intervention neither employed the presentation of an image nor instructed the students to create an image, as only the verbal presentation of the word was given. The Picture Presentation intervention incorporated image presentation, as the vocabulary word was paired with an image. The Image Creation- No Picture and Image Creation- Picture interventions both had an image creation component. In the Image Creation- No Picture intervention, the students were responsible for creating their own image based on the definition and drawing it; and in the Image Creation- Picture intervention, the students saw a picture and drew their own version on paper. The latter intervention was useful for examining if there was an additive effect of image presentation and image creation. A training condition was implemented at the beginning of the study to familiarize the students with the tasks.

Training condition. Before each intervention was carried out by the researcher, a training condition was conducted using the word “dog.” This word was chosen as it is simple and familiar to the students, allowing them to focus on the type of task they would be engaging in, rather than on the definition of the word itself. Each group was instructed via the intervention they were assigned to. For example, the students who were assigned to Picture Presentation were shown a picture of a dog; the Image Creation- No Picture treatment participants were told to come up with an image of a dog in their minds and to draw it; the Image Creation- Picture treatment participants saw a picture of a dog and then drew it on paper; and the Word Only treatment participants heard the word dog repeated a second time. See Appendix H for the transcripts of the training conditions.

Word Only intervention. For the Word Only treatment, a variation of the procedure used in a 1978 study by Hargis and Gickling (as presented in Sadoski, 2005) was used. In their study, which focused on abstract and concrete words, the vocabulary was presented in the following way: participants were presented with the words on flashcards in random order, they heard the word pronounced, heard it used in a sentence, used it in a sentence of their own, and repeated the word. In this study, instead of being asked to use the word in a sentence of their own, as these words were complicated and represented unfamiliar science concepts, the participants were given the definition of the vocabulary word. For example, the researcher first presented the participants with the word written on a 4” X 6” index card. Second, the researcher pronounced the word. Then, the researcher provided a sentence containing the word. Fourth, the researcher gave the participants the definition of the word. Next, the researcher presented the word on the index card again, and finally, the researcher repeated the word.

Picture Presentation intervention. For the Picture Presentation intervention, the aforementioned procedure was carried out. However, instead of repeating the word, in step six, the researcher presented a picture of the word. For example, if the word “school” was taught, a picture of a schoolhouse was provided on an index card. Therefore, in this intervention the researcher presented the student with the word on an index card, pronounced the word, used the word in a sentence, provided the definition, showed the word written on an index card for the second time, and then presented the picture index card.

Image Creation- No Picture intervention. The procedure used for the Picture Presentation intervention was repeated; however, instead of showing a picture, the researcher instructed the student to create a mental image of the word and to draw it on a sheet of 8 ½” X 11” paper. In this intervention, the researcher presented the student with the word on an index card, stated the word, used the word in a sentence, provided the definition, presented the word written on an index card for the second time, and instructed the participants to create an image in their heads and draw it on paper. The decision to have the participant draw the word was formulated to make the process active and to check to see that indeed an image was created in response to the word.

Image Creation- Picture intervention. The procedure used for the Image Creation- No Picture presentation was repeated; however, the fifth step was modified. Instead of showing the participants the word written on an index card, they were presented with a picture of the word. This step was changed to help clarify what the definition meant, assuring that students would not form inaccurate images in their heads. In this intervention, the researcher presented the student with the word on an index card, stated the word, used the word in a sentence, provided the definition, showed the students a picture of the word on an index card, and finally instructed the participants to create an image in their heads and draw it on paper. This sequence made the process active by having the students draw their image on paper. Students were told that they did not need to copy the picture shown, but could use it to help guide them.

All four groups were shown the word, heard the word, had it presented in a sentence, and given a definition, in the same sequence in order to equalize the treatments. The fifth and sixth steps varied between the interventions. See Table 1 for the format in which each intervention was carried out. Also, in order to equalize the exposure to the words, the amount of time for the variable steps was held constant at 30 seconds. This means that the word and picture cards were held up for a total of 30 seconds and students were only given this amount of time in which to create their pictures before moving to the next word.

Table 1

Format of the Interventions

Word Only Intervention	**Picture Presentation Intervention**	**Image Creation-No Picture Intervention**	**Image Creation-Picture Intervention**
1. Participants were presented with word on an index card 2. Word was pronounced 3. Word was used in a sentence 4. Definition of word was given **5. Word was presented on index card again** **6. Word was repeated**	1. Participants were presented with word on an index card 2. Word was pronounced 3. Word was used in a sentence 4. Definition of word was given **5. Word was presented on index card again** **6. Picture was presented on an index card**	1. Participants were presented with word on an index card 2. Word was pronounced 3. Word was used in a sentence 4. Definition of word was given **5. Word was presented on index card again** **6. Student was instructed to create a mental image and draw it on paper**	1. Participants were presented with word on an index card 2. Word was pronounced 3. Word was used in a sentence 4. Definition of word was given **5. Student was shown a picture of the word on an index card** **6. Student was instructed to create a mental image and draw it on paper**

Post-Intervention Measures

Students' acquisition and retention of the science vocabulary was assessed by a battery of experimenter designed vocabulary comprehension tests. The measures were given a day after the instruction of the vocabulary words, to assess immediate recall, and two weeks later. The tests given two weeks after the vocabulary instruction enabled the researcher to determine if the interventions allowed for efficient retention of the vocabulary words. At each time point, the students' vocabulary knowledge was assessed using two measures: a word fill-in task and definition word match task.

According to the National Reading Panel (2000), experimenter designed measures are more sensitive than standardized tests (Coyne et al., 2009). The sensitivity of these tests to intervention effects is the reason they were used in this study.

Word fill-in task. The word fill-in tasks were similar to Cloze tests in that they consisted of simple sentences with blanks in place of the vocabulary words instructed. Students were given a series of sentences with one or two blanks for the biology words. Ten words out of the 15 instructed comprised the answers on the measures, but all 15 were included on each as possible answer choices.

Students were instructed to pick the word from the choices provided next to the blank in order to correctly fill in the sentence. This required students to not only remember the definitions of the vocabulary words they were taught, but also to select the specific words that made sense in the context of the sentences. The number of correct words filled in the blanks was added to determine the amount of points awarded.

The sentences for this outcome measure were reviewed by the two independent fifth grade teachers who previously assessed the 25 sentences and definitions, to be sure that the difficulty level was appropriate.

The delayed word fill-in tasks were comprised of the same word choices as the immediate recall fill-in tasks, but the content of the sentences was slightly altered to prevent students from remembering their answer choices. See Appendix I for the immediate and delayed recall fill-in tasks.

Definition word match. All fifteen words instructed were incorporated in the definition word match tasks. Students received three word matches, each with five words for the biology terms. All of the tests were formatted in the same fashion.

On the left side of the page, students were presented with all five vocabulary words. On the right side of the page, they were provided with the five definitions of the words, in a rearranged format. Students were instructed to select the definition that corresponded to each vocabulary word.

The delayed definition word match tasks were rearranged, by mixing up the groups of words, to prevent any repeated testing effects. See Appendix J for the immediate and delayed recall word match tasks.

Qualitative Measures

After completing the delayed recall measures, participants were assessed using two qualitative measures: vocabulary learning evaluation forms and student discussions. These measures allowed the researcher to gain a deeper understanding of the students' vocabulary learning and their perspectives as to the utility of the interventions. Through the use of these two qualitative components, the participants' opinions of the interventions they experienced were elicited.

Vocabulary learning evaluations. Upon completion of the delayed recall measures, each student was given an evaluation checklist (see Appendix K). This was used to elicit students' opinions about the intervention he/she was exposed to. Each student wrote his/her identification number on the top left of the form and was given 10 minutes to complete it.

Student discussions. After the students filled out the vocabulary learning evaluations, the researcher randomly selected eight students per class, two from each intervention group, by picking their identification numbers out of a hat, and asking them if they wanted to participate in a small group discussion. The researcher removed students, intervention group by intervention group, from the rest of the class for approximately 15 minutes for the purpose of this discussion. Students were asked to describe what methods they used when attempting to learn and remember the vocabulary words that were presented to them. This was used as a fidelity check. In other words, the researcher was able to gauge whether or not the participants used the intervention method to which they were assigned, or whether they used their own strategies to help them remember the vocabulary words. This also gave a sense of what the students believed works best for them in terms of vocabulary and concept learning. The questions were presented just to facilitate discussion. The students were encouraged to mention anything else they think is relevant to the discussion of the vocabulary interventions. All responses were recorded by the researcher in a notebook while the students were speaking. See Appendix L for the questions asked.

Research Design

A quasi-experimental design was used for the purpose of this study. While students were randomly assigned to each intervention, they could not be randomly assigned to classes, as these were intact groups.

The independent variable was the interventions, which consisted of four “levels”. These levels varied in terms of the manipulations with regards to image presentation and image creation. The way in which the manipulations were manifested within the interventions is shown by Figure 1 below.

		Image Creation	
		No	**Yes**
Image Presentation	**No**	Word Only	Image Creation-No Picture
	Yes	Picture Presentation	Image Creation-Picture

Figure 1. Layout of the interventions.

Each of the four interventions varied with regards to depth of processing and whether or not imagery was involved. Figure 2 depicts each intervention, taking the theoretical frameworks into consideration.

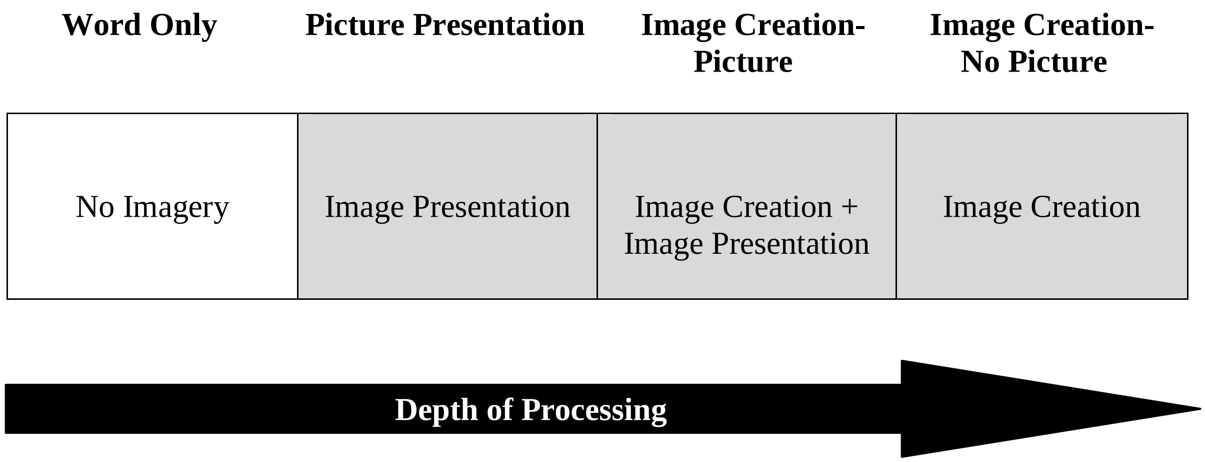


Figure 2. Theories underlying the interventions.

The dependent variable in this study was vocabulary comprehension which was measured by two different tasks: word fill-in and definition word match at two different time points: both immediately after the interventions and two weeks later, to examine delayed recall. Therefore, this study also employed a 2 (outcome task: word fill-in, definition word match) X 2 (time point: immediate recall, delayed recall) within-subjects design. However, the results were analyzed using the composite scores at each time interval separately to increase power.

This set-up afforded a more detailed look at vocabulary comprehension and the effectiveness of the interventions. The relationship between the composite scores at the two time intervals was also examined. Administering the measures at two time points enabled the researcher to obtain data regarding both vocabulary acquisition and retention. Overall, four measures were collected per student: two outcome measures at two time points.

Procedure

Administrative approval to conduct the study was sought from Long Island school district offices. After receiving the superintendents' permission, principals, assistant principals, and fifth grade teachers of Long Island elementary schools were contacted by the researcher to recruit the schools for the study. The researcher set up meetings within each school to explain the details of the study, the time requirements, and provide examples of the measures.

Once all parties had given consent, permission forms were distributed to all of the students in the fifth grade classes to have their parents or guardians sign. As soon as these were returned, the study was explained to the students and they were asked for their assent to participate. Upon collection of all of the permission forms, the experimenter began pretesting.

The researcher visited all participating fifth grade classes and randomly assigned the students numbers ranging from 1 to 99. Students were told to remember their numbers for the duration of the study, as they were to write this number on top of every sheet that they handed back to the experimenter. The participants were given an index card with their number on it, and instructed to keep the card in their desks and not to discuss it with other students. The students' names and the number they were assigned to were recorded on a sheet of paper called the "master list." There was a separate master list for each class. This list was placed in a sealed envelope and stored separately. It was only to be opened and consulted in the event that a student forgot his/her number, which did not happen in this study. The fifth grade teachers and the researcher were not able to match the student to his/her code number, protecting the students' confidentiality.

The participants then filled out the demographic information forms. They were told to write their number on the upper left hand corner, and were given 5 minutes to complete the form. After this, the participants took the biology vocabulary pretest. They were instructed to record their numbers on the upper left hand corners of the papers, and were allowed approximately 30 minutes to complete these tests. After one class was finished, the researcher rotated through the remaining classes, so all of the pretests could be analyzed together. This was possible for the two Rockville Centre classrooms. The remaining three Long Beach classrooms took the pretest at a later time, once the intervention phase began in Rockville Centre.

Once all of the pretests were scored, the researcher selected 15 biology vocabulary words with which 80% or more of the students were unfamiliar, and which were deemed by the researcher to easily facilitate imagery. These words were used for the interventions and outcome measures.

The researcher then rotated through the classes in the same order assessing the participants' initial vocabulary knowledge using the *Peabody Picture Vocabulary Test-IV* (PPVT-IV, Dunn & Dunn, 2007). Students were removed from the classroom one by one for approximately 12 to 15 minutes to complete this assessment. The number of each student was recorded on the upper left hand corner of the researcher's result sheet. The researcher informed the students that she would be coming back in the near future to play a series of vocabulary games with them.

For the purpose of the intervention phase of the study, the researcher focused on one class at a time. Within each class, students were randomly assigned to one of the four interventions. The researcher instructed the students from the first group on the 15 biology vocabulary words as per the intervention each group was assigned to. While the researcher was working with each group, the other three groups continued with their normal classroom activities. Students who declined to participate or did not return parental permission forms also continued with their regularly scheduled assignments.

Twenty-four hours after the instruction of the biology terms, the researcher returned to the class and administered the biology outcome measures. She gave the students the biology fill-ins and word matches, and instructed them to record their identification numbers on the papers. Participants were given 10 to 15 minutes to complete these assessments.

Two weeks after the initial vocabulary instruction, the researcher returned with the delayed outcome measures to assess retention of the biology vocabulary words. The same procedure used for the immediate recall outcome measures was employed.

After the words were instructed and assessed using the comprehension measures, the researcher visited the class to give the students the vocabulary learning evaluations. Students were told to record their numbers on the upper left hand corner and were given 10 minutes to complete this assessment.

Finally, the researcher randomly selected eight numbers from the class, two from each group, and asked the students that corresponded to these numbers if they would like to participate in a short group discussion. Additional numbers were drawn until two students from each group willing to participate were obtained. The researcher removed these participants from class for approximately 15 minutes, group pair by group pair, and asked them what methods they used when learning the vocabulary words, as per the student discussion questions. All responses were recorded on a note pad.

At the culmination of the study, the master list was consulted to remove the students who participated without parental permission. Some students, even after being instructed not to fill out the forms if they had not submitted a parental permission form, continued to do so. These numbers were deleted from the SPSS data grid.

The above intervention and post-intervention procedure was repeated for the remaining classes. Table 2 summarizes the procedure used.

Table 2

Study Procedure

Activity	Time Period
• **School and district permission**	• March- April 2010
• **Parental/guardian permission**	• September 2010
• **Student assent**	• September 2010
• **Assignment of numbers to students**	• September 2010 **(Day 1 pre-intervention phase)**
• **Demographic information (5 minutes)**	• September 2010 **(Day 1 pre-intervention phase)**
• **Vocabulary pretest* (15 minutes)**	• September 2010 **(Day 1 pre-intervention phase)**
• **Selection of words for interventions**	
• **PPVT-IV (12-15 minutes per student)**	• September- October 2010 **(Days 2-10 pre-intervention phase)**
• **Random assignment of students to each of the four interventions**	• October 2010 **(Day 1 intervention phase)**
• **Instruction of biology words via the intervention assigned (20 minutes per group)**	• October 2010 **(Day 1 intervention phase)**
• **Immediate recall outcome measures for the biology words the day after instruction (10-15 minutes)**	• October 2010 **(Day 2 intervention phase)**
• **Delayed recall measures for the biology words two weeks later (10-15 minutes)**	• October 2010 **(Day 3 intervention phase)**
• **Vocabulary learning evaluations (10 minutes)**	• October 2010 **(Day 1 post-intervention phase)**
• **Random selection of students for discussion and student discussions (15 minutes)**	• October 2010 **(Day 1 post-intervention phase)**
• **Repetition of intervention and outcome measure phases for the remaining classes**	• Depending on the locations of the schools the days may coincide with one another

*Not carried out as originally intended

Data Analyses

Statistical analyses enabled the researcher to determine how effective the interventions were in improving the participants' science vocabulary acquisition and retention. Descriptive statistics were computed for each outcome measure and the PPVT-IV to examine the means and standard deviations, as well as identify any outliers.

Examination of the relationships between the variables. Demographic variables, such as age, gender, ethnicity, number of older or younger siblings, and number of languages spoken, were entered into a general linear model to determine if any were significant predictors of the outcome scores. The PPVT scores were then added into these models to examine whether or not the demographics contributed to any differences in the outcome variables at immediate and delayed recall once the covariate was taken into account.

Benefits of imagery and deep levels of processing (Hypotheses 1, 2, and 3). To test the first two hypotheses, as well as the third regarding the benefits of imagery as well as deep levels of processing, a series of statistical tests was carried out. A one-way analysis of covariance (ANCOVA) was used to examine any differences between the students in the intervention groups for fill-in and word match tasks, using the composite score. This test was conducted at both the immediate and delayed recall time points. The PPVT-IV scores were used as a covariate in the statistical model. Pairwise comparisons were also conducted to determine where any observed statistical differences lie.

Change scores were also computed (delayed composite scores- immediate composite scores) to determine if there was a significant difference between the two time points. This was used to handle the repeated measures component of the study.

Participants' perceptions regarding the utility of the interventions (Hypothesis 4). To examine the fourth hypothesis focusing on the utility of the interventions, the first four questions of the vocabulary learning evaluation form were dummy coded to represent the answers the students provided. Numbers were assigned to the answer choices in the following way: 3= completely agree, 2= somewhat agree, 1= somewhat disagree, and 0= completely disagree. An analysis of covariance (ANCOVA) was carried out for each question to explore any differences between students' perceived usefulness of the interventions and the particular intervention they were assigned to. For question 5, regarding the use of other methods to enable the student to learn the vocabulary words, the number of students who responded yes in each intervention group was tallied and the means were compared using an ANCOVA. Finally, the written in answers to question 6, which asked the students to describe any methods that they used, other than the interventions, to help them learn the words were transcribed. The researcher looked for any commonalities amongst the approaches both within each group and across the groups.

The first three discussion questions were also analyzed to examine this hypothesis. For questions 1, 2, and 3, which required simple yes or no answers, the responses from each group were tallied. This allowed the researcher to determine the percentage of students from each intervention who found the method they were exposed to useful, fun, and the percentage of those who believed they would remember the vocabulary words.

