**Huntington University**

# THE EFFECT OF CONCEPT MAPPING ON SCIENCE VOCABULARY ACQUISTION AND RETENTION

By

[redacted]

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# INTRODUCTION

## Problem Statement and Contextual Rationale

Throughout my career as an English teacher, I have always appreciated the value of using vocabulary strategies to help students master unfamiliar vocabulary words. During my time as a middle school teacher, I used a vocabulary workbook along with multiple vocabulary strategies to help my students both learn and retain unfamiliar vocabulary. The strategies seemed to help my students' comprehension; however, the use of a vocabulary workbook made all vocabulary study out of context, which seemed to undermine the importance of learning new words.

This past year, I have been paired with a biology teacher in a new class entitled BioLit. This class combines Biology I with English 9 in a problem-based, one-to-one computer classroom. This pairing has provided excellent opportunity for the use of new vocabulary words in context, allowing our students to see the relevance of learning new words as they use them both in tests and quizzes and in completing authentic projects. However, in this new environment, I did not use the vocabulary strategies that I had used in the past. Adjusting to a wall-to-wall problem-based learning (PBL) environment and creating brand new curriculum that combined biology and English took over my time, and I did not pursue the use of any

vocabulary strategies to assist students in their learning and retention of unfamiliar biology vocabulary words.

At the end of the year, my team teacher and I began a short review unit in order to help our students prepare for the Biology ECA. It was during this time that it became evident that our students learned the biology vocabulary well enough to pass the tests and quizzes during the school year, but they did not fully understand or retain this knowledge. It is my hope that the use of a vocabulary notebook will show both short-term and long-term gains in students' success in *learning* (rather than just *memorizing*) unfamiliar biology vocabulary words.

In addition to improving students' understanding and retention of unfamiliar words in order to help them be more successful on the Biology ECA, I am also interested in implementing a vocabulary notebook as part of meeting the requirements of the new Common Core Standards. According to the Common Core State Standards Initiative (2010), Indiana has recently adopted the National Common Core Standards for English/Language Arts, Literacy and Mathematics. Superintendent of Public Instruction Dr. Tony Bennet stated that Indiana adopted this initiative in order to "ensure our students are held to the highest academic standard" (Indiana Depart of Education [IDOE], 2010). He then went on to state "while these common standards will serve as guidelines for success, it will be up to our outstanding educators to decide how best to deliver instruction to make sure our students receive an academically rigorous and globally competitive education" (IDOE, 2010).

The result of the switch to the Common Core Standards and my combination with a science class is a focus on content-area literacy. The Common Core Standards provide me with specific Reading Standards for Literacy in Science and Technical Subjects. This means that I now am responsible for teaching students not only my traditional English/Language Arts

Standards but must also focus on these new Reading Standards for Literacy in Science and Technical Subjects. One of these standards states that students need to be able to "determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics" (Common Core State Standards Initiative, 2010). As Dr. Bennet said, it is up to me as an "outstanding educator" to "decide how best to deliver instruction to make sure [my] students receive an academically rigorous and globally competitive education" (IDOE, 2010).

## Purpose of Action Research

The purpose of this action research project is to determine the effect of concept mapping on biology vocabulary acquisition and retention. The target group for this study will be freshmen BioLit students.

# LITERATURE REVIEW

## The Importance of Vocabulary Instruction in the Science Classroom

Up until about thirty years ago, teaching was not systematically studied in a scientific manner. It was not until the 1970's that scientists began to look at the effect of instructional methods on student learning (Marzano, Pickering, & Pollock, 2001). In recent times, the plethora of scientific research on education has changed teaching from an art to a science. Effective teaching today focuses on research-based pedagogy. Important aspects of that pedagogy are the curriculum that teachers choose to implement and instructional methods that teachers use (Marzano, et al., 2001). One part of the curriculum that is especially important in content areas is that of vocabulary development.