Participants' awareness of the components of the interventions (Hypothesis 5). To examine the fifth hypothesis regarding the participants' awareness of the components of the interventions, the answers to the last four student discussion questions were analyzed. For questions 4, 5, 6, and 7, which were open-ended and dealt with students' specific vocabulary learning methodologies, answers were transcribed and analyzed. The researcher looked for common themes which appeared both within each intervention group and across groups.

In addition, the number of students from each group who were able to identify the components of the intervention they were placed in (question 4), be it presentation of a picture or creating a mental image, were tallied. The percentage of students who were able to correctly describe the approach that was used to teach them the vocabulary words from each intervention group was compared. This allowed the researcher to determine students' awareness of the components of the interventions.

Finally, the number of students from the Word Only and Image Creation- No Picture groups who expressed the need for pictures to help them remember the words was recorded.

Missing Data

Four students were missing from immediate recall, so a total of 85 sentence fill-in and word match tasks were completed. These four students were not given the delayed measures, and an additional 5 students were not present at delayed recall. A total of 80 students completed the delayed sentence fill-in and word match tasks.

To handle the missing data, the scores for the outcome measures of the students present in that particular intervention group and class were averaged. This value was entered as the missing participants' score. This was also done for those who did not fill in the intervention evaluation form. This was a reasonable way to approach the missing data as it was the mean of all other students undergoing the same combination of treatment within the same class placement. This is known as a single imputation for missing data. Essentially, the average of the data that was collected was used to fill in the "holes."

In terms of the demographic variables measured, there were no major differences between the students who were missing at immediate recall, delayed recall, or at both time points and those who were present for both outcome measure administrations. There were a total of nine students who missed one or both of the outcome measures. These students had a mean age of 10 years (*SD* = .4330 months; Range = 9 years to 10 years and 6 months). Their mean PPVT age equivalent was 132.22 months (*SD* = 19.143 months; Range = 8 years and 10 months to 13 years and 1 month) and the mean grade equivalent of these students on the PPVT was 5.256 (*SD* = 1.3648; Range = 3.4 to 7.0). The rest of the sample, excluding the missing students, had a mean age of 10 years and 2.33 months (*SD* = 5.006 months; Range = 9 years to 11 years and 6 months), a mean PPVT age equivalent of 135.95 months (*SD* = 15.896 months; Range = 8 years and 9 months to 15 years and 8 months), and PPVT grade equivalent of 5.529 months (*SD* = 1.1768; Range = 3.2 to 9.8). The difference between those who were missing for one or more measures and those who were not in terms of chronological age ($p = .192$), PPVT age equivalent (in months) ($p = .515$), and PPVT grade equivalent ($p = .517$) were not significant ($p < .05$). There were also no differences between the two sub samples in terms of number of languages spoken ($p = .141$), number of younger siblings ($p = .263$), or number of older siblings ($p = .825$). Therefore it is reasonable to assume that the characteristics of those who missed one or more measures were similar to those who did not.

The data was laid out to include the participants, the school they were in, class they were in, chronological age, PPVT age equivalent, PPVT grade equivalent, the intervention used (dummy coded to reflect Word Only, Picture Presentation, Image Creation- No Picture, and Image Creation- Picture), and the outcome measure scores of both tests at immediate and delayed recall. The dummy coded answers to the questions from the vocabulary learning evaluation forms were also included.

Design Justification

While an alternate factorial design was considered, it was not used due to the layout of the study. In a factorial design, a factor is the major independent variable, and the level is the subdivision of a factor (Trochim, 2006). Furthermore, "The 2 x 2 factorial design calls for randomizing each participant to treatment A or B to address one question and further assignment at random within each group to treatment C or D to examine a second issue, permitting the simultaneous test of two different hypotheses" (Stampfer, Buring, Willett, Rosner, Eberlein, & Hennekens, 1985, p. 111).

In the study presented, a 2 X 2 factorial design would imply that the major factors were image presentation and image creation, which is not the case. Rather, these manipulations are components of the interventions. For example, while the Word Only intervention lacked both the image creation and image presentation components; these were instead replaced by the presentation of the word on an index card and the verbal pronunciation of the word.

The interventions were based upon the concept of imagery and its possible use in facilitating both acquisition and retention of science vocabulary words. To further examine the usefulness of the different interventions, depth of processing was employed as a lens in which to explore the effects of imagery on the students' learning abilities. Therefore, the study employed a 1 between-subjects variable, which was the intervention, complete with four levels: Word-Only, Picture Presentation, Image Creation- No Picture, and Image Creation- Picture.

While the hypotheses and literature review could have been restructured to create a factorial design, thus enabling a different, more stringent set of statistical tests, this was not the inherent purpose of the study. The study did not look separately at image creation and image presentation; instead it examined various manipulations taking depth of processing and imagery into consideration. Three out of the four interventions relied on imagery and each imagery intervention increased the level of processing. Four different interventions were being compared to one another.

CHAPTER 4

Results

This chapter describes the results of the study. Hypotheses related to imagery, depth of processing, and participants' perceptions of the interventions are explored through an analysis of the data.

Missing Data

There was relatively little missing data because the study commenced the second week of school in Rockville Centre and shortly thereafter in Long Beach. The teachers said it was quite common to have students with 100% attendance in their schools. During the pretest, intervention, and the vocabulary assessments at immediate and delayed recall, almost all of the students were present. Accommodations were made for testing the students with the PPVT-IV if they were absent.

No students missed the intervention phase of the study. Four students missed the immediate recall measures, and as such were not given delayed recall measures two weeks later. While this led to a greater amount of missing data, those who were absent for part of the process could not be included. These students may have spoken to other students in the class about what the outcome measures entailed or may have attempted to study the words on their own, knowing that there would be a follow up assessment. By removing these students from the sample of those who took the outcome measures, an additional confounding effect due to environmental influences was avoided.

All missing data points were handled using a single imputation approach in which the average of the students present for that intervention and class was assigned as the value. As mentioned, only 4 students were absent for immediate recall and an additional

5 missed the delayed measures. Therefore this approach was used to complete a total of 13 data points.

Vocabulary Pretest

Due to issues with contacting the second site at Long Beach, the pretest could not be given to all students in the study at once. Instead, the pretest was given only to the Rockville Centre classes before the words were chosen. All of the words were unfamiliar to a majority of the students, and as such, none were eliminated.

The pretest was still given to the Long Beach students to be certain that the overwhelming majority were not familiar with any of the words previously selected for the intervention phase of the study. After grading the Long Beach student pretests, the following words were eliminated: cytoplasm, esophagus, mitochondria, nucleus, and pistil. From those five words, the only one that had previously been selected for the study was pistil. Out of the entire sample of students who took the pretest, 21.7 % of the students were familiar with the word pistil, which is 1.7% over the cutoff. This difference is most likely negligible.

When presenting the instructions for the pretest, it was stressed that the students not simply “guess” the correct answers, but try their best and circle “Not sure/Do not remember” if they were unfamiliar with any of the words. The students appeared to take the test very seriously and listened to all of the instructions. Most of the pretests were returned with the “Not sure/Do not remember” choice checked off for all 25 questions. While these students checked off the same answers for every question, they appeared to spend a great deal of time reading the words and definitions before choosing their final answers. None of the students handed in their pretests early; all used the time allotted to think about the words and take the test.

One student said when he returned the test, “I wasn’t able to answer anything so I had to put the same answer for all of them.” He was assured that the point of the exercise was to identify words that he and his classmates were unfamiliar with and that he did an excellent job.

Results of the Demographic Data

Data were collected from 89 students in two schools. Two classrooms from the Rockville Centre school took part in this study and three classrooms from the Long Beach school were included. Forty-five students from the total sample were male and 44 were female. The mean of the students’ chronological ages was 122.09 months, or 10 years and 2.09 months of age (*SD* = 5.044 months; Range = 9 years to 11 years and 6 months).

The results of the demographic information sheet disseminated to the participants are displayed in Table 3. As shown, the data obtained from both schools were comparable. A majority of students in both schools were Caucasian, learned English first, spoke English in the home, and spoke only one language. Most students in both schools had zero to one older siblings and zero to one younger siblings.

Table 3

Demographic Information Data

		Rockville Centre	Long Beach	Totals
Mean Age		10 years 2.6 months (*SD* = 5.162)	10 years 1.5 months (*SD* = 4.915)	**10 years 2.1 months (*SD* = 5.044)**
Gender	Male	23	22	**45**
	Female	24	20	**44**
Ethnicity	Caucasian	38	34	**72**
	African American	1	3	**4**
	Hispanic	3	2	**5**
	Asian	1	1	**2**
	Other	3	3	**6**
First Language	English	43	39	**82**
	Spanish	2	3	**5**
	Italian	1	0	**1**
	Russian	0	1	**1**
Languages Spoken at Home	English	40	33	**73**
	Spanish	2	1	**3**
	English and Spanish	1	4	**5**
	English, Spanish, and Italian	1	0	**1**
	English and French	1	0	**1**
	Russian	0	1	**1**
	English and Russian	0	1	**1**
	Indian	1	0	**1**
	Italian	0	1	**1**
	Bangla	0	2	**2**
Number of Languages Spoken	One	39	32	**71**
	Two	5	11	**16**
	Three	2	0	**2**

Number of Older Siblings	Zero	22	19	**41**
	One	17	15	**32**
	Two	4	5	**9**
	Three	1	2	**3**
	Four	2	1	**3**
	Five	0	1	**1**
Number of Younger Siblings	Zero	19	20	**39**
	One	22	17	**39**
	Two	5	4	**9**
	Three	0	2	**2**

There were some issues that arose with the demographic information sheet. For question 3, which asked students to check off a box describing their ethnicity, some students had trouble classifying themselves. Many raised their hands and said that they did not have one answer. The students were then told to check all of the boxes they felt described who they are. This was done so the students would not feel uncomfortable picking one box, and instead allowed them to capture their complete identities.

Students who checked multiple boxes for question 3 were assigned a value of “5” for the data analysis, which corresponds to “Other.” For example, one student identified himself as Caucasian/White, African American, Hispanic, and Native American. Other students, who checked one box and then clarified by writing in their nationality, were assigned the number corresponding to the first box they checked. For example, one girl checked Caucasian/White and Other, and wrote in Irish and Czechoslovakian. She was assigned the value of “0” which corresponds to Caucasian/White.

To examine the effect of the demographic variables on the composite outcome scores at both immediate and delayed recall, the participants’ chronological age (in months), PPVT age equivalent (in months), gender (dummy coded: 0= male, 1 = female), the school (dummy coded: 0 = RVC, 1 = LB) and classroom the students were in (assigned numbers 1 to 5), number of older and younger siblings, and the intervention the students were assigned to, were incorporated into a general linear model.

Ethnicity was not taken into consideration or added in to the model, because this demographic did not have enough variability. In terms of ethnicity, 80.9% of the sample was Caucasian. There was also very little variability on the language characteristics of the students, which were determined by demographic questions regarding first language learned, language spoken at home, and total number of languages spoken. English was the first language learned by 92.1% of the students. Eighty-two percent of the sample spoke English at home, and 79.8% spoke only one language. Again, since there was relatively no spread in the data, these variables could not be examined in terms of their impact on the outcome measures.

After the possible predictor variables (chronological age, PPVT age equivalent, gender, school, classroom, number of older siblings, number of younger siblings, intervention assigned) were added in, the normality of data assumption was checked for the continuous variables. While this assumption was met for age and number of younger siblings, it was not met for the number of older siblings. The distribution of number of older siblings was skewed (sk = 1.673), so a square root transformation was used to normalize the data. This transformation served to effectively normalize the data (sk = .365).

Looking at all the aforementioned demographic variables at immediate recall, by entering them into a general linear model to screen for any potential demographic predictors, the transformation of the number of older siblings showed significance *F*(8,88) = 4.222, *p* = .043. This suggested that it could possibly have been a predictor of the outcome scores; however, at delayed recall, this variable was no longer significant *F*(8,88) = .060, *p* = .807. Once PPVT age, as a measure of receptive vocabulary, and the intervention condition were added into the model, along with the number of older siblings; the transformation of the number of older siblings no longer predicted anything *F*(5,88) = 1.609, *p* = .208. Therefore, this particular variable did not explain any variance in the immediate recall outcome scores once the covariate and intervention were brought into the model. When all of the demographic variables were added into the model, correcting for the covariate and intervention assigned, the older siblings transformation did not reach significance either *F*(12,88) = 3.727, *p* = .057.

Based on Table 4, taking into consideration all of the demographic variables at immediate recall, and adjusting the values to reflect the covariate and intervention, only the intervention showed significance at (*p* = .001).

Table 4

Demographic Predictors at Immediate Recall

Tests of Between-Subjects Effects

Dependent Variable:Immediate Recall Composite Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	744.853[a]	12	62.071	2.743	0.004
Intercept	0.072	1	0.072	0.003	0.955
PPVTAge	85.684	1	85.684	3.786	0.055
Intervention	417.419	3	139.14	6.148	0.001
School	34.02	1	34.02	1.503	0.224
ClassNumber(School)	112.683	3	37.561	1.66	0.183
Gender	0.013	1	0.013	0.001	0.981
Age2	6.405	1	6.405	0.283	0.596
NumberYoungerSiblings	4.744	1	4.744	0.21	0.648
SQRT_NUMBEROLDERSIBLINGS	84.346	1	84.346	3.727	0.057
Error	1720.024	76	22.632		
Total	24930	89			
Corrected Total	2464.876	88			

a. R Squared = .302 (Adjusted R Squared = .192)

None of the other factors were significant in predicting the variance of the outcome scores. Therefore, the differences between students of different schools, classes, genders, chronological ages, with varying numbers of older and younger siblings were of negligible importance in predicting the outcome scores. As can be seen by Table 5, this was also the case at delayed recall, in that the intervention was the only predictor to show significance (p = .000).

Table 5

Demographic Predictors at Delayed Recall

Tests of Between-Subjects Effects

Dependent Variable:Delayed Recall Composite Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	725.509[a]	12	60.459	2.83	0.003
Intercept	0.056	1	0.056	0.003	0.959
PPVTAge	47.948	1	47.948	2.245	0.138
Intervention	510.33	3	170.11	7.964	0
School	10.47	1	10.47	0.49	0.486
ClassNumber(School)	106.782	3	35.594	1.666	0.181
Gender	5.26	1	5.26	0.246	0.621
Age2	11.185	1	11.185	0.524	0.472
NumberYoungerSiblings	28.469	1	28.469	1.333	0.252
SQRT_NUMBEROLDERSIBLINGS	3.236	1	3.236	0.151	0.698
Error	1623.367	76	21.36		
Total	25454	89			
Corrected Total	2348.876	88			

a. R Squared = .309 (Adjusted R Squared = .200)

Overall, this analysis demonstrates that the intervention was effective and was not contingent upon the demographics of the sample. Demographic variables had nothing to do with the results seen once the intervention was taken into account.

PPVT Results

The PPVT raw scores were determined based upon the last picture number of the ceiling set, in which students had eight or more errors, and the overall amount of incorrect answers. After computing the raw score, the PPVT-IV norms booklet (PPVT-IV, Dunn & Dunn, 2007) was consulted to obtain the age and grade equivalent of each participant (see Appendix M).

The mean PPVT age, which for the purpose of this study served as a measure of receptive vocabulary, was 135.57 months (*SD* = 16.169 months). This is equivalent to 11 years and 3.57 months of age. The minimum PPVT age was 105 months and the maximum was 188 months. The mean PPVT grade equivalent was 5.501 (*SD* = 1.1914), which is equivalent to 5 months after the start of the fifth grade year. The minimum was 3.2 and the maximum was 9.8.

Outcome Data

The mean and median were very close for both immediate and delayed recall, thus the assumption of normality was met. There was relatively no skew or kurtosis so there were no outliers which affected the results (see Table 6).

Table 6

Normality of the Outcome Data

Statistics

		Immediate Recall Composite Score	Delayed Recall Composite Score
N	Valid	89	89
	Missing	0	0
Mean		15.89	16.11
Median		16	17
Std. Deviation		5.292	5.166
Skewness		-0.067	-0.349
Kurtosis		-0.578	-0.826
Minimum		3	5
Maximum		25	25

The results presented in Table 7 indicate that the homogeneity of regression assumption was also met (p =.512). This means that the relationship between the covariate and outcome measure was the same for each intervention.

Table 7

Homogeneity of Regression of the Data

Tests of Between-Subjects Effects

Dependent Variable:Immediate Recall Composite Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	609.081[a]	7	87.012	3.798	.001
Intercept	35.282	1	35.282	1.540	.218
PPVTAge	101.682	1	101.682	4.438	.038
Intervention	32.667	3	10.889	.475	.700
Intervention * PPVTAge	53.162	3	17.721	.773	.512
Error	1855.795	81	22.911		
Total	24930.000	89			
Corrected Total	2464.876	88			

a. R Squared = .247 (Adjusted R Squared = .182)

As shown in Table 8, homogeneity of variances was not met. However, since the size of each intervention group was so similar, any effects of this violation are negligible.

Table 8

Homogeneity of Variance of the Data

Levene's Test of Equality of Error Variances[a]

Dependent Variable:Immediate Recall Composite Score

F	df1	df2	Sig.
4.258	3	85	0.007

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PPVTAge + Intervention

Acquisition Results

Hypotheses 1 and 2. Hypothesis 1, based on the dual coding theory, stated that students in the imagery interventions would score significantly higher on their immediate recall outcome measures compared to those in the Word Only intervention. Hypothesis 2, which was based on depth of processing, predicted that those in the Image Creation-Picture intervention should score the highest, followed by those in the Image Creation-No Picture intervention, Picture Presentation intervention, and finally those placed in the Word Only intervention group.

After all students had been randomly assigned to each of the four interventions within each class, a total of 21 were placed in the Word Only intervention; 22 in the Picture Presentation intervention; 22 in the Image Creation- No Picture intervention; and 24 in the Image Creation- Picture intervention.

A one-way ANCOVA was used, entering the PPVT age equivalent as the covariate. The between-subjects factor was the four levels of the intervention and the within-subjects factor was the immediate recall composite score on the two outcome measures.

Presented in Table 9.1 are the findings from a one-way analysis of covariance model in which immediate recall serves as the dependent variable. Receptive vocabulary (PPVT) is the covariate and intervention is the “focal” independent variable in this analysis. At immediate recall, there was a significant difference between participants placed in the different intervention groups $F(3,84) = 6.939$, $p = .000$.

As shown by the Source Table (see Table 9.2), the effects of both the covariate and the focal independent variable, PPVT ($p = .009$) and intervention condition ($p =$

.000), were statistically significant (both, $p < .05$). As shown by the section of the output labeled “Parameter Estimates” (see Table 9.3), the relationship between the covariate and the dependent variable was positively signed ($b = .087$), indicating that higher scores on the PPVT, which is a measure of receptive vocabulary, were associated with a greater number of words remembered at immediate recall, controlling for the effects of the four intervention conditions.

Table 9.1

Immediate Recall Overall Results

Univariate Tests

Dependent Variable:Immediate Recall Composite Score

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	473.053	3	157.684	6.939	0
Error	1908.957	84	22.726		

The F tests the effect of Intervention Assigned. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Table 9.2

Immediate Recall Source Table

Tests of Between-Subjects Effects

Dependent Variable:Immediate Recall Composite Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	555.920[a]	4	138.98	6.116	0
Intercept	18.761	1	18.761	0.826	0.366
PPVTAge	163.489	1	163.489	7.194	0.009
Intervention	473.053	3	157.684	6.939	0
Error	1908.957	84	22.726		
Total	24930	89			
Corrected Total	2464.876	88			

a. R Squared = .226 (Adjusted R Squared = .189)

Table 9.3

Immediate Recall Parameter Estimates

Parameter Estimates

Dependent Variable:Immediate Recall Composite Score

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Intercept	7.115	4.355	1.634	0.106	-1.545	15.775
PPVTAge	0.087	0.032	2.682	0.009	0.022	0.151
[Intervention=0]	-6.538	1.455	-4.492	0	-9.432	-3.644
[Intervention=1]	-3.416	1.408	-2.426	0.017	-6.217	-0.616
[Intervention=2]	-2.443	1.426	-1.713	0.09	-5.279	0.393
[Intervention=3]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

With respect to the interventions, follow-up pairwise comparisons (see Table 9.4) among the four intervention conditions indicate that fifth graders assigned to the Word Only intervention demonstrated a statistically significant difference from those in the Picture Presentation condition (p = .037), the Image Creation- No Picture presentation (p = .006), and the Image Creation- Picture presentation (p = .000).

The pairwise comparisons indicate that the fifth graders assigned to the Picture Presentation condition did not differ significantly from those in the Image Creation- No Picture group (p = .503). However, the composite recall scores of those in the Picture Presentation group were significantly different from those in the Image Creation- Picture group (p = .017).

Finally, the students in the Image Creation- No Picture group did not differ significantly from those in the Image Creation- Picture group (p = .090).

Table 9.4

Immediate Recall Pairwise Comparisons

Pairwise Comparisons

Dependent Variable:Immediate Recall Composite Score

(I) Intervention Assigned	(J) Intervention Assigned	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
Word Only	Picture Presentation	-3.122*	1.475	0.037	-6.055	-0.189
	Image Creation- No Picture	-4.095*	1.456	0.006	-6.99	-1.2
	Image Creation- Picture	-6.538*	1.455	0	-9.432	-3.644
Picture Presentation	Word Only	3.122*	1.475	0.037	0.189	6.055
	Image Creation- No Picture	-0.973	1.449	0.503	-3.854	1.907
	Image Creation- Picture	-3.416*	1.408	0.017	-6.217	-0.616
Image Creation- No Picture	Word Only	4.095*	1.456	0.006	1.2	6.99
	Picture Presentation	0.973	1.449	0.503	-1.907	3.854
	Image Creation- Picture	-2.443	1.426	0.09	-5.279	0.393
Image Creation- Picture	Word Only	6.538*	1.455	0	3.644	9.432
	Picture Presentation	3.416*	1.408	0.017	0.616	6.217
	Image Creation- No Picture	2.443	1.426	0.09	-0.393	5.279

Based on estimated marginal means

*. The mean difference is significant at the .050 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Trends of the adjusted means (see Table 9.5), taking the covariate into account, show that those in the Image Creation- Picture group scored the highest (M = 18.879), followed by those in the Image Creation- No Picture group (M = 16.436), followed by the Picture Presentation group (M = 15.462), and finally the Word Only group (M = 12.341).

Table 9.5

Immediate Recall Intervention Trends

Estimates

Dependent Variable:Immediate Recall Composite Score

Intervention Assigned	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Word Only	12.341[a]	1.052	10.248	14.433
Picture Presentation	15.462[a]	1.02	13.434	17.491
Image Creation- No Picture	16.436[a]	1.02	14.406	18.465
Image Creation- Picture	18.879[a]	0.983	16.923	20.834

a. Covariates appearing in the model are evaluated at the following values: PPVT Age Equivalent (measured in months) = 135.57.

Summary. In the data on immediate recall, Hypothesis 1 was fully supported, while Hypothesis 2 was partially supported.

Hypothesis 1. Hypothesis 1, which was based on the dual coding theory, stated that students assigned to the imagery interventions would score significantly higher than those in the Word Only intervention. This was supported. Students in the Picture Presentation, Image Creation- No Picture, and Image Creation- Picture interventions all scored significantly higher than those assigned to the Word Only intervention.

Hypothesis 2. According to Hypothesis 2, which was based on depth of processing, those in the Image Creation- Picture intervention should score the highest, followed by those in the Image Creation- No Picture intervention, those in the Picture Presentation intervention, and finally the students assigned to the Word Only intervention. This hypothesis was partially supported. Trends do follow this pattern; however, as shown by the pairwise comparisons, not all differences between the groups were statistically significant.

Retention Results

Hypothesis 3. Hypothesis 3 stated that students in the imagery intervention groups should score significantly higher than those placed in the Word Only group at delayed recall. However, the differences between each of the groups would not be as clearly defined as those predicted for immediate recall.

Another one-way ANCOVA was used, entering the PPVT age equivalent as the covariate. This time, the within-subjects factor was the composite score on the two delayed outcome measures.

As shown by Table 10.1, there were significant differences between the interventions at delayed recall (p = .000). As shown by the Source Table (see Table 10.2), both the covariate PPVT (p = .053) and intervention condition (p = .000) were statistically significant. Based on Table 10.3, labeled "Parameter Estimates," the relationship between the covariate and the dependent variable was positively signed (b = .062), which indicates that higher scores on receptive vocabulary were associated with a greater number of words remembered at delayed recall, controlling for the effects of the four intervention conditions.

Table 10.1

Delayed Recall Overall Results

Univariate Tests

Dependent Variable:Delayed Recall Composite Score

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	504.116	3	168.039	7.83	0
Error	1802.821	84	21.462		

The F tests the effect of Intervention Assigned. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Table 10.2

Delayed Recall Source Table

Tests of Between-Subjects Effects

Dependent Variable:Delayed Recall Composite Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	546.056[a]	4	136.514	6.361	0
Intercept	68.191	1	68.191	3.177	0.078
PPVTAge	82.573	1	82.573	3.847	0.053
Intervention	504.116	3	168.039	7.83	0
Error	1802.821	84	21.462		
Total	25454	89			
Corrected Total	2348.876	88			

a. R Squared = .232 (Adjusted R Squared = .196)

Table 10.3

Delayed Recall Parameter Estimates

Parameter Estimates

Dependent Variable:Delayed Recall Composite Score

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Intercept	10.201	4.232	2.41	0.018	1.785	18.616
PPVTAge	0.062	0.031	1.961	0.053	-0.001	0.124
[Intervention=0]	-6.003	1.414	-4.245	0	-8.816	-3.191
[Intervention=1]	-3.576	1.368	-2.613	0.011	-6.297	-0.854
[Intervention=2]	-0.599	1.386	-0.432	0.667	-3.356	2.157
[Intervention=3]	0[a]	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

With respect to these interventions, follow-up pairwise comparisons among the four conditions (see Table 10.4) indicate that fifth graders assigned to the Word Only intervention did not show statistically significant differences from those in the Picture Presentation group (p = .094). However, they were significantly different from those in the Image Creation- No Picture group (p = .000) and those in the Image Creation- Picture group (p = .000).

In terms of the scores on the delayed composite outcome measures, those in the Picture Presentation group were significantly different from those in the Image Creation- No Picture group (p = .037) and those in the Image Creation- Picture group (p = .011). There was no statistically significant difference between those in the Image Creation- No Picture group and those in the Image Creation- Picture group (p = .667).

Table 10.4

Delayed Recall Pairwise Comparisons

Pairwise Comparisons

Dependent Variable:Delayed Recall Composite Score

(I) Intervention Assigned	(J) Intervention Assigned	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
Word Only	Picture Presentation	-2.428	1.433	0.094	-5.278	0.423
	Image Creation- No Picture	-5.404*	1.415	0	-8.217	-2.59
	Image Creation- Picture	-6.003*	1.414	0	-8.816	-3.191
Picture Presentation	Word Only	2.428	1.433	0.094	-0.423	5.278
	Image Creation- No Picture	-2.976*	1.408	0.037	-5.776	-0.177
	Image Creation- Picture	-3.576*	1.368	0.011	-6.297	-0.854
Image Creation- No Picture	Word Only	5.404*	1.415	0	2.59	8.217
	Picture Presentation	2.976*	1.408	0.037	0.177	5.776
	Image Creation- Picture	-0.599	1.386	0.667	-3.356	2.157
Image Creation- Picture	Word Only	6.003*	1.414	0	3.191	8.816
	Picture Presentation	3.576*	1.368	0.011	0.854	6.297
	Image Creation- No Picture	0.599	1.386	0.667	-2.157	3.356

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

*. The mean difference is significant at the .050 level.

Based on the trends, as shown by the mean score of how many questions the students answered correctly on the sentence fill-in and definition word match tasks at delayed recall (see Table 10.5), the results were the same as at immediate recall. Those in the Image Creation- Picture group scored the highest (M = 18.561), followed by the participants in the Image Creation- No Picture intervention (M = 17.961), those in the

Picture Presentation intervention (*M* = 14.985), and finally the students in the Word Only intervention (*M* = 12.558).

Table 10.5

Delayed Recall Intervention Trends

Estimates

Dependent Variable:Delayed Recall Composite Score

Intervention Assigned	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Word Only	12.558[a]	1.022	10.525	14.591
Picture Presentation	14.985[a]	0.991	13.014	16.957
Image Creation- No Picture	17.961[a]	0.992	15.989	19.934
Image Creation- Picture	18.561[a]	0.956	16.661	20.461

a. Covariates appearing in the model are evaluated at the following values: PPVT Age Equivalent (measured in months) = 135.57.

Summary. The results of the delayed recall composite outcome measures lend support to Hypothesis 3. The students in the imagery interventions did better than those without imagery, though the differences were not always significant. Also, as the depth of processing increased, students answered more questions correctly. As was the case with the immediate recall measures, those in the Image Creation- Picture intervention scored the highest, which suggests a possible additive effect of image presentation and creation. The differences between the intervention groups were not as extreme as in the immediate recall outcome measures, and did not reach significance in all instances.

Repeated Measures Results

Instead of carrying out a repeated measures analysis in the traditional sense, repeated measures were accommodated by examining the difference or change scores (delayed recall- immediate recall) and then using these change scores as the outcome variable in a one-way, between-subjects, analysis of covariance.

Table 11.1 displays the frequency distribution of students' change scores. Those with a negative score did worse over time and had lower scores on the composite delayed outcome measures, compared to their composite immediate measures. Those with positive scores did better and improved from the administration of the immediate recall outcome measures to the delayed recall outcome measures. As can be seen by the table, some participants scored higher at delayed recall, and improved over time, whereas others did worse.

Table 11.1

Change in the Number of Words Recalled Between Test Administrations

CHANGE IN THE # OF WORDS RECALLED B/T TEST ADMINISTRATIONS					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-13.00	1	1.1	1.1	1.1
	-9.00	2	2.2	2.2	3.4
	-8.00	3	3.4	3.4	6.7
	-6.00	2	2.2	2.2	9
	-5.00	4	4.5	4.5	13.5
	-4.00	9	10.1	10.1	23.6
	-3.00	8	9	9	32.6
	-2.00	7	7.9	7.9	40.4
	-1.00	6	6.7	6.7	47.2
	0.00	7	7.9	7.9	55.1
	1.00	5	5.6	5.6	60.7
	2.00	8	9	9	69.7
	3.00	4	4.5	4.5	74.2
	4.00	9	10.1	10.1	84.3
	5.00	2	2.2	2.2	86.5
	6.00	3	3.4	3.4	89.9
	7.00	2	2.2	2.2	92.1
	8.00	1	1.1	1.1	93.3
	10.00	3	3.4	3.4	96.6
	11.00	1	1.1	1.1	97.8
	12.00	1	1.1	1.1	98.9
	15.00	1	1.1	1.1	100
	Total	89	100	100	

Overall, there only appears to be a difference worth noting for the students in the Image Creation- No Picture group (see Table 11.2). They scored on average 1.4545 points higher on the delayed composite outcome measures.

The overall mean of the change scores obtained from Table 12.2 (*M* = .2247) shows that on average people did not remember any more at delayed recall than they did at immediate recall. This may have been due to the nature of the intervention since the words were only presented once. This intervention was rather benign, as a more intense intervention would have been difficult to implement in an elementary classroom without first testing its utility and establishing its need.

Table 11.2

Change Score Trends

Descriptive Statistics

Dependent Variable:CHANGE IN THE # OF WORDS RECALLED B/T TEST ADMINISTRATIONS

Intervention Assigned	Mean	Std. Deviation	N
Word Only	0.0952	6.3317	21
Picture Presentation	-0.4091	4.43642	22
Image Creation- No Picture	1.4545	4.49049	22
Image Creation- Picture	-0.2083	5.03016	24
Total	0.2247	5.07613	89

Through a closer examination of the data, there was no statistically significant difference shown by the change scores (see Tables 11.3 and 11.4). Thus, there is no evidence to suggest that any one group remembered more or less at delayed recall $F(3, 84) = .682$, $p = .566$.

Table 11.3

Change Score Source Table

Tests of Between-Subjects Effects

Dependent Variable:CHANGE IN THE # OF WORDS RECALLED B/T TEST ADMINISTRATIONS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	60.650[a]	4	15.163	0.577	0.68
Intercept	15.417	1	15.417	0.587	0.446
PPVTAge	13.685	1	13.685	0.521	0.472
Intervention	53.749	3	17.916	0.682	0.566
Error	2206.856	84	26.272		
Total	2272	89			
Corrected Total	2267.506	88			

a. R Squared = .027 (Adjusted R Squared = -.020)

Table 11.4

Change Score Overall Results

Univariate Tests

Dependent Variable:CHANGE IN THE # OF WORDS RECALLED B/T TEST ADMINISTRATIONS

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	53.749	3	17.916	0.682	0.566
Error	2206.856	84	26.272		

The F tests the effect of Intervention Assigned. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Summary. Based on the results of the difference in change scores from immediate recall to delayed recall, there is no conclusive evidence to determine if students retained more vocabulary over time, or failed to retain the meaning of words they had learned. No significant difference over time was found.

Results from the Vocabulary Learning Evaluations

Hypothesis 4. Hypothesis 4 examined students' perceptions of the interventions they were exposed to. It was predicted that the answers they gave on the intervention evaluation forms and during the discussions would reflect the trends displayed by the quantitative results.

An ANCOVA was carried out for questions 1 through 5 on the vocabulary learning evaluation form, entering the intervention the student was assigned to as the factor and the PPVT age equivalent as the covariate.

Question 1. With regards to the first question dealing with the participants' perceptions of their ability to learn the words, no significant differences were shown between the students assigned to the different interventions $F(3, 84) = .224$, $p = .880$. Students overall were slightly positive in that the mean was 2.18, which is higher than answer choice 2, "somewhat agree."

Question 2. In reference to the second question, which asked the participants about their perceptions of their ability to remember the words, there were no significant differences between those assigned to the different intervention groups $F(3,84) = .166$, $p = .919$. Students were slightly negative about this issue, as there was an overall response mean of 1.87. For this question an answer of 1 was equivalent to "slightly disagree" and 2 was equivalent to "slightly agree."

Question 3. For question 3, which focused on the participants' perceptions of how useful the method they were exposed to was, again there was no statistically significant difference between those assigned to the different interventions $F(3,84) =$

.486, p = .693. The overall mean was 2.04, so the participants somewhat agreed that the interventions were useful for helping them learn the words.

Question 4. Question 4, which asked the students how fun the intervention they were exposed to was, displayed no statistically significant difference between the participants assigned to the different groups $F(3,84) = .441$, $p = .724$. The overall mean was 2.33, so again the students somewhat agreed that the interventions they were assigned to were fun.

Question 5. In response to question 5, which asked the students whether or not they had to use another method to help them remember the vocabulary words in addition to, or besides the one they were exposed to, the number of students who said yes within each intervention condition was not significantly different from one another $F(3,84) = 1.741$, $p = .165$. The overall mean was .16, which suggests that overwhelmingly students did not use another method, because 0 = No and 1 = Yes. In fact, 84.3% of the students reported that they did not use any other method besides the one provided.

Looking at the number of students who answered affirmatively in each group, those in the Image Creation- Picture group had the largest percentage of students who answered yes, followed by Picture Presentation, then Word Only, and finally Image Creation- No Picture. This was surprising as Image Creation- Picture was hypothesized to be the most effective method for assisting students in acquiring the new vocabulary words, and as such the students should only have used the method provided.

Question 6. Question 6 asked students to describe any methods they had used beside the one provided to help them remember the words. Students gave a variety of answers. No students in the Word Only condition answered this particular question. Four students in the Picture Presentation intervention answered question 6. Most described spending time working with the words, e.g., working with a partner such as a parent, spending time writing the words down, and creating rhymes to help remember the words. One student in the Image Creation- No Picture intervention answered this question and the strategy involved repeating the words. In the Image Creation- Picture intervention, seven students answered this question. Their strategies ranged from using the pictures provided to guessing. However, being that pictures were provided in this particular intervention, this strategy suggestion was not counted as a novel approach to learning vocabulary. Only one student described a truly novel approach, which was ruling out answer choices that did not work when filling out the outcome measures. See Appendix N for students' answers to question 6 on the vocabulary learning evaluation form.

Summary. Based on the results of the student evaluation forms, Hypothesis 4 was not supported, as no statistically significant differences were demonstrated between the students assigned to the different intervention groups. The answers on the evaluation forms did not reflect the quantitative results, as the answers provided by the students in each of the four interventions were similar to one another. No clear trend could be discerned.

Results of the Student Discussions

Figure 3 shows the discussion participants' answers to the first six questions according to the intervention to which they were assigned.

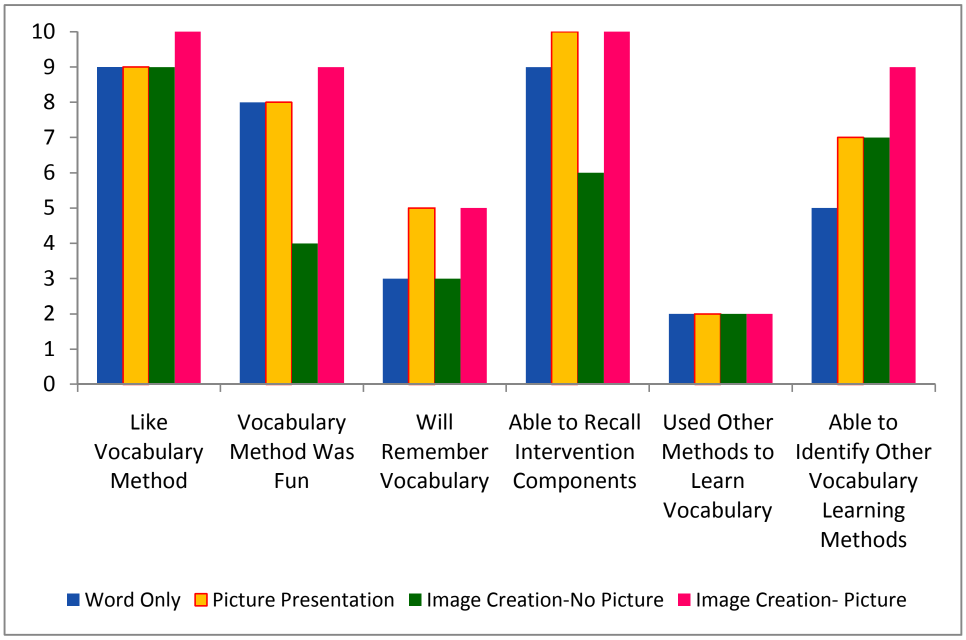


Figure 3. Participants' answers to the discussion questions.

Hypothesis 4. The first three questions of the student discussion also required participants to discuss their perceptions of the interventions to which they had been assigned. This provided additional data regarding whether or not the qualitative results were similar to the quantitative results, which was also explored by the intervention evaluation forms.

Questions 1, 2, and 3. Table 12 shows the results of the first three questions, which asked students to answer with a simple yes or no. Some students refused to answer with a simple yes or no, even when asked, and as such their specific answers are also included in the table below.

Table 12

Answers to First Three Discussion Questions

1. Did you like the vocabulary learning method we used?

	Yes	9
Word Only	**No**	1
	Yes	9
Picture Presentation	**No**	1
	Yes	9
Image Creation- No Picture	**No**	1
	Yes	10
Image Creation- Picture	**No**	0

2. Did you think the vocabulary learning method was fun?

	Yes	8
Word Only	**No**	2
	Yes	8
Picture Presentation	**No**	1
	So/So	1
	Yes	4
Image Creation- No Picture	**No**	5
	So/So	1
	Yes	9
Image Creation- Picture	**No**	1

3. Do you think you will remember these words?

	Yes	3
Word Only	**No**	7
	Yes	5
Picture Presentation	**No**	5
	Yes	3
Image Creation- No Picture	**No**	4
	So/So	3
	Yes	5
Image Creation- Picture	**No**	3
	Maybe	2

Specifically with regards to the first three questions, which asked for either a yes or no answer, some interesting trends were noted. Students in all four intervention groups, across the classes, appeared to like the intervention method that they were exposed to.

The second question asked the students if they felt that the intervention was fun. While those in the Word Only, Picture Presentation, and Image Creation- Picture interventions reported that it was, those in the Image Creation- No Picture intervention were about evenly split. This is interesting because most students who described the interventions noted that the drawing was the best part. Perhaps, since these students were not provided with an image before having to draw their own picture, they were more mentally taxed than those who could simply copy or reference the picture and enjoy themselves while drawing.

For the third question, which asked if students would remember the words, the responses were more evenly mixed. Those who elaborated after their simple yes or no response often explained that there were too many words or the words were too hard to remember. It is also interesting to note that for both the second and third question, students were more hesitant to give a yes or no answer, which is why columns such as “So/So” and “Maybe” were added.

Summary. No clear support for Hypothesis 4 was shown by the answers to the first three questions of the student discussions. Students’ answers to question 1 were similar across all intervention groups, as were those in question 3. For question 1, students in all groups were positive about the learning method used, and in question 3 students across all intervention groups were mixed with regards to their ability to remember the vocabulary words. For question 2, which asked whether or not the intervention was fun, the majority of the students who participated from the Image Creation- No Picture intervention had mixed feelings. Students in the three other intervention groups were relatively positive in response to this question.

Hypothesis 5. Hypothesis 5 predicted that students would be able to identify the steps of the intervention they were exposed to and why the intervention did or did not help them learn the vocabulary. Qualitative analyses were carried out for the purpose of examining the methods the students used when learning the vocabulary more closely and to examine the students' awareness of these components. These analyses also served as a check for fidelity to the treatments. Appendix O contains the students' answers to the discussion questions.

Question 4. From those placed in the Word Only condition, 9 out of 10 students who participated in the small group discussions were able to recall the components of the intervention. In the Picture Presentation condition, all 10 students described the pictures; in the Image Creation- No Picture intervention, 6 out of 10 students discussed the pictures they created; and finally all 10 students from the Image Creation- Picture intervention discussed the pictures they drew; however, only 6 of them described being presented with pictures before drawing.

In the Word Only group, 9 students mentioned that they were given a word and a definition. While most mentioned the definition, two recalled that they were provided with a sentence and one said that an example was given. The last student had a little more trouble, only recalling that the group was given words and worksheets to fill out. Most of the intervention itself was not described.

For the Picture Presentation group, all 10 students mentioned the pictures they were presented with. One student, #18, even described some of the words she remembered because of the pictures, such as benthos.

In the Image Creation- No Picture group, six students mentioned drawing pictures or using crayons to draw. The two students from class 3 and two from class 5 did not mention this. One in class 3 did not remember and the other said that there were a lot of words. The two in class 5 mentioned the tests and worksheets that were given during the outcome measure portion of the study. Overall this group had the most trouble answering this question.

Finally, in the Image Creation- Picture intervention, all 10 students described the process of drawing the pictures in addition to hearing the meanings of the words. However, four of these students did not mention that they were first presented with pictures by the researcher before being asked to draw them.

Question 5. This question asked if students used any methods, besides the ones given to them during the intervention, to help them remember the words. In each of the intervention groups, 8 out of the 10 students questioned did not report using any other method than that to which they were assigned.

A variety of answers were provided by the two students in each group who described using other methods. In the Word Only group, one student described making pictures in his head and the other said that she studied the words in her head. In the Picture Presentation intervention, the pictures reminded one student of things that helped her to recall the words, and the other student just thought of the words in his head when he took the outcome measures. In the Image Creation- No Picture intervention, one student looked for words within the words and the other closed her eyes to think of the words during the tests. Finally, in the Image Creation- Picture intervention, one said that he thought of similar words and the other noted that she relied on her memory.

Question 6. This question required students to identify other methods that could facilitate their learning of vocabulary. In the Word Only intervention, 5 out of 10 students came up with new strategies. In the Picture Presentation intervention, 7 presented novel ideas; 7 in the Image Creation- No Picture intervention gave suggestions; and finally 9 offered suggestions in the Image Creation- Picture intervention. A strategy was only counted if it was novel and did not involve a component of the intervention to which the students had already been exposed.

In the Word Only condition, one student said that candy would help to facilitate her learning. One student also mentioned the need for a picture of the word. This is important, because it shows that students, this one in particular, felt that imagery facilitates learning. Other strategies that were noted were having another individual test the student, repeating the words over and over again, and cutting up the word into its parts to help with memorization. This student may have been referring to identifying any root words, prefixes, or suffixes, which provide the learner with clues about its meaning.

In the Picture Presentation intervention condition, one student said she would have liked to have been provided with the parts of flowers corresponding to the words being instructed. This is an interesting idea, because it appeals to the visual domain, similar to imagery, and also adds in a tactile component. Another student mentioned that being tested on the meanings of the words on the day they were taught would have helped. Other strategies mentioned were sounding out the words, studying the definitions over time, writing the words down in a notebook, looking in a textbook, studying the base of each word, and having someone say the definition and asking them to provide the missing word.

In the Image Creation- No Picture Group, two students said that they needed pictures of the words to help them. This is important, because they were not provided with anything before being asked to create their own picture. Other strategies mentioned were writing the words down, thinking of the first letter of the words, repeating the words over and over again, studying for a while, and making up a game.

In the Image Creation- Picture Group, students described the usefulness of writing the words in their books, using dictionaries, keeping index cards with the definitions, practicing, and having someone else quiz them. They also wanted time to study the words and play games with them.

Question 7. Question 7 was only given to students in the Word Only and Image Creation- No Picture groups since they were not provided with pictures. It asked the students if they had trouble visualizing the meanings of the words. Seven out of 10 students in the Word Only condition had trouble visualizing the words, and 5 out of 10 in the Image Creation- No Picture intervention reported having difficulty.

Summary. Based on the results of questions 4 through 7, students appeared to be able to identify the components of the interventions, as well as other methods that would facilitate their vocabulary learning. This somewhat supports Hypothesis 5. While many students were able to identify the components, not many articulated why the particular intervention may have helped facilitate acquisition and recall.

Overall Summary

The first three hypotheses were supported. Imagery facilitates learning, as does depth of processing at both immediate and delayed recall. While significance was not shown in between each and every individual intervention group, the trends followed the predictions made. Not as many significant differences were found at delayed recall.

Hypothesis 4 was not supported, as students' perceptions of the interventions did not reflect the quantitative results. Finally, Hypothesis 5 was somewhat supported in that students were overall able to identify the components of the interventions, but not all were completely clear on which specific components actually led to word learning.

CHAPTER 5

Discussion

This chapter focuses on the interpretations of the results, and draws conclusions related to the hypotheses formed. Limitations of the study are described, as well as ideas for future research and the educational implications of the study.

Influence of Demographic Variables

Analyses of the data showed that none of the demographic variables were significant predictors of the outcome measures at either immediate or delayed recall. This is important because it enables the potential of other confounding variables to be ruled out. Therefore, any differences observed between the groups were due to the interventions the students were assigned to and were not artifacts of any component of the participants' demographics.

The only variable which appeared to present an issue at the outset was the number of older siblings. This makes sense as research has shown that as family size increases, students' academic achievement decreases, as those with fewer siblings show higher academic competence (Robinson, Weinberg, Redden, Ramey, & Ramey, 1998). Therefore it is possible that students from larger families had lower scores on the outcome measures. However, after taking the covariate and intervention assigned into account, the predictive value of this variable no longer achieved significance.

Initial Vocabulary Level of the Students

The PPVT-IV was a good measure of the children's vocabulary knowledge and was extremely useful for the purposes of this study. It was relatively easy to administer and did not set the examinees up for extensive failure. The students were attentive during the task, as it engaged them and held their interest. This allowed for complete and accurate data, as none of the students terminated the task prematurely.

The use of the PPVT may have had one unintentional influence on the results of the study. The aim of the study was to examine the effect of imagery, both presented by the researcher and created by the students, on their ability to learn vocabulary words. Students who otherwise may not have used images when memorizing the vocabulary words may have been primed to do so after the PPVT was administered. Students such as these, may not have considered the possibility of using pictures to facilitate learning, but after seeing the ease with which words can be paired with images on the picture plates, may have done so. This would have confounded the results for the Word Only intervention. Students who were instructed just to pay attention to the verbal presentation of the words may have also created mental images to help them with the vocabulary task. This confounding variable was slightly mitigated by the use of questions 5 and 6 on the intervention evaluation forms and question 5 of the student discussion, which focused on students' use of other methods to help them memorize the vocabulary words. If students used imagery, even when not instructed to, they should have reported this. However, only one student mentioned creating pictures in his head on question 5 of the discussion.

One important observation, with regards to use of use of imagery, made during the administration of the PPVT, was that students attempted to use previously stored mental pictures in recalling words or meanings from memory. In response to the picture plate "concave," one girl said, "I just thought of a cave which looks like this [as she motioned the shape of a cave] so I picked that one." Another student said in response to the word prompt "illuminating," "I remember what that word is from the picture in my

Titanic book at home." Even without prompting, students attempted to relate words to their meanings through the use of imagery.

During the PPVT task many students asked questions about the meanings of the words, which were not answered. Many students also wanted to check the accuracy of their answers at the end and requested to receive a grade. The students were told that the purpose of the PPVT was to identify vocabulary words they knew and those that they did not know, and that the answers could not be checked at that time. They were all told that they had done an exceptional job on the task.

An interesting observational trend, which was shown by the student responses to the PPVT, was that the way in which many boys and girls handled the words they were unsure of differed. The boys would often guess and quickly want to move on to the next plate. The girls were much more hesitant to give an answer, would wait longer in coming up with their final decision, and often said "I do not know." This could be evidence of the different ways in which males and females are reared within the community. In future studies this should be systematically recorded and examined.

Another difference witnessed between students was whether or not they guessed or asked to skip to the next picture plate. Some students told the researcher that they had guessed on several occasions. One student said, "I completely guessed on all of those." Other students, rather than guessing said "skip" or "pass." Girls were much more likely to respond in this way when they were not sure of the answer. This too could be systematically recorded in future studies; however this was out of the scope of the current research.

Imagery

Hypotheses 1 and 3 focused on the use of imagery in facilitating the acquisition and retention of science content vocabulary by fifth grade learners. It was predicted that those in the imagery interventions (Image Creation- Picture, Image Creation- No Picture, and Picture Presentation) would score significantly higher on the outcome measures at both time points, compared to the students in the Word Only intervention.

Based on the pairwise comparisons, the participants in the Word Only group scored significantly lower than the students in all three intervention groups involving imagery at immediate recall. The scores of this particular group were not even comparable to students in any other intervention group. Therefore imagery is an important component of vocabulary interventions.

Those in the Picture Presentation group scored significantly lower than those in the Image Creation- Picture group, but the difference between the Picture Presentation students and those in the Image Creation- No Picture group was not significant. This is interesting, because it suggests that the difference really occurred when the components of image presentation (being shown a picture) and image creation (having to draw a picture) were combined. Those who just had to draw a picture, as in the Image Creation- No Picture group, or those who were just shown a picture, as in the Picture Presentation group, did not differ from one another. Either approach is better than no imagery at all, but neither, image presentation or creation, is better than the other.

When comparing the students assigned to the Image Creation- No Picture and those assigned to the Image Creation- Picture groups, there were no statistically significant differences. This suggests that having to create an image in one's mind is helpful in facilitating memory for vocabulary, and adding the extra presentation of a picture may not always be necessary, since the groups did not significantly differ from one another. This may also be a result of the particular words chosen for this intervention, because the words that were selected were done so on the basis that they were concrete and easily facilitated the formation of images based on the sentences and definitions. Perhaps a difference between the groups would be demonstrated with more abstract words which require the presentation of a picture to help clarify the meaning. However, constructing pictures of abstract or ambiguous words would present an additional challenge.

Students appeared to be more anxious in taking the delayed outcome measures compared to the immediate recall measures. Many were quick to exclaim that they would no longer remember the words, however according to the results, they still retained a lot.

Follow-up pairwise comparisons showed that those in the Word Only group were statistically similar to those in the Picture Presentation group, but different from both image creation groups. This is an important finding, in that perhaps over time, depth of processing is more important than imagery, as those who had to create a picture on their own did significantly better two weeks later than those who did not. Those whose intervention involved no imagery at all (Word Only) essentially did the same as those who were presented with a picture (Picture Presentation). The students in the two imagery groups also scored statistically similar to one another.

The reactions of the students to the creation of the pictures were also very interesting. Students in the Image Creation- No Picture intervention in class 5 were very vocal about wanting to hold on to their pictures over night. When the study resumed the day after the interventions, one student said, "I wasn't trying to remember them [the words]. I was just drawing the pictures. I only remember my pictures." This student was particularly frustrated since he was not able to take the pictures with him to help him remember the words. A female from that same group said "I know this! I remember drawing this!" It appeared as if the students had mixed reactions to not being permitted to retain their pictures. However, it is interesting to note that they were well aware of imagery as a strategy for facilitating learning and recall. They were vocal about its use in helping them retain the meanings of the words.

Overall, after examining the results of the immediate and delayed recall outcome measures, Hypotheses 1 and 3 were supported. Imagery was shown to facilitate science vocabulary learning. However, it is important to note that while some of the effects may be attributed to the dual coding theory, the benefits witnessed may also be explained by depth of processing.

Depth of Processing

Hypotheses 2 and 3 related to depth of processing and its potential effects in facilitating the acquisition and retention of the science content words. It was hypothesized that the Image Creation- Picture intervention would help the students acquire and retain the novel vocabulary words the best. This may possibly be a developmental issue. Image Creation- Picture, when compared to the Image Creation- No Picture intervention, helps to clarify the meanings of the vocabulary words, as students are presented with the images first. For Image Creation- No Picture, the student must focus on understanding and learning the definition, as well as creating a plan for drawing a picture of the word. This may be easier for older students, but such an active and cognitively difficult strategy may not be productive for the younger students.

With older children, such as secondary education students, the Image Creation- No Picture method may prove to be even more beneficial because it enables the students to process the word at a deep level. The student is not only creating a mental image, but also putting it on paper, thereby making it more salient in memory and more personally meaningful. This approach may not be as difficult for them as for early elementary students.

The results demonstrated that there was a significant difference in the outcome scores at immediate recall between students placed in different intervention groups. Upon closer inspection of the means, the trends follow the prediction made in Hypothesis 2 regarding depth of processing and the possible benefits of including both imagery presentation and creation components in the Image Creation- Picture intervention. Those in the Image Creation- Picture intervention did the best, followed by those in the Image Creation- No Picture group, followed by Picture Presentation, and finally Word Only. The high outcome measure scores of those placed in the Image Creation- Picture intervention suggest that the added presentation of the picture helped students learn the words as the image was potentially able to clarify the meaning for the participants.

The order of the outcome scores of students placed in different interventions follow the results found in the aforementioned Gambrell and Jawitz (1993) study. In their experiment, children told to form images while exposed to a story with illustrations outperformed those who formed images and read an unillustrated version of the story. These students scored higher than those who read an illustrated version of the story, but were not told to create images, and were finally followed by the students in the control group. These results demonstrate the benefits of both creating and presenting imagery, and the advantage of having to mentally create images over viewing them.

The results of the present also show that the relationship between the covariate and intervention was positive, which means that those with a higher PPVT score, or initial receptive vocabulary, did better on the interventions. However, when initial vocabulary level and its influence were removed from the model, the differences between the interventions were still significant. Those who knew more vocabulary to begin with did better on the outcome measures, but this did not lead to the differences observed in the outcome measures. The significant differences between students on the outcome measures were a result of the intervention to which they were assigned.

As demonstrated by the pairwise comparison results discussed in the previous section, significant differences were not found between each and every intervention, however this should not be discouraging. Fifteen words were taught to the students in one sitting. Perhaps a larger number of words, spaced out, with multiple exposures to each of them would have led to more significant results. However, this would have required the help of several research assistants, and placed undue demands on the teachers and students in these particularly busy classrooms.

Differences between the interventions were once again significant at delayed recall, measured two weeks later. This is important because it shows that even one exposure to the words was sufficient to help a student remember vocabulary over time. If students learned the words and quickly forgot them, the intervention would not be useful, as it only allowed for quick surface learning, rather than deep encoding. The fact that the students displayed differences two weeks later suggests that the meanings of the words must have made their way into long-term memory. The relationship between the covariate and intervention was again significant, demonstrating that those with a higher initial vocabulary level did better on the delayed recall interventions.

The mean scores on the delayed composite measures once again demonstrated that those in the Image Creation- Picture intervention score the highest, followed by Image Creation- No Picture, Picture Presentation, and Word Only.

As mentioned in the imagery section, follow-up pairwise comparisons revealed that those in the Word Only group were not statistically different from those students placed in the Picture Presentation group. However the Word Only students performed significantly lower on the delayed outcome measures than those in both image creation groups. This suggests that depth of processing may be more essential in helping students retain their vocabulary knowledge over time, as those who had to create a picture scored higher two weeks later.

The Picture Presentation group scored significantly lower than the two imagery groups. The Image Creation- No Picture group and Image Creation- Picture group were not statistically different from one another in terms of their delayed composite scores. Again, this supports the idea that depth of processing may matter more than imagery over time.

Overall Hypotheses 2 and 3 were supported as the deeper the students processed the information, the better they learned the words. The outcome score means at immediate and delayed recall followed the anticipated results; however, statistically significant differences were not witnessed between all of the groups. Specific differences between the groups were not predicted in Hypothesis 3 regarding delayed recall, because it was anticipated that over time the differences between the groups would be blurred. In fact, it appears that those whose depth of processing was greater, e.g., those in the image creation interventions, were significantly different from those in the Picture Presentation and Word Only interventions. This finding suggests that depth of processing is what is responsible for maintaining the meanings of the words over time. It is important to realize that there were many limitations to this study, so a definitive conclusion regarding this issue cannot be drawn at this point.

Immediate and Delayed Recall Time Points

As shown by the change scores between the composite delayed recall outcome measures and those taken at immediate recall, there was no significant difference between the two time points. While some students improved over time, as shown by higher outcome measure scores, others did worse. The overall differences between the time points were negligible.

The absence of differences in recall over time can be both positive and negative. On the one hand, it is good that students did not show large decreases in scores, which would have demonstrated that they were not able to retain the vocabulary knowledge. On the other hand, it would be great if students did better over time, demonstrating a real mastery of the words and ability to identify their meanings on outcome measures. As demonstrated by the aforementioned Upadhyay and DeFranco (2008) study, vocabulary gains can be maintained best over time when the information is linked to prior knowledge. If students in all three imagery groups demonstrated significant gains, it would mean that the use of pictures or act of creating pictures helps to tie the meanings of vocabulary words to prior experiences and information.

It is important to remember that this intervention was extremely benign, as the words were only presented once and in a relatively short period of time. It was imperative that there was no disruption of the flow of the classroom to maintain a relationship with the schools. Perhaps with evidence garnered in support of these interventions, schools will allow much more elaborate trials to take place to demonstrate the utility of the interventions with multiple exposures to the words.

Students' Perceptions of the Interventions

Vocabulary learning evaluations. While the vocabulary learning evaluations brought in a qualitative piece to the study, the first five questions were quantitatively analyzed. Analyses of covariance were used for the first five questions of these forms.

Regarding the first four questions, it was interesting that no differences were found between the intervention groups in terms of their perceptions of their ability to learn the words, remember the words, the utility of the interventions, and how fun they perceived them to be. In addition, no differences were found between the students exposed to the different interventions in terms of how many used another method to help them remember the words as asked by question 5.

However, this is not all that surprising. The intervention evaluation form was given to the students two weeks after the initial instruction of the vocabulary words. Perhaps too much time passed in order for the students to accurately remember how they learned the words and the specifics of the interventions to which they were exposed. Some students had trouble describing the exact components of the intervention and why they did or did not work, which will be described in the review of the students' discussions.

It is interesting that the 12 students who answered question 6 of the intervention evaluation form, which asked them to list any other methods they used to help them learn the vocabulary, were from one of the three interventions which involved imagery. No students from the Word Only intervention chose to answer this question. The students in the Word Only intervention may not have been aware of other possible strategies to use when learning and remembering words since their instruction was relatively straightforward and did not involve much creativity.

One common trend, which appeared mostly across the Picture Presentation intervention, was the use of mental effort. Students basically described strategies which involved working with the words by repeating them or writing them down. Perhaps these memory techniques are those most frequently taught in school for the purpose of vocabulary learning or these are the ones which have worked best for these particular students in the past.

It is also interesting that of the seven students who answered this question from the Image Creation- Picture intervention, only one discussed a truly novel strategy, which was checking to see which word made sense. The other six students either described using images, which was provided to them in this intervention, or just guessing. Perhaps the students found the presentation and creation of the images so helpful that they wanted to stress how much this strategy aided their vocabulary acquisition and retention.

Hypothesis 4 was not supported by the results of the evaluation forms. The students' answers did not reflect those shown by the quantitative results. Perhaps if students were given more time and open-ended questions, they could have been more explicit as to their perceptions of the interventions and expressed their ideas about vocabulary learning more clearly.

Student discussions. Students were eager to discuss the interventions they were exposed to. They were told to give their honest opinions about the exercise and that no matter what they said, they would not offend the researcher. It was explained to them that their feedback would be used as a way to understand how they learn vocabulary and what methods they prefer.

Most of the students in the imagery interventions: Picture Presentation, Image Creation- No Picture, or Image Creation- Picture reported that the interventions were helpful in aiding them with the memorization of the vocabulary words. They explained that being able to visually see the words helped them remember the meanings.

The first three questions of the discussions asked students if they liked the interventions they were exposed to, thought they were fun, and would remember the words. Being that these questions focused on the students' perceptions of the interventions they were exposed to, the data obtained were used to examine Hypothesis 4. No support was shown for this hypothesis. The results were inconclusive and as such did not replicate the quantitative results. This is not all that surprising. First, students' operational definitions of liking the intervention, how fun the intervention was, and ability to remember words may have all differed. It is very difficult to get everyone to interpret the questions in the same way. Also, with limited choices provided, students were expected to select from one of four choices in representing their feelings. Perhaps open-ended questions would have been more useful.

The last four questions of the student discussions were open ended and were used to provide qualitative data to examine Hypothesis 5, regarding the students' awareness of the components of the interventions. The results lend some support to this hypothesis in that students were able to identify the components of the interventions to which they were exposed. However, the students did not clearly state why the components did or did not work for them in terms of helping remember the vocabulary words. Clearer results may have surfaced if students were provided with prompts to discuss certain aspects of the interventions and their utility or lack thereof.

For question 4, which asked the students what methods the researcher provided them with when the words were being instructed, most students were able to identify the components of the intervention. It appeared to be the most complicated for the students from the Image Creation- No Picture intervention to recall what they were exposed to. This was surprising since they were given boxes of crayons and were allowed to draw pictures. However, as shown by the answers to the third question, many of the students in this particular intervention did not find it fun. Overall, this group had the most trouble answering this question.

For question 5, which asked students about any other methods they used to help them learn the vocabulary, most of the students were quick to report that they just used those provided by the researcher. Eight students across the interventions elaborated more and described other methods. It is interesting that from all four interventions, 6 out of 8 students who described using a method other than the one provided were females.

In the Word Only intervention, the strategies described were creating pictures in one's head and studying. This is interesting, because it demonstrated that students in the

Word Only intervention may still have used imagery. While only one reported it, others may have used it and just not been aware of, or reported it. This can potentially confound the results of the study.

Question 6 dealt with the methods the students felt they could use to help them remember vocabulary words. Only suggestions that were not a part of the original interventions were counted. For example, some students in the imagery interventions mentioned using pictures and one student mentioned that having a sentence would facilitate learning. Since these were already included in their particular interventions, they were not noted as new examples of useful techniques.

The importance of imagery was demonstrated by several of the students' responses. One girl in the Word Only condition said that a picture would help her. Another student in the Picture Presentation said that providing students with the parts of a flower corresponding to the words being instructed would make the task easier. Both of these answers underline the importance of a visual component in facilitating learning.

Many mentioned that seeing the words more than once would have helped. This is important as it demonstrates the need for multiple exposures to new vocabulary words for learning to occur. Students may have learned and retained more words if they were exposed to them more than once.

The answers to question 7, which asked students if they had trouble visualizing the words, were particularly enlightening. A majority of the students in the two interventions that were not provided with pictures, Word Only and Image Creation- No Picture, had trouble creating mental images. This highlights the importance of imagery for word learning.

Many of the students who said that they did not have difficulty said they thought of the words in their heads, which made it easier. This demonstrates that those who did not find the task as difficult created mental images on their own, even if they were not necessarily instructed to, as in the Word Only condition.

Student Engagement

During the intervention phase of the study, most of the students were very engaged. They listened to the sentences and definitions; and those in the image creation interventions used the time allotted to draw their pictures. See Appendix P for samples of the student pictures drawn.

It is interesting to note how eager the students were to learn the words. When holding up some of the vocabulary words, such as “corolla,” students shouted out that they knew the definition. One said, “I know- it’s a type of car.” He was told that he was very bright, but this was not the type of corolla we would be discussing. Most of the students also made the hand motion of a gun when they heard the word “pistil.” They appeared happy to participate and excited to find out the meanings of the novel vocabulary words.

Overall Discussion

For a visual display of all of the hypotheses and the support they received from this study see Table 13 (p. 158). The first three hypotheses regarding the use of imagery and deep levels of processing to facilitate the acquisition and retention of novel vocabulary words were supported. Significant differences between the interventions in terms of word learning at immediate and delayed recall were shown. However, there were not as many significant differences between each of the interventions at retention, compared to those at the acquisition time point. Instead, at delayed recall, there was just a major difference between the imagery creation interventions (Image Creation- Picture and Image Creation- No Picture) and the Word Only and Picture Presentation groups.

In this study, the mean scores on the outcome measures demonstrated that those in the Image Creation- Picture group scored the highest, followed by the Image Creation- No Picture group, Picture Presentation group, and finally the Word Only Group at both immediate and delayed recall. Interestingly, in the mini pilot study which preceded this research, this was not the case. Those in the Image Creation- Picture group scored significantly higher than those in the Image Creation- No Picture group; and the mean score of those in the Image Creation- Picture group participants was the highest, followed by the Picture Presentation group, and finally the Image Creation- No Picture group. Therefore, the order of the Image Creation- No Picture and Picture Presentation interventions was reversed. The Word Only intervention was not included in the mini pilot.

The reason for this discrepancy may be twofold. The focus of the mini pilot was to refine the interventions and to be certain that they were appropriate for a fifth grade sample. Therefore, it did not necessarily matter to such a great extent if the sample was representative of the larger population and only consisted of 18 students. The students included in the pilot study were from a private Jewish day school, and were competent speakers of both Hebrew and English. The classroom management in this sample was also lacking to an extent. Most of the students were acting out during the interventions and their attention was never fully on the researcher. Since they were not paying as close attention to the interventions and the methods employed, compared with the students used for this larger study, they may have relied more heavily on the visual prompts provided in the Image Creation- Picture and Picture Presentation interventions. Also, since they spoke two languages and were taught vocabulary twice during the school day, they were more accustomed to being presented with isolated words and their pictures, and as such may have been more comfortable with the interventions in which the pictures were provided. These students may also have just been interested in learning the word and not necessarily grasping the meaning at a deeper level. Most of the tasks in their classrooms involved writing the words three times each, which does not require a deep understanding of the meaning of the word.

In the sample for this larger study, management and order were priorities in all five classrooms. As such, the students were more focused on the tasks and learning the meanings of the words. They may have benefitted more from the image creation interventions since they were able to really think about the words and process them at a deeper level in distraction free environments.

Hypothesis 4 regarding the students' perceptions of the interventions was not supported as no significant differences were shown between the intervention groups. Thus, the results of the intervention evaluation forms did not reflect the quantitative results obtained from the outcome measures.

Hypothesis 5 was partially supported as students were able to describe the components of the interventions, but were not explicit as to why they may or may not have facilitated word learning.

Overall, this study did lend support to both the dual coding and depth of processing theories. Imagery and a deep understanding of the meanings of words were shown to lead to vocabulary learning. This study provided a way to connect abstract psychological concepts with actual classroom practice. These theories are worth examining further so as to devise more effective interventions to implement in the classroom.

Table 13

Support for the Study Hypotheses

Hypothesis	Supported/ Not Supported
Hypothesis 1 **Imagery would facilitate the acquisition of the science vocabulary words.**	**Supported** Those in the imagery groups (Image Creation- Picture, Image Creation- No Picture, and Picture Presentation) scored higher than those in the Word Only intervention group at immediate recall.
Hypothesis 2 **The deeper the words were processed, the better the students' performance would be on the outcome measures at immediate recall. The Image Creation- Picture students would score the highest, as a benefit would be conferred due the inclusion of a picture along with the deep level of processing required in this intervention.**	**Partially Supported** Image Creation- Picture > Image Creation- No Picture > Picture Presentation > Word Only

Hypothesis 3 **Imagery and depth of processing, as described in the previous two hypotheses, would facilitate the retention of the science vocabulary words.**	**Supported** Those in the imagery groups (Image Creation- Picture, Image Creation- No Picture, and Picture Presentation) scored higher than those in the Word Only intervention group at delayed recall.
Hypothesis 4 **Students' perceptions of the interventions, as measured by the intervention evaluation forms and student discussions, would mirror the quantitative results.**	**Not Supported** There were no significant differences shown between students in the different intervention groups.
Hypothesis 5 **Students would be able to describe the components of the interventions they were exposed to and why they did or did not work.**	**Partially Supported** While students were able to describe the components of the interventions during the student discussions, they were not explicit as to why the method they were exposed to worked or did not work in terms of facilitating the acquisition and retention of the science words.

Limitations

While great care was taken to reduce as many confounding variables as possible, there were limitations to this study. While these limitations may not have affected the results in any major way they are important to discuss.

The overwhelming majority of students in these five classrooms were Caucasian. Being that there was not much ethnic diversity, the differences between the ethnicities in terms of the scores on their outcome measures could not be examined. This limits the generalizability of the results.

Absenteeism was another limitation of this study. For the vocabulary pretest, the selection criterion for the target words was made stricter to account for the smaller sample. Words selected were unfamiliar to 80% or more of the sample who took the pretest, even though this sample did not reflect the entire group of students who participated in the study.

No students were absent during the intervention phase of the study. However, there were instances of missing data at both the immediate and delayed recall time points. Four students missed the immediate recall outcome measures and an additional five were not present for the delayed outcome measures. In terms of the students who were absent for the outcome measures, nothing could have been done to correct for this, which resulted in missing data. If the outcome measures were given to the students upon their return, they would have had a greater length of time in between vocabulary instruction and testing than the other students. If the missing students were presented with the words again and then tested, the additional instruction might have influenced the results. Students who did not take immediate outcome measures were not given delayed outcome measures, as they had gone a longer period of time without being tested compared to the other students who were present at all study time points.

Taking the average of the students present for the particular intervention and the class the absent students were assigned to, was a reasonable way to handle the missing data. This single imputation approach utilized the data that was available to fill in any holes. The scores of the students who were present in each group where there was a missing data point were relatively close to one another, so it is likely that the absent student would have had a similar score if present.

Gender also may have influenced the results of the study. While differences between males and females were not shown on the outcome measures, differences between those who agreed to participate and those who declined were observed. All seven students who declined to participate from both schools were boys. At the school in Rockville Centre a boy in class 2 said “Research is boring,” which prompted his friend to decline to participate as well. The male students in the three Long Beach classes that declined to participate were not sitting near one another and appeared to make the decision not to partake in the study on their own. The reason why they declined to participate is not known. So as not to appear coercive, the only question that they were asked was if they wanted to be a part of the study.

This difference may be worth exploring further. Perhaps females enjoy participating in research activities more or are more interested in vocabulary learning. While in one class it appeared to be a result of peer pressure from one particularly dominant boy, the reason that the other five boys from different classes chose not to participate is not known. The reason why males were hesitant to take part in the study before even giving it a chance should be questioned.

The timing in which the PPVT-IV was administered was another limitation of the study. It was intended to be administered prior to the intervention phase of the study, as it measures initial vocabulary knowledge. However, ten students were assessed in between the immediate and delayed recall measures. Being that the teachers were extremely busy, the research had to be carried out, taking their schedules into consideration. This should not present a huge problem, as the PPVT was still used to assess the children in the beginning of the school year. Also, none of the words that were instructed during the intervention phase appeared on the PPVT, preventing any practice effects or additional reinforcement of the science vocabulary.

Another limitation was the individual differences of the participants, which included their prior knowledge and abilities. In terms of prior knowledge, vocabulary words which centered on content familiar to certain participants may have been more easily remembered by them. Also, Paul (1989) has found that children acquire a great deal of their knowledge from direct experiences. Some children may have had many experiences and learned numerous words, whereas others may not have had the same opportunities or learned the labels for their experiences. The administration of the PPVT-IV was able to counter this limitation to an extent by ascertaining the degree of the participant's prior vocabulary knowledge. The use of words which 80% or more of the students were unfamiliar with, also removed some of influence of individual differences, as it was less likely that the students had experienced the words before. Individual differences exert confounding effects on many vocabulary and imaging studies.

As was evidenced by the Anderson and Kulhavy study (1972), it is difficult to assume that the children were not forming images on their own, even if they were not explicitly told to do so. In the aforementioned study, analysis of a post-experimental questionnaire demonstrated that a majority of those in the control group consisting of high school seniors reported forming images during reading. Perhaps in the current study, students used strategies to memorize the vocabulary words besides those which were presented to them in their intervention condition. This was shown in the qualitative assessment used after testing, as some students described other strategies they used to help them remember the vocabulary words. Even though students were told to use the interventions provided, this cannot be entirely prevented or controlled.

For students assigned to the Image Creation- No Picture and Image Creation- Picture interventions, one issue which arose during the administration of the interventions was “cheating.” As in the pilot, there were some issues with students copying others’ work. Many would comment on the drawings of their neighbor, and in some cases alter their own pictures. The students were instructed to spread out, giving them enough space to prevent this; however it did not always work. Students were told that they were represented by a number, their work could not be traced back to them, and that it did not matter how many answers they got right or how accurate their drawings were. The researcher stressed the importance of focusing on their own work to the students and they were told to do their best in illustrating the definitions they heard. This stopped the students from looking at others in mostly all of the cases. However, those who may have altered their mental images and changed their pictures in response to their peers’ pictures were influenced.

Finally, the results of this study may not apply to vocabulary words from all disciplines and content areas. Requiring students to create their own images may not be possible in all situations. As per the dual coding theory, visual imagery may not work as effectively for abstract words. The concreteness of the vocabulary on which one is instructed plays a major role in the ability of students to create imagery and to learn it. Further research must be done to determine when dual coding is valuable as an intervention, and when it is not.

Future Research

Future research should aim to determine how the interventions used in this study would differentially affect students of different ethnicities. The majority of this sample was Caucasian and as such differences could not be examined.

Being that the image creation interventions were shown to be the most effective, it would be interesting to find out if there was a possible motivational component to this finding, such as intrinsic interest. Perhaps just by drawing the pictures, students were more inherently interested in the task, and as such learned the words more effectively. However, as shown by the students' discussions, more than half of those who were questioned in the Image Creation- No Picture intervention described it as not being a fun task. It would be interesting to give the students a motivation scale relating to the interventions.

It would also be beneficial to separate results in terms of the quality and quantity of memory to see how effective the interventions actually are. For example, quality is the thoroughness with which information is remembered, such as how detailed the definitions are upon recall. The quantity of memory focuses on how much is remembered, or how many definitions can be recalled, despite their total accuracy. While this study examined quantity, it did not look at quality. Perhaps measures in which students are instructed to write the definitions from memory should be incorporated into future research. These definitions could then be studied in terms of the level of understanding and specificity they convey.

The optimal number of exposures to the words which would enable the students to learn their meanings within each intervention would also be interesting to investigate.

Perhaps the interventions which employ a deeper level of processing would need fewer instructional periods in order for students to reach the ceiling on both outcome measures.

It would also be worthwhile to investigate ways in which instructors can teach fifth grade students to create images on their own. For example, what types of methods would help students learn to create imagery? Would simple instruction to picture the text be helpful, as per the Image Creation- No Picture intervention? This may present a problem for early elementary school students, and for students who are completely unfamiliar with the meaning of the term they are trying to represent, making the presentation of a picture before the creation necessary, as in the Image Creation- Picture intervention. Could technology be used to accompany the teacher's instructions and facilitate imagery creation? Also, how can an educator effectively stress the importance of imagery strategies?

The composition of the images used should also be investigated. For example, does the amount of detail present in the picture alter its effectiveness in facilitating recall and comprehension? If so, what attributes of the picture should be emphasized?

One interesting observation noted in response to the questions posed above is that it may not even matter what the students draw, but rather just that they draw something. For example, one girl said that she thought she did well when she handed in her delayed outcome measure because she remembered blue for benthos. "Blue" was not part of the definition or sentence, but rather the focus of her drawing which she described as a "big blue blob." She heard the definition and associated it with the color blue, which helped her two weeks later on the outcome measure. Perhaps students just need to latch on to any one portion of the definition or sentence to facilitate memory for meaning. The component of the definitions and sentences that students focus on most often is important to explore.

Research should also aim to assess the image evoking ability of various types of words and texts. This would enable curriculum designers to implement interventions in content areas in which little to no imagery is evoked by the reading materials.

Educational Implications

If a person has a large vocabulary, it typically indicates that he/she is a highly educated individual. A large vocabulary base facilitates education in that it is strongly related to school achievement (Beck, McKeown, & Kucan, 2002). Explicit instruction is needed to increase and improve vocabulary knowledge and comprehension of novel content material.

Furthermore, for educators to prevent or reduce achievement gaps, they must place children on to the right trajectory of vocabulary growth and reading development early on. Less able readers and students with poor vocabulary tend to read books with simpler levels of vocabulary and are exposed to fewer words, further perpetuating the vicious cycle. The interaction between low levels of vocabulary knowledge and instructional constraints explains why vocabulary measured at grade two is predictive of vocabulary levels and reading performance beyond the primary years (Biemiller, 2003). Instruction in vocabulary, in terms of the interventions described by this study, as early as preschool would be extremely beneficial.

Even though significant differences were not witnessed between every single intervention on the pairwise comparisons, this study has important implications. Students were instructed on only 15 vocabulary words and were tested both the day after instruction and two weeks later. As research has shown, perhaps multiple exposures to the vocabulary would have led to even more significance.

This study also has implications regarding the way to organize instruction, specifically in terms of the presentation of vocabulary in the science content area. With an understanding of how students best learn new vocabulary, we can develop ways to enhance comprehension. We can also design interventions to target those with learning disabilities or English Language Learners. By providing students with effective interventions early on, we are putting them on the path to be skilled lifelong readers.

By devising interventions which prove to be educationally valuable, teachers will be able to enhance students' vocabulary learning, as well as help their students generalize this knowledge to improvement in overall comprehension. There is also hope that by making students more aware of the Picture Presentation and image creation techniques, and their benefits for learning, they can take this knowledge, and when exposed to new vocabulary, will use these strategies on their own.

Finally, the interventions in this study can be implemented in a variety of content area classrooms and serve to connect literacy with different disciplines. As previously mentioned, by integrating literacy within the specific disciplines, teachers reduce the problem of time constraints during the school year and strengthen learning in both subjects. By infusing literacy into content area curricula, students will improve in their overall ability to understand and communicate their content specific knowledge. Students will be able to efficiently learn the words needed for basic understanding, speeding up the pace with which they move from easy concepts to more complex ideas.

Concluding Remarks

It is imperative for young students to be capable of learning vocabulary and to comprehend the material they read, especially in content areas such as science. Being that so much is taught in the classroom and students are presented with a great deal of novel vocabulary terms, those who are left behind in the beginning will only struggle to catch up and suffer greater setbacks throughout their education. By incorporating vocabulary instruction and literacy in the content areas, we are teaching literacy across the curriculum, and improving both vocabulary and science skills.

Many limitations confounded the results. However, extraneous variables, even with all of the precautions taken, are likely to arise using a fifth grade sample under specific time constraints. Even with these outside influences, the students reported learning a great deal and seemed to enjoy the exercises and strategies they were taught. The end result was also clear: imagery-based strategies influence vocabulary learning in the science content domain. The participants progressed from not recognizing the words to being able to supply them on an outcome measure. The students will hopefully remember the interventions they underwent and will be able to apply the techniques used in their own academic endeavors.

Overall, this study has shed light on the learning processes of elementary school students, as well as ways to instruct vocabulary in the classroom. Regardless of which type of intervention is implemented, teachers must remember to stress the importance of vocabulary learning and comprehension strategies early on and incorporate them in content area learning. This will serve both to further assist those who are doing well in continuing to learn, and to bridge the achievement gap between students.

Appendix A
School Permission Form

School Permission Form

Permission for School Participation in Science Vocabulary Research

Date ____________

My name is Marisa Cohen and I am a student in the Educational Psychology Ph.D. Program at The Graduate Center of the City University of New York (CUNY). I am conducting a project dealing with science vocabulary learning for my dissertation entitled “Improving the Acquisition and Retention of Science Material by Fifth Grade Students Through the use of Imagery Interventions.” I am working under the guidance and expertise of my advisor, Dr. Helen Johnson, a professor in the Educational Psychology department. I will be recruiting fifth grade students from various schools and would like permission to contact students and their parents.

The purpose of the study is to identify fun and effective ways for children to learn new vocabulary and concepts in the science domain. I will be presenting students with biology vocabulary. Using a topic that is typically instructed in middle school will ensure that most students do not yet know the vocabulary and will allow for a clear test of the interventions’ effectiveness. This will also help prepare them for important concepts they will be learning in the future. The lessons will be presented in an enjoyable and interactive way to sustain the students’ interest and make their learning experience positive.

I will be pretesting the students to identify their vocabulary ability, teaching them new words, and assessing their ability to recall the definitions. These tasks will take place over a total of eight sessions, each lasting no more than 30 minutes. Some students may be asked to spend an additional 15 minutes in a small group discussion to describe what they enjoyed about the experience during my last visitation. If a child chooses not to participate, he/she will simply continue with the regular classroom activity. At the completion of the study, each student will be given a token of appreciation.

All data will be confidential and participation by the students is completely voluntary. The risks from participating in this study are no more than encountered in everyday life. The benefits of the students’ participation are that they will learn new words and interesting science material. They will also provide valuable information about the way children learn in school.

The Institutional Review Board of The Graduate Center of the City University of New York (CUNY) has approved this study. If you have questions about parent and participants' rights, you can contact Kay Powell, IRB Administrator, The Graduate Center/City University of New York, (212) 817-7525, kpowell@gc.cuny.edu. You can also contact me about the study or to request a research summary at (917)748-8164, mcohen1@gc.cuny.edu. You can also contact my advisor Professor Helen Johnson at (212)817-8298, hjohnson@gc.cuny.edu.

Thank you very much for considering my study. I hope that the information garnered from this research can be used to complement the wonderful work that you are already doing to provide your students with quality learning experiences.

Sincerely,

Marisa Cohen
Doctoral Student
Educational Psychology
CUNY Graduate Center

Permission for School Participation in Science Vocabulary Research

Permission Statement: I have read and understood the information described above. I allow my school to participate in the vocabulary research.

School______________________

Please print your name __________________________________

Signature: ___________________________________Date:__________

Researcher Signature: __________________________Date:___________

Appendix B
Parental/Guardian Permission Form

Parental/Guardian Permission Form

Permission to Participate in Science Vocabulary Research

Date ____________

My name is Marisa Cohen and I am a student in the Educational Psychology Ph.D. Program at The Graduate Center of the City University of New York (CUNY). I am conducting a project dealing with science vocabulary learning. I am working under the guidance and expertise of my advisor, Dr. Helen Johnson, a professor in the Educational Psychology department.

I am asking you for permission for your child to participate in this vocabulary research study. The purpose of the study is to help identify fun and effective ways for children to learn new science vocabulary. The risks from participating in this study are no more than encountered in everyday life. The benefits of your child's participation are that he/she will learn new words and interesting science material. He/she will also provide valuable information about the way children learn in school.

Approximately 90 students will be involved with the study. I will be pretesting the students to identify their vocabulary ability, teaching them new words, and assessing their ability to recall the definitions. These tasks will take place over a total of eight sessions, each lasting no more than 30 minutes. Some students may be asked to spend an additional 15 minutes in a small group discussion to describe what they enjoyed about the experience during my last visitation. If your child chooses not to participate, he/she will simply continue with the regular classroom activity. At the completion of the study, each student will be given a token of appreciation.

I will protect your child's confidentiality. What your child communicates will be confidential and his/her name will not be recorded anywhere on the vocabulary worksheets. He/she will be represented by a unique identification number. The results will be kept in a locked file cabinet in my office to which only my advisor will have access. I may publish results of the study, but names of people, or any identifying characteristics, will not be used in any of the publications. If you would like a copy of the study, please provide me with your address and I will send you a copy in the future.

Participation is voluntary. Your child can withdraw from the study at any time, and for any reason. There is no penalty for declining to participate in the interview or for withdrawing from the study if your child changes his/her mind. The study is not related to your child's school and his/her participation (or lack of) with not affect his/her grades.

If you have any questions about the study or request a research summary you can contact me at (917)748-8164, mcohen1@gc.cuny.edu. You can also contact my advisor Professor Helen Johnson at (212)817-8298, hjohnson@gc.cuny.edu. If you have questions about your child's rights as a participant in this study, you can contact Kay Powell, IRB Administrator, The Graduate Center of the City University of New York (CUNY), at (212) 817-7525, kpowell@gc.cuny.edu.

Thank you very much for considering my study.

Sincerely,

Marisa Cohen
Doctoral Student
Educational Psychology
CUNY Graduate Center

I have read and understood the information described above. Ms. Cohen answered all the questions I had to my satisfaction and allow my child participate in the vocabulary research.

Please print your name ______________________________________

Please print your child's name__________________________________

Parent Signature: ___________________________________Date:____________

Researcher Signature: _______________________________Date:_____________

Appendix C
Student Assent Form

Student Assent Form

Assent to Participate in Science Vocabulary Research

Date ____________

My name is Marisa Cohen and I am a student in the Educational Psychology Ph.D. Program at The Graduate Center of the City University of New York (CUNY). I am conducting a project dealing with science vocabulary learning. I am asking your parents for their permission to allow you to participate in my study, but also want your agreement.

If you agree, you will learn new exciting ways to better help you remember vocabulary. I will first assess your vocabulary level and identify words which fifth grade students do not yet know. I will then teach you these words using activities such as hearing sentences and definitions, hearing the words pronounced, and seeing and drawing pictures. Then we will see how many each of you can remember.

I will come in and work with groups of students during regular school hours. Your answers and feedback will only be seen by me and my advisor, and will not count towards your grades in class. This is meant to be a fun learning experience for you. I hope that this research will provide useful results to help teachers instruct their students better in the future.

This study is not related to your school and if you participate, or choose not to, it will not affect your grades. Your participation is voluntary and you may choose to stop at any time. When I discuss or write about the results of this study, I will not use your name or anything that can identify you to others. At the completion of the study, you will be given a token of appreciation.

If you have any questions about this research, you can contact me at (917)748-8164, mcohen1@gc.cuny.edu. You can also contact my advisor Professor Helen Johnson at (212)817-8298, hjohnson@gc.cuny.edu.

Assent to Participate in Science Vocabulary Research

I have understood the information described. Ms. Cohen answered all the questions I had to my satisfaction and agree to participate in the research.

Please print your name ______________________________________

Signature: _______________________________________Date:____________

Researcher Signature: _____________________________Date:_____________

Appendix D
Definitions and Sentences of Words

Definitions provided by:

Merriam-Webster's collegiate dictionary. (10th ed.). (1996). Springfield, MA: Merriam-Webster, Incorporated.

Pearson Education, Inc. (2009). *Glossary of biological terms.* Retrieved from http://www.phschool.com/science/biology_place/glossary/index.html

**= words that were included in the interventions

Biology Vocabulary

****Abdomen:**
In mammals, the portion of the trunk containing internal organs other than the heart and lungs.

The patient had pain in his abdomen, which is the mid section of the body, and went to the see the doctor to find out what was causing it.

****Anther:**
The pollen sac, inside which pollen grains form in the flower of flowering plants.

Pollen grains form in the anthers of flowering plants.

****Benthos:**
The region that includes the bottom of a lake, sea, or ocean.

The benthos region of a lake or sea is often dark and very cold, as it is all the way at the bottom.

Cell membrane:
Outer membrane of the cell that selects what enters and exits the cell; traffic cop of cell.

The cell membrane is the outer membrane of the cell through which particles may pass.

Conifer:
A plant whose reproductive structure is the cone, and includes pines, firs, redwoods, and other large trees.

A pine tree is a type of conifer. It produces pine cones, which are its reproductive structures.

****Corolla:**
Petals, which are usually colored flower parts.

The corolla of a sunflower consists of brightly colored yellow petals.

****Cotyledon:**
The one or two seed leaves of the embryo of a flowering plant.

The cotyledon of the lima bean plant the students grew in their class consisted of two tiny leaves.

Cytoplasm:
Jellylike substance within a cell.

The cytoplasm of the cell is the jellylike substance in which all of the organelles are suspended.

****Diatom:**
Microscopic one-celled algae.

A colony of green diatoms were found in the sample of swampy water, but were too small to see without the use of a microscope.

****Erythrocyte:**
A red blood cell; which functions in transporting oxygen in the circulatory system.

Red blood cells, which transport oxygen in the circulatory system of human beings are also known as erythrocytes.

Esophagus:
A channel that conducts food from the back of the mouth to the stomach.

After swallowing my food, it passed through my esophagus and was on its way to my stomach.

Lysosome:
A membrane-enclosed bag of enzymes found in the cytoplasm of certain cells; digestion center.

The lysosome is known as the digestion center, because it contains chemicals used to break compounds down in certain cells.

****Microtubules:**
Hollow cylinders that support and shape cells.

Microtubules are used to shape cells and look like hollow cylinders.

Mitochondria:
Organelle in the cell that serves as the site of cellular respiration; "powerhouse" of cell.

Many consider the mitochondria the powerhouse of the cell because of its role in cellular respiration.

Nucleus:
Spherical organelle bounded by a membrane; cell's brain.

The nucleus is often called the cell's brain as it is in charge of what is going on within the cell.

****Petiole:**
The stalk of a leaf, which joins the leaf to the stem.

The petiole of that leaf, which attached it to the stem was bright green.

****Phloem:**
The portion of the vascular system in plants consisting of living cells arranged into elongated tubes that transport sugar and other nutrients throughout the plant.

The phloem is important to plants, because it consists of cells which transport nutrients.

****Pistil:**
The female reproductive organ of a flower which contains the seeds.

The pistil of the flower contains the seeds.

Root cap:
A cone of cells at the tip of a plant root that protects it.

The root cap at the tip of plant roots is important for protection.

****Sepals:**
Modified leaves in flowering plants that enclose and protect the flower bud before it opens.

In flowering plants, the sepals protect the flower before it opens up.

****Solute:**
A substance that is dissolved in a solution.

The solute, or substance dissolved in my salt water solution, is the salt.

****Solvent:**
The dissolving agent of a solution.

In my salt water solution, the solvent is the water.

Stamen:
The pollen-producing male reproductive organ of a flower.

The stamen of flower is responsible for pollen production.

****Vacuole:**
Membrane-bound sac that stores food and waste; cell's warehouse.

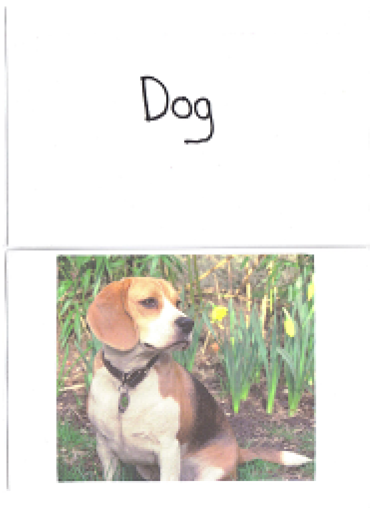
The vacuole is an organelle sometimes called the warehouse, because it stores food and waste.

Xylem:
The tube-shaped, nonliving portion of the vascular system in plants that carries water and minerals from the roots to the rest of the plant.

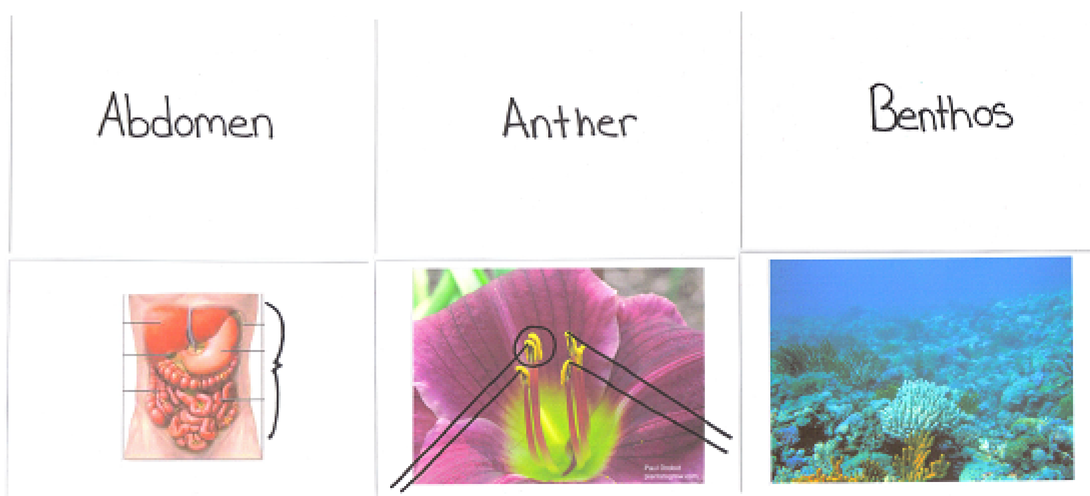
The xylem is a nonliving part of a plant, but is important because it carries water and minerals up from the roots to the rest of the plant.

Appendix E
Picture Card Samples

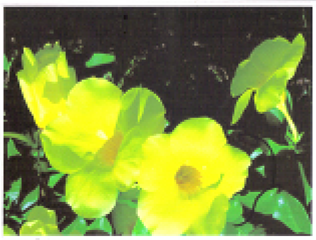
Test card



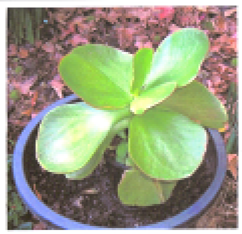
Biology Vocabulary Words



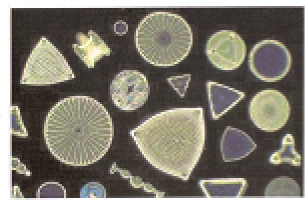
Corolla



Cotyledon

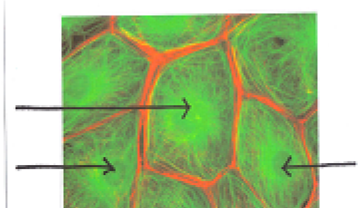


Diatom



Erythrocyte

Microtubules

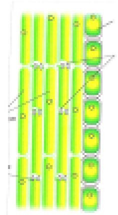


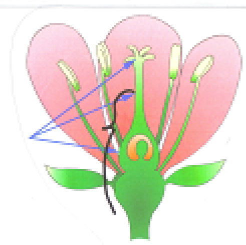
Petiole

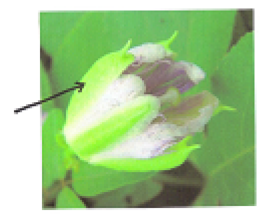
Phloem

Pistil

Sepals



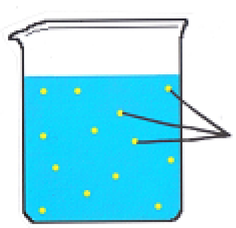


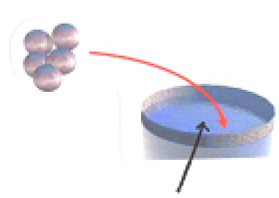


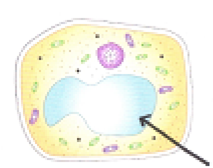
Solute

Solvent

Vacuole







Appendix F
Demographic Information Form

Number:________

Demographic Information

Directions: Check the box that best describes you. If you check "other," please write in your answer.

1. **What is your age?**

☐ 8.5

☐ 9

☐ 9.5

☐ 10

☐ 10.5

☐ 11

☐ Other ________________

2. **What is your gender?**

☐ Male

☐ Female

3. **How would you classify yourself?**

☐ Caucasian/ White

☐ African American

☐ Hispanic

☐ Asian

☐ Native American

☐ Other ________________

4. What was the first language you learned?

☐ English

☐ Spanish

☐ Chinese

☐ Korean

☐ Japanese

☐ Russian

☐ Other ___________________

5. What language(s) do you speak at home? (Check all that apply.)

☐ English

☐ Spanish

☐ Chinese

☐ Korean

☐ Japanese

☐ Russian

☐ Other ___________________

6. How many <u>older</u> brothers or sisters do you have?

☐ 0

☐ 1

☐ 2

☐ 3

☐ Other ___________________

7. How many <u>younger</u> brothers or sisters do you have?

☐ 0

☐ 1

☐ 2

☐ 3

☐ Other ___________________

Appendix G
Biology Vocabulary Pretest

Number:________

<u>**Vocabulary Pretest: Biology Vocabulary**</u>

<u>Directions:</u> Check the box next to the best definition for each word. Check the box “Not sure/ Do not remember” if you do not know or do not remember the definition. <u>Your scores on the test cannot be traced back to you and will not count against you.</u> Please do not guess.

**These are very difficult words, which most fifth graders do not know. Do not worry if you do not know them.

Petiole:

☐ The pollen sac, inside which pollen grains form in the flower of flowering plants.

☐ Petals, which are usually colored flower parts.

☐ The stalk of a leaf, which joins the leaf to the stem.

☐ Not sure/Do not remember.

Mitochondria:

☐ Membrane-bound sac that stores food and waste; cell’s warehouse.

☐ Organelle in cell that serves as the site of cellular respiration; “powerhouse” of cell.

☐ Part of cell where proteins are made.

☐ Not sure/Do not remember.

Solvent:

☐ A liquid mixture of two or more substances.

☐ The dissolving agent of a solution.

☐ A substance that is dissolved in a solution.

☐ Not sure/Do not remember.

Benthos:

☐ Microscopic one-celled algae.

☐ The region that includes the bottom of a lake, sea, or ocean.

☐ A vascular plant.

☐ Not sure/Do not remember.

Stamen:

☐ The female reproductive organ of a flower which contains the seeds.

☐ Modified leaves in flowering plants that enclose and protect the flower bud before it opens.

☐ The pollen-producing male reproductive organ of a flower.

☐ Not sure/Do not remember.

Vacuole:

☐ Membrane-bound sac that stores food and waste; cell's warehouse.

☐ Organelle in cell that serves as the site of cellular respiration; "powerhouse" of cell

☐ Part of cell where proteins are made.

☐ Not sure/Do not remember.

Sepals:

☐ A flowering plant, which forms seeds inside a protective chamber.

☐ The pollen-producing male reproductive organ of a flower.

☐ Modified leaves in flowering plants that enclose and protect the flower bud before it opens.

☐ Not sure/Do not remember.

Solute:

☐ A substance that is dissolved in a solution.

☐ The dissolving agent of a solution.

☐ A homogeneous, liquid mixture of two or more substances.

☐ Not sure/Do not remember.

Phloem:

☐ The portion of the vascular system in plants consisting of living cells arranged into elongated tubes that transport sugar and other organic nutrients throughout the plant.

☐ The tube-shaped, nonliving portion of the vascular system in plants that carries water and minerals from the roots to the rest of the plant.

☐ The one or two seed leaves of the embryo of a flowering plant.

☐ Not sure/Do not remember.

Conifer:

☐ A cone of cells at the tip of a plant root that protects it.

☐ Collectively, the sepals of a flower, which are the tiny green leaves.

☐ A plant whose reproductive structure is the cone, and includes firs, redwoods, and other large trees.

☐ Not sure/Do not remember.

Corolla:

☐ Petals, which are usually colored flower parts.

☐ The pollen sac, inside which pollen grains form in the flower of flowering plants.

☐ The stalk of a leaf, which joins the leaf to the stem.

☐ Not sure/Do not remember.

Xylem:

☐ The tube-shaped, nonliving portion of the vascular system in plants that carries water and minerals from the roots to the rest of the plant.

☐ The one or two seed leaves of the embryo of a flowering plant.

☐ The portion of the vascular system in plants consisting of living cells arranged into elongated tubes that transport sugar and other organic nutrients throughout the plant.

☐ Not sure/Do not remember.

Abdomen:

☐ The inner layer of the skin.

☐ In mammals, the portion of the trunk containing internal organs other than the heart and lungs.

☐ A channel that conducts food from the back of the mouth to the stomach.

☐ Not sure/Do not remember.

Cotyledon:

☐ The portion of the vascular system in plants consisting of living cells arranged into elongated tubes that transport sugar and other organic nutrients throughout the plant.

☐ The one or two seed leaves of the embryo of a flowering plant.

☐ The tube-shaped, nonliving portion of the vascular system in plants that carries water and minerals from the roots to the rest of the plant.

☐ Not sure/Do not remember.

Nucleus:

☐ Spherical organelle bounded by a membrane; cell's brain.

☐ Hollow cylinders that support and shape cells.

☐ Jellylike substance within a cell.

☐ Not sure/Do not remember.

Pistil:

☐ Modified leaves in flowering plants that enclose and protect the flower bud before it opens.

☐ The pollen-producing male reproductive organ of a flower.

☐ The female reproductive organ of a flower which contains the seeds.

☐ Not sure/Do not remember.

Cell membrane:

☐ Double membrane across the midline of a dividing plant cell.

☐ Protective layer external to the plasma membrane in plant cells, bacteria, and fungi that shapes and supports the cell.

☐ Outer membrane of the cell that selects what enters and exits the cell; traffic cop of cell.

☐ Not sure/Do not remember.

Erythrocyte:

☐ A spherical body within the nucleus, active in the creation of ribosomes.

☐ A red blood cell; which functions in transporting oxygen in the circulatory system.

☐ A membrane-enclosed bag of enzymes found in the cytoplasm of certain cells; digestion center.

☐ Not sure/Do not remember.

Microtubules:

☐ Spherical organelle bounded by a membrane; cell's brain.

☐ Hollow cylinders that support and shape cells.

☐ Jellylike substance within a cell.

☐ Not sure/Do not remember.

Root cap:

☐ Collectively, the sepals of a flower, which are the tiny green leaves.

☐ A plant whose reproductive structure is the cone, and includes pines, firs, redwoods, and other large trees.

☐ A cone of cells at the tip of a plant root that protects it.

☐ Not sure/Do not remember.

Anther:

☐ Petals, which are usually colored flower parts.

☐ The pollen sac, inside which pollen grains form in the flower of flowering plants.

☐ The stalk of a leaf, which joins the leaf to the stem.

☐ Not sure/Do not remember.

Cytoplasm:

☐ Jellylike substance within a cell.

☐ Spherical organelle bounded by a membrane; cell's brain.

☐ Hollow cylinders that support and shape cells.

☐ Not sure/Do not remember.

Esophagus:

☐ In mammals, the portion of the trunk containing internal organs other than the heart and lungs.

☐ A channel that conducts food from the back of the mouth to the stomach.

☐ The inner layer of the skin.

☐ Not sure/Do not remember.

Lysosome:

☐ A spherical body within the nucleus, active in the creation of ribosomes.

☐ A membrane-enclosed bag of enzymes found in the cytoplasm of certain cells; digestion center.

☐ A red blood cell; which functions in transporting oxygen in the circulatory system.

☐ Not sure/Do not remember.

Diatom:

☐ Microscopic one-celled algae.

☐ The region that includes the bottom of a lake, sea, or ocean.

☐ A vascular plant.

☐ Not sure/Do not remember.

Appendix H
Training Condition Scripts

The researcher followed the script of the intervention that each group was assigned to. The students were informed that they would be working with vocabulary words and to follow the directions presented.

Word Only intervention:

We are going to be working with vocabulary today. I am going to give you some vocabulary words and I want you to try and learn them. It will be an exciting way for you to see how good your memory is. Don't worry; this will not count as part of your class grade. We are going to practice first with a word I am sure you all know very well: dog.

Here is the word dog. See dog. Now I will say the word: dog. I will now use it in a sentence. My friend Dan just got a cute, furry dog. Now I will give you the definition of the word. A dog is a domestic animal related to a wolf (Merriam-Webster's collegiate dictionary, 1996). Here is the word written on an index card again. I will now say this word one more time: dog. The point of this is to remember what the vocabulary word means. We are now going to try this with some new, challenging science vocabulary words that many of you will not know. Remember- this will not count as part of your class grade, but I want you to try and remember the definitions of the words.

Picture Presentation intervention:

We are going to be working with vocabulary today. I am going to give you some vocabulary words with pictures and I want you to try and learn them. It will be an exciting way for you to see how good your memory is. Don't worry; this will not count as part of your class grade. We are going to practice first with a word I am sure you all know very well: dog.

Here is the word dog written on an index card. See dog. Now I will say the word: dog. I will now use it in a sentence. My friend Dan just got a cute, furry dog. Now I will give you a definition of the word. A dog is a domestic animal related to a wolf (Merriam-Webster's collegiate dictionary, 1996). Here is the word written on an index card again. Now I will show you a picture of a dog. The point of this is to remember what the vocabulary word means. We are now going to try this with some new, challenging science vocabulary words that many of you will not know. Remember- this will not count as part of your class grade, but I want you to try and remember the definitions of the words.

Image Creation- No Picture intervention:

We are going to be working with vocabulary today. I am going to give you some vocabulary words, then you are going to draw pictures of them, and I want you to try and learn them. It will be an exciting way for you to see how good your memory is. Don't worry; this will not count as part of your class grade. We are going to practice first with a word I am sure you all know very well: dog.

Here is the word dog written on an index card. See dog. Now I will say the word: dog. I will now use it in a sentence. My friend Dan just got a cute, furry dog. Now I will give you a definition of the word. A dog is a domestic animal related to a wolf (Merriam-Webster's collegiate dictionary, 1996). Here is the word written on the index card again. Now I want you to think of an image of a dog in your head. Once you have come up with a good picture, draw it on this piece of paper. The point of this is to remember what the vocabulary word means. We are now going to try this with some new, challenging science vocabulary words that many of you will not know. Remember- this will not count as part of your class grade, but I want you to try and remember the definitions of the words.

Image Creation- Picture intervention:

We are going to be working with vocabulary today. I am going to give you some vocabulary words and show you pictures of them. Then you are going to draw pictures of them, and I want you to try and learn them. It will be an exciting way for you to see how good your memory is. Don't worry; this will not count as part of your class grade. We are going to practice first with a word I am sure you all know very well: dog.

Here is the word dog written on an index card. See dog. Now I will say the word: dog. I will now use it in a sentence. My friend Dan just got a cute, furry dog. Now I will give you a definition of the word. A dog is a domestic animal related to a wolf (Merriam-Webster's collegiate dictionary, 1996). Here is a picture of the word dog. Now I want you to think of an image of the word dog in your head and draw it on a piece of paper. The point of this is to remember what the vocabulary word means. We are now going to try this with some new, challenging science vocabulary words that many of you will not know. Remember- this will not count as part of your class grade, but I want you to try and remember the definitions of the words.

Appendix I
Immediate and Delayed Recall Word Fill-In Tasks

Number:________

Biology Fill-In: Immediate Recall

Directions: Please read each statement carefully. Select the word from the parentheses that best completes the statement and write it on the line. Some sentences have more than one blank. Each word can only be used once. If you do not know the answer, please leave the space blank.

1. The first grade students planted lima bean plants with their teachers. After a couple of days, they noticed that a __________ (**cotyledon/ pistil**) had sprouted from the soil.

2. The girl ripped the leaf right at the __________ (**erythrocyte/ petiole**), separating it from the stem.

3. The __________ (**phloem/ benthos**) is important for plants, as it consists of the cells that send nutrients throughout the plant, keeping it alive and healthy.

4. When I create a solution of salt water, the __________ (**solute/ solvent**) is the salt.

5. I was surprised that the __________, (**sepals/ anthers**) which protect the flower bud before it opens give way to the beautiful red __________ (**corolla/ conifer**) of the flower.

6. The researcher collected a sample of water from the ___________ (**vacuole/ benthos**) region of the lake. When she examined the sample under a microscope, she saw that the water contained ___________ (**diatoms/ sepals**), which were too small for the naked eye to see.

7. In order to find out why the girl had such severe pain in her ___________, (**abdomen/ vacuole**) the doctor took a sample of ___________ (**diatoms/ erythrocytes**) to examine them for infection.

Answer Key:

1. Cotyledon
2. Petiole
3. Phloem
4. Solute
5. Sepals; corolla
6. Benthos; diatoms
7. Abdomen; erythrocytes

Number:________

Biology Fill-In: Delayed Recall

Directions: Please read each statement carefully. Select the word from the parentheses that best completes the statement and write it on the line. Some sentences have more than one blank. Each word can only be used once. If you do not know the answer, please leave the space blank.

1. The new doctor checked the patient's __________ (**abdomen/ vacuole**), and asked if she felt any pain. He also took a sample of __________ (**diatoms/ erythrocytes**) to send to the lab for tests.

2. The __________ (**cotyledon/ pistil**) is typically the first portion of the plant to sprout from the soil.

3. The chemist dissolved the __________ (**solute/ solvent**) into the liquid, making a solution.

4. If you were to remove the __________ (**phloem/ benthos**) from a plant, it would have no way to move nutrients around.

5. There is a big difference in color between the dark green __________, (**sepals/ anthers**) which protect the flower bud before it opens and the bright yellow __________(**corolla/ conifer**) of the flower once it blooms.

6. The __________ (**erythrocyte/ petiole**) which attaches the leaf to the stem of the flower is the same beautiful bright green color as the leaf.

7. The ___________ (**vacuole/ benthos**) region of a lake is often very cold because it is all the way at the bottom. Many creatures will not survive at this temperature; however ___________ (**diatoms/ sepals**) can be found here, which are microscopic one-celled algae.

Answer Key:

1. Abdomen: Erythrocytes
2. Cotyledon
3. Solute
4. Phloem
5. Sepals; corolla
6. Petiole
7. Benthos; diatoms

Appendix J
Immediate and Delayed Recall Word Match tasks

Number:________

Biology Definition Word Match: Immediate Recall

Directions: Match each word to its definition by writing the letter of the definition in the space provided next to the vocabulary word. Each letter can only be used once.

Match 1

1. ___ Solvent
2. ___ Erythrocyte
3. ___ Abdomen
4. ___ Cotyledon
5. ___ Anther

A. The dissolving agent of a solution.

B. The one or two seed leaves of the embryo of a flowering plant.

C. In mammals, the portion of the trunk containing internal organs other than the heart and lungs.

D. A red blood cell; which functions in transporting oxygen in the circulatory system.

E. The pollen sac, inside which pollen grains form in the flower of flowering plants.

Match 2

1. ___ Sepals
2. ___ Pistil
3. ___ Solute
4. ___ Phloem
5. ___ Petiole

A. The stalk of a leaf, which joins the leaf to the stem.

B. The female reproductive organ of a flower which contains the seeds.

C. The portion of the vascular system in plants consisting of living cells arranged into elongated tubes that transport sugar and other organic nutrients throughout the plant.

D. A substance that is dissolved in a solution.

E. Modified leaves in flowering plants that enclose and protect the flower bud before it opens.

Match 3

1. ___ Diatom	A. The region that includes the bottom of a lake, sea, or ocean.
2. ___ Vacuole	B. Petals, which are usually colored flower parts.
3. ___ Microtubules	C. Microscopic one-celled algae.
4. ___ Corolla	D. Hollow cylinders that support and shape cells.
5. ___ Benthos	E. Membrane-bound sac that stores food and waste; cell's warehouse.

Answer Key:

Match 1

1. A
2. D
3. C
4. B
5. E

Match 2

1. E
2. B
3. D
4. C
5. A

Match 3

1. C
2. E
3. D
4. B
5. A

Number:________

Biology Definition Word Match: Delayed Recall

Directions: Match each word to its definition by writing the letter of the definition in the space provided next to the vocabulary word. Each letter can only be used once.

Match 1

1. ___ Diatom
2. ___ Abdomen
3. ___ Corolla
4. ___ Benthos
5. ___ Solute

A. A substance that is dissolved in a solution.

B. Petals, which are usually colored flower parts.

C. The region that includes the bottom of a lake, sea, or ocean.

D. Microscopic one-celled algae.

E. In mammals, the portion of the trunk containing internal organs other than the heart and lungs.

Match 2

1. ___ Petiole
2. ___ Phloem
3. ___ Sepals
4. ___ Cotyledon
5. ___ Erythrocyte

A. A red blood cell; which functions in transporting oxygen in the circulatory system.

B. The stalk of a leaf, which joins the leaf to the stem.

C. The one or two seed leaves of the embryo of a flowering plant.

D. The portion of the vascular system in plants consisting of living cells arranged into elongated tubes that transport sugar and other organic nutrients throughout the plant.

E. Modified leaves in flowering plants that enclose and protect the flower bud before it opens.

Match 3

1. ___ Microtubules
2. ___ Anther
3. ___ Pistil
4. ___ Solvent
5. ___ Vacuole

A. Hollow cylinders that support and shape cells.

B. The pollen sac, inside which pollen grains form in the flower of flowering plants.

C. Membrane-bound sac that stores food and waste; cell's warehouse.

D. The female reproductive organ of a flower which contains the seeds.

E. The dissolving agent of a solution.

Answer Key:

Match 1

1. D
2. E
3. B
4. C
5. A

Match 2

1. B
2. D
3. E
4. C
5. A

Match 3

1. A
2. B
3. D
4. E
5. C

Appendix K
Vocabulary Learning Evaluations

Number:________

Vocabulary Learning Evaluation

Directions: Check the box that best describes your feelings about your vocabulary learning experience.

1. I was able to learn the vocabulary words.

☐ Completely agree

☐ Somewhat agree

☐ Somewhat disagree

☐ Completely disagree

2. I was able to remember the vocabulary words.

☐ Completely agree

☐ Somewhat agree

☐ Somewhat disagree

☐ Completely disagree

3. The method that was demonstrated to me was useful for helping me learn the words.

☐ Completely agree

☐ Somewhat agree

☐ Somewhat disagree

☐ Completely disagree

4. The method that was demonstrated to me was fun.

☐ Completely agree

☐ Somewhat agree

☐ Somewhat disagree

☐ Completely disagree

5. I used other methods on my own to help me remember the vocabulary words.

☐ Yes

☐ No

6. If you answered YES to question 5, please list the methods you used below and explain them.

____

____

____

____

____

____

____

____

Appendix L
Student Discussion Questions

1) Did you like the vocabulary learning method we used?
2) Did you think the vocabulary learning method was fun?
3) Do you think you will remember these words?
4) How did you remember the words? What did I tell you to do?
5) Did you use any other specific method? Did you do anything else to remember the words?
6) What else may help you remember these words?
7) **(If in the Word Only or Image Creation- No Picture presentation):** Did you have trouble visualizing the meaning of the word? If so, what may have helped you?

Appendix M
PPVT Data

Participant #	School	Class #	Gender	Chronological Age (in months)	PPVT age equivalent (in months)	PPVT Grade equivalent
1	RVC	2	F	126	145	6.1
2	RVC	2	M	120	143	6
3	RVC	2	F	126	131	5.1
4	RVC	2	M	126	157	7
5	RVC	2	F	120	133	5.3
6	RVC	2	M	120	166	8
7	RVC	2	F	126	136	5.5
8	RVC	2	F	120	133	5.3
9	RVC	2	M	120	147	6.3
11	RVC	2	F	126	157	7
13	RVC	2	M	120	123	4.7
14	RVC	2	F	120	129	5
16	RVC	2	M	126	112	3.7
17	RVC	2	F	114	127	4.9
18	RVC	2	F	120	121	4.5
19	RVC	2	M	120	129	5
20	RVC	2	M	120	149	6.4
21	RVC	2	F	126	129	5
22	RVC	2	F	120	138	5.6
23	RVC	2	F	132	122	4.6
24	RVC	2	F	120	133	5.3
25	RVC	2	M	120	161	7.3
26	RVC	1	M	126	166	8
27	RVC	1	F	126	131	5.1
28	RVC	1	M	120	152	6.5
30	RVC	1	F	120	147	6.3
31	RVC	1	M	120	147	6.3
32	RVC	1	F	120	129	5
33	RVC	1	M	120	138	5.6
34	RVC	1	M	120	125	4.8
35	RVC	1	M	126	127	4.9
36	RVC	1	M	108	157	7
37	RVC	1	F	138	122	4.6
38	RVC	1	M	132	118	4.3
39	RVC	1	F	120	157	7
40	RVC	1	M	126	129	5
41	RVC	1	F	114	122	4.6
42	RVC	1	F	126	135	5.4
43	RVC	1	M	120	188	9.8
44	RVC	1	F	126	149	6.4
45	RVC	1	F	120	129	5
46	RVC	1	F	120	159	7.2
47	RVC	1	M	126	145	6.1
48	RVC	1	F	126	152	6.5
49	RVC	1	M	120	147	6.3
50	RVC	1	M	132	141	5.9
51	LB	5	F	120	155	6.8
52	LB	5	F	120	118	4.3
53	LB	5	M	120	145	6.1

54	LB	5	F	126	131	5.1
55	LB	5	M	114	121	4.5
57	LB	5	F	126	157	7
58	LB	5	M	120	121	4.5
59	LB	5	M	120	136	5.5
60	LB	5	F	126	135	5.4
61	LB	5	F	126	106	3.4
62	LB	5	F	126	127	4.9
63	LB	5	F	120	131	5.1
64	LB	5	F	132	115	4
65	LB	5	M	126	136	5.5
66	LB	5	M	120	105	3.2
67	LB	5	M	126	157	7
68	LB	4	M	120	141	5.9
69	LB	4	F	120	155	6.8
70	LB	4	F	114	147	6.3
71	LB	4	F	114	115	4
72	LB	4	M	126	167	8.2
73	LB	4	M	120	123	4.7
74	LB	4	M	120	129	5
75	LB	4	F	120	119	4.4
76	LB	4	F	114	135	5.4
77	LB	4	M	126	129	5
79	LB	4	M	120	122	4.6
81	LB	4	M	120	149	6.4
82	LB	4	M	120	118	4.3
83	LB	4	M	120	145	6.1
84	LB	3	F	120	127	4.9
85	LB	3	M	108	109	3.5
86	LB	3	M	120	139	5.8
87	LB	3	F	120	139	5.8
88	LB	3	M	120	157	7
89	LB	3	F	126	114	3.9
90	LB	3	M	120	112	3.7
91	LB	3	F	126	127	4.9
95	LB	3	M	126	122	4.6
96	LB	3	F	126	139	5.8
97	LB	3	M	132	106	3.4
98	LB	3	M	114	125	4.8
99	LB	4	F	126	127	4.9

Appendix N
Students' Answers on the Vocabulary Learning Evaluation

Intervention	Class Number	Participant Number	Comment on Question 6
Picture Presentation	2	4	• Work with dad • TV show • School • Just knew
Picture Presentation	2	18	• I wrote it down a few times. • I do these packets.
Picture Presentation	4	70	If I knew the answer to one question and one of the choices was a choice on another question, I knew the answer to the other question.
Picture Presentation	4	72	I would read worksheets over. I would make up rhymes like corolla color corolla color. I would repeet words over in my head.
Image Creation-No Picture	3	96	I have to repeate the words over and over again.
Image Creation-Picture	1	30	One method I used is the words I pay most attention to were the easyest.
Image Creation-Picture	1	37	I guest because I didn't remember them.

Image Creation-Picture	2	5	Really I just used pictures to help me remember. Especially for Benthos. That is the method that I use.
Image Creation-Picture	4	75	The picuter you shoewed helped me rember because if I look back at the picture I might know what it is.
Image Creation-Picture	4	82	I remembered a lot of them, usually there were not that much of answers I did not remember. If I did not understand the word I guessed.
Image Creation-Picture	4	83	One way was by saying what makes scens and the other was by thinking what to ask.
Image Creation-Picture	5	64	I thinked. I thout of the ahef of the words.

* All comments are copied in their original form.

Appendix O

Students' Answers to the Discussion Questions

Rockville Centre
Class #1
Word Only Group

	#39	#47
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	Yes	No, not that long.
4. How did you remember the words? What did I tell you to do?	You gave us the word and the definition.	You also gave us an example.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	No
6. What else may help you remember these words?	I am not sure.	Nothing.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	Not really.	Some of the words were hard to picture. It would have been helpful if you gave us a picture.

Rockville Centre
Class #1
Picture Presentation Group

	#38	#45
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	No	Yes. I liked the ones with the pictures.
3. Do you think you will remember these words?	Yes	Yes, but some you will forget.
4. How did you remember the words? What did I tell you to do?	I remembered the definitions after I saw the pictures.	When I saw the words I thought of the pictures.
5. Did you use any other specific method? Did you do anything else to remember the words?	No, I just kept the picture in my head.	The pictures reminded me of things. The color of a flower is the corolla. The benthos is at the bottom.
6. What else may help you remember these words?	You should have given us a flower to remember the flower parts. I could have seen a corolla.	It would be helpful if you gave us something that tested the word.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Rockville Centre
Class #1
Image Creation- No Picture Group

	#33	#36
1. Did you like the vocabulary learning method we used?	Yes- I somewhat agree.	Yes
2. Did you think the vocabulary learning method was fun?	Yes- I somewhat agree.	Yes
3. Do you think you will remember these words?	Yes- I somewhat agree.	Yes
4. How did you remember the words? What did I tell you to do?	You gave us the word and the definition and then you made us draw the picture.	You gave us the word and the definition and then we colored.
5. Did you use any other specific method? Did you do anything else to remember the words?	No, no method.	No
6. What else may help you remember these words?	Not really, but if you gave us a picture that could have helped.	I needed a picture.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	A little bit.	Yes- a picture would have helped me.

Rockville Centre
Class #1
Image Creation- Picture Group

	#27	#42
1. Did you like the vocabulary learning method we used?	Yes- I somewhat agree.	Yes
2. Did you think the vocabulary learning method was fun?	Yea- I could use more words that my friends will be like "What the heck are you saying?"	Yes
3. Do you think you will remember these words?	Yes- somewhat.	Maybe
4. How did you remember the words? What did I tell you to do?	We got to draw our own picture and we saw one which helped us to see what it is.	You gave us the word, the definition, a picture, and we got to make our own picture.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	No
6. What else may help you remember these words?	We could go over them once in a while and write the words in our books.	Maybe we could look in the dictionary. We could also write it, study it, and remember it.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Rockville Centre
Class #2
Word Only Group

	#2	#23
1. Did you like the vocabulary learning method we used?	Yes. It was a little easy for me, because I knew most of the words.	No
2. Did you think the vocabulary learning method was fun?	The way you did it was fun, because most people would just bore students to death learning these words.	Yes
3. Do you think you will remember these words?	Yes- I remember some.	No
4. How did you remember the words? What did I tell you to do?	You gave us a word and then you asked us what they meant.	You gave us the word and a sentence to remember it.
5. Did you use any other specific method? Did you do anything else to remember the words?	I made pictures in my head which matched the words.	No
6. What else may help you remember these words?	If you can remember the picture.	If we had candy.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	Yes. That is why I made a picture in my head.	Yes

Rockville Centre
Class #2
Picture Presentation Group

	#9	**#18**
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	No	No- they are hard.
4. How did you remember the words? What did I tell you to do?	I used the photograph.	You gave us a picture and a definition, like benthos is the bottom of an ocean or lake.
5. Did you use any other specific method? Did you do anything else to remember the words?	No, just a picture.	No
6. What else may help you remember these words?	I don't know.	No
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Rockville Centre
Class #2
Image Creation- No Picture Group

	#13	#21
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	No	No, not really.
3. Do you think you will remember these words?	No, not many.	No, not really.
4. How did you remember the words? What did I tell you to do?	We had to draw a picture of what we thought the words were.	You had us fill in the blank and connect the words to the definitions on paper. You also gave us the word, definitions, and crayons in order to draw the picture.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	No
6. What else may help you remember these words?	I just remember them once for a test and then forget them. I also remember easy words.	Writing words down helps me.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	No	No

Rockville Centre
Class #2
Image Creation- Picture Group

	#8	#19
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	Yes, kind of.	Maybe
4. How did you remember the words? What did I tell you to do?	We used the pictures we saw and drew to remember them.	We used pictures and colored like with the red blood cells.
5. Did you use any other specific method? Did you do anything else to remember the words?	I used my memory.	I just used the pictures.
6. What else may help you remember these words?	We could keep studying them or play some games.	Mostly studying and using our memories.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Long Beach
Class #3
Word Only Group

	#84	#91
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	No- too hard.	Yes- some of them. It was very hard.
4. How did you remember the words? What did I tell you to do?	You gave us the word and we had the definition.	You gave us the meaning.
5. Did you use any other specific method? Did you do anything else to remember the words?	I studied them in my head.	No
6. What else may help you remember these words?	I can take a paper and then you ask someone to tell you the word and then I spell it.	You can cut up the words into their parts to help you memorize them.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	Yes	Not really, because I have good pictures in my head.

Long Beach
Class #3
Picture Presentation Group

	#85	#86
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	So/so
3. Do you think you will remember these words?	No, the words were really hard.	Yes, some of them.
4. How did you remember the words? What did I tell you to do?	You showed us the words and sounded them out and gave us a picture.	You gave us the words and pictures. You also gave us the definitions and sheets to fill out later.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	I just tried to think of them in my head and then I remembered the ones that I knew.
6. What else may help you remember these words?	You can keep saying it and sounding them out.	The pictures can help. You can also study the definitions.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Long Beach
Class #3
Image Creation- No Picture Group

	#88	**#96**
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	In between.	Yes
3. Do you think you will remember these words?	Yes, but if not then it was because the words were too hard.	I don’t know. It’s not hard, but there are a lot of words.
4. How did you remember the words? What did I tell you to do?	You gave us the word and then I don’t remember.	You told us to draw out the words, but there were a lot of words- 15.
5. Did you use any other specific method? Did you do anything else to remember the words?	I usually look for words inside of the word and try to remember those.	No
6. What else may help you remember these words?	Thinking of the first letter.	I repeat things a lot. Or, if I see the picture, I keep it in my head like with the other thing we did with the four pictures. That was much easier.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	I was able to picture the word in my head.	Yes- I needed the picture to see what I needed to think of.

Long Beach
Class #3
Image Creation- Picture Group

	#90	#97
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	No, not really.	Yes
3. Do you think you will remember these words?	Yes, some of them.	Yes, but they are really big words.
4. How did you remember the words? What did I tell you to do?	You gave us the word and we drew a picture of it and we did sheets.	You gave us the words and the sheets to fill in to see what they are. We also drew some pictures.
5. Did you use any other specific method? Did you do anything else to remember the words?	If they were similar to a word, I thought of that word.	Last year we learned about the pistil and stuff, so the flower words were easy for me.
6. What else may help you remember these words?	It would help to see them a lot.	Making a picture really helped.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Long Beach
Class #4
Word Only Group

	#68	#69
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	No	No
3. Do you think you will remember these words?	No- they are hard.	No- too many.
4. How did you remember the words? What did I tell you to do?	You gave us the word and the definition.	You gave us a word and a sentence using the word.
5. Did you use any other specific method? Did you do anything else to remember the words?	Nope- I just thought of them.	Not really.
6. What else may help you remember these words?	Not sure.	It helps to have a sentence.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	It was hard to think of what the word was.	Not really.

Long Beach
Class #4
Picture Presentation Group

	#70	#72
1. Did you like the vocabulary learning method we used?	Yes- kinda.	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	Yes some of them. Some of them have to do with the same topic so they are harder because they are all too similar.	Yes, I remember some of them already.
4. How did you remember the words? What did I tell you to do?	You gave us the picture of the word and read the definition.	You gave us the word and a paper. You also showed us a picture and explained a bit about it.
5. Did you use any other specific method? Did you do anything else to remember the words?	I just used what you gave me.	No
6. What else may help you remember these words?	I like to write down the information, because it helps me remember better.	I look in a textbook. I think of the base word too.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Long Beach
Class #4
Image Creation- No Picture Group

	#76	#77
1. Did you like the vocabulary learning method we used?	Yes, well so/so.	Yes
2. Did you think the vocabulary learning method was fun?	No, not really.	Yes kinda.
3. Do you think you will remember these words?	No, because there were so many words that I can't remember them.	No, because I don't remember them now. I only remember two words.
4. How did you remember the words? What did I tell you to do?	There was a word, a definition, and you had to draw a picture.	We had a word and we drew pictures. We also answered questions about them later.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	No
6. What else may help you remember these words?	Our teacher sometimes makes up a game. You need to move words to the item in the game.	I just try to remember them.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	No	A couple of the words were hard to come up with. Those are the words that I don't think I can remember.

Long Beach
Class #4
Image Creation- Picture Group

	#71	#75
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	No, because the words were probably from eighth grade.	No, because they are really hard and I'm not good at remembering them. I also don't have anything to memorize them on.
4. How did you remember the words? What did I tell you to do?	We saw the word and we would have to draw them.	There was a word, a picture, an example, and we drew.
5. Did you use any other specific method? Did you do anything else to remember the words?	I used what you gave me.	No
6. What else may help you remember these words?	If I memorize them by looking at them a lot.	If we keep index cards with the definitions.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Long Beach
Class #5
Word Only Group

	#51	#62
1. Did you like the vocabulary learning method we used?	Yes	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	No- some were hard.	No- too many words.
4. How did you remember the words? What did I tell you to do?	We got the word and the definition.	You gave us the words and a paper to fill out.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	I remembered the three first words really good and then it got too much.
6. What else may help you remember these words?	Nothing- I really never study vocabulary. I just say that I study.	Reading them over and over.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	Some of them.	Yes- I had trouble.

Long Beach
Class #5
Picture Presentation Group

	#52	#67
1. Did you like the vocabulary learning method we used?	No, not really.	Yes
2. Did you think the vocabulary learning method was fun?	Yes	Yes
3. Do you think you will remember these words?	No- they were hard.	No- we did them too quickly.
4. How did you remember the words? What did I tell you to do?	You gave us the word and we saw a picture.	You gave us words and pictures.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	No
6. What else may help you remember these words?	I don’t know.	Say a definition and guess the word, like with a test.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Long Beach
Class #5
Image Creation- No Picture Group

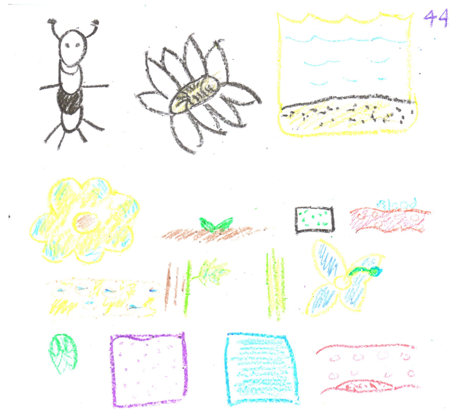
	#57	#60
1. Did you like the vocabulary learning method we used?	Yes – I kinda liked it.	No
2. Did you think the vocabulary learning method was fun?	No	Kinda, but not really
3. Do you think you will remember these words?	I don't know, they were kinda hard.	I think if I think about them I'll remember them again. I have a photographic memory and I shut my eyes and then I remember them.
4. How did you remember the words? What did I tell you to do?	You gave us a word and a little test.	You gave us the words and the two worksheets.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	I closed my eyes and then I saw the word and I think really hard to try to remember them.
6. What else may help you remember these words?	If I study it over and over again.	If you watch TV- but not really. Only if you watch the discovery channel.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	Yes- a picture would have helped.	No- I can think of the words in my head.

Long Beach
Class #5
Image Creation- Picture Group

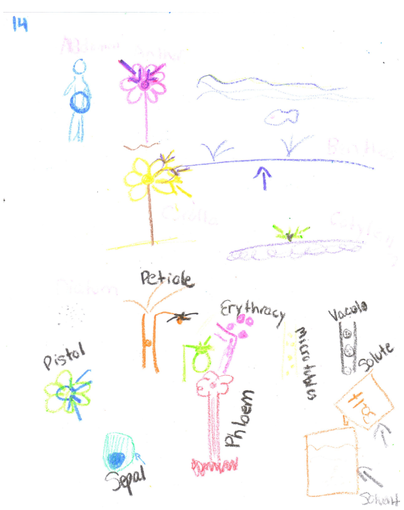
	#55	#61
1. Did you like the vocabulary learning method we used?	Yes- kinda.	Yes
2. Did you think the vocabulary learning method was fun?	Yes- a little.	Yes
3. Do you think you will remember these words?	Yes	Probably not- there was so many
4. How did you remember the words? What did I tell you to do?	You gave us the words and the pictures. Then we drew them.	You gave us the word and the definition and then we had to draw them.
5. Did you use any other specific method? Did you do anything else to remember the words?	No	Some of them I knew when you said them so I didn't have to do anything.
6. What else may help you remember these words?	Maybe practicing them a little.	Sometimes I quiz myself and sometimes my brother helps me as partners.
7. (If in the Word Only or Image Creation- No Picture presentation): Did you have trouble visualizing the meaning of the word? If so, what may have helped you?	N/A	N/A

Appendix P
Samples of Students Image Creation Drawings

Image Creation- No Picture Intervention



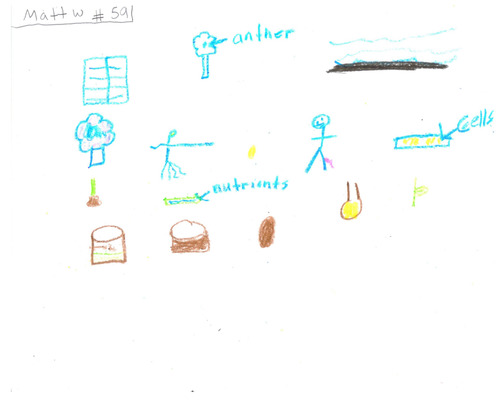
Class #1- Rockville Centre



Class #2- Rockville Centre

Class #3 – Long Beach

Class #4- Long Beach

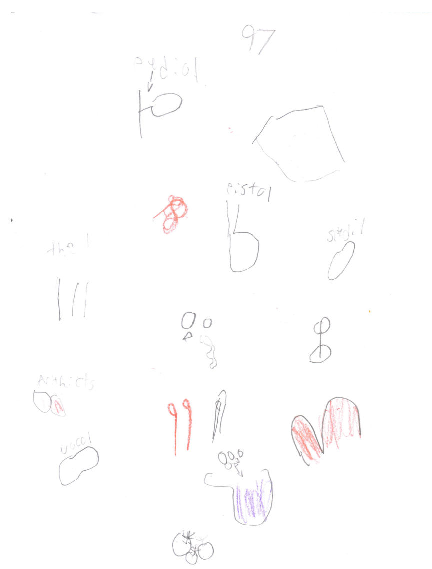


Class #5- Long Beach

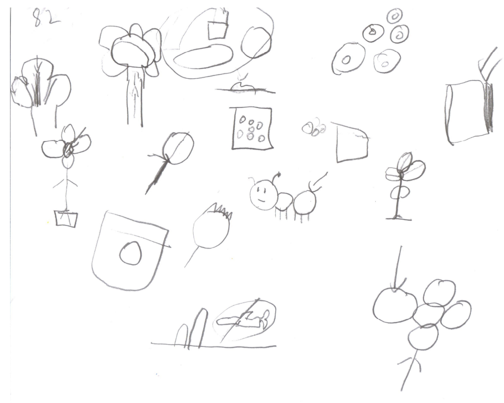
Image Creation- Picture Intervention

Class #1- Rockville Centre

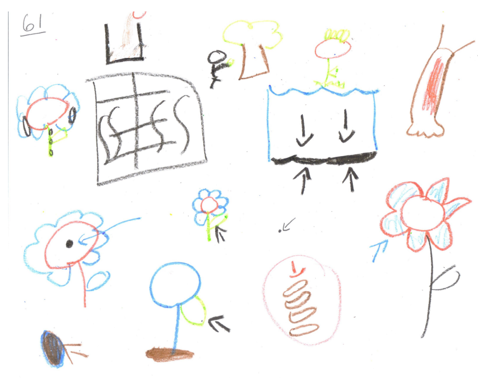
Class #2- Rockville Centre



Class #3- Long Beach



Class #4- Long Beach



Class #5- Long Beach

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