Vocabulary instruction is an integral part of building content knowledge. According to Burke (1999), having a deep understanding of a wide range of words and knowing how to use these words effectively can help students in many ways. First of all, a strong vocabulary provides a foundation that helps students read and comprehend challenging text that is present in many content-area textbooks (Burke, 1999). Secondly, a large vocabulary helps students

become better communicators by providing them with more precise and content-appropriate words to choose from. A focus on vocabulary instruction also raises students' scores on standardized tests such as the SAT and ECA assessments. Finally, vocabulary study can improve the quality of classroom discussion by creating a common, content-area-specific vocabulary that is shared by the teacher and class (Burke, 1999).

In her book *When Kids Can't Read: What Teachers Can Do*, Beers (2003) makes it clear that although it is true that a focused study of vocabulary in the content-area classroom is an important part of research-based pedagogy, traditional vocabulary instruction normally fails students. The basic structure of a traditional vocabulary lesson is the same in many schools: students are given a list of words on Monday, students study the words either on their own or through a workbook throughout the week, students are given a quiz on Friday, students forget the meaning of the words by Saturday morning. This method of teaching vocabulary, though quite popular, is ineffective because the words never enter the students' long-term memory, and, thus, are quickly forgotten (Beers, 2003).

Though traditional vocabulary instruction has proven to be ineffective, new methods of research-based strategies have emerged in recent years. These strategies usually have three characteristics in common according to Marzano (2004) in *Building Background Knowledge for Academic Achievement*. First of all, they do not rely on dictionary definitions of new words. Instead they focus on personal or class descriptions of concepts. Secondly these strategies use both linguistic and nonlinguistic ways of representing knowledge of word meaning. This dual coding of information makes the concepts learned more easily stored in permanent memory. Finally, research-based strategies rely heavily on multiple exposures of the new word so that

students can gradually shape the word meaning in a way that connects to their schemata (Marzano, 2004).

These strategies are especially important in content-area subjects—specifically science classrooms. In science classrooms, knowing content-specific words is crucial to understanding the text, which is often complex in nature. Cervetti and Hiebert (2011) state that scientific words are conceptually challenging because they are often unfamiliar and interrelated to other unknown terms in the text. In addition, academic gains in content-area knowledge are crucial in today's world. Recent studies cited by Daughterty and Merrill (2010) have shown that the United States' performance in the areas of science, technology, engineering, and mathematics (STEM) have placed our nation in risk of losing its edge in a world-wide competitive market, and students lacking STEM skills will not have the ability to enter in the 21st century jobs of tomorrow (Daughterty & Merrill, 2010). Therefore, effective vocabulary instruction in the science classroom must focus on terms that are important to the science content (Marzano, 2004). There can be no doubt that using research-based vocabulary strategies is an essential part of any science classroom.

## Effective Strategies to Support Student Vocabulary Development

Research has provided many effective strategies that support student vocabulary development in content-area classrooms. After much reading and sifting through this research, four methods surfaced in many different studies as proving especially beneficially to student learning. These methods are as follows: reading, nonlinguistic representation, comparison/contrast, and root words.

In her book *Words, Words, Words: Teaching Vocabulary in Grades 4-12*, Allen (1999) stated that it has been shown that "the amount of time spent reading was the best predictor of

vocabulary growth" (p. 21). Therefore, one of the most effective ways of developing vocabulary is through the reading that already happens in a strong literary program (Allen, 1999). This is especially true in a science classroom—in fact, a scientific document uses as many as 128 rare words per every 1,000 (compared to adult communication, which offers 17 rare words per 1,000 or television, which offers 22 rare words per 1,000) (Beers, 2003). This means that content-area reading offers students a chance to be exposed to many rare words every day. The Texas Education Agency (2000) states in their Reading Initiative that reading also allows students to use context clues to discover the meaning of unfamiliar words by connecting this word to the surrounding text. Though the complexity of science textbooks means that students are not always able to pick up the meaning of a new word in context, wide reading of scientific text exposes students to these new words multiple times, which does lead to vocabulary comprehension (The Texas Education Agency, 2000). Wide reading is most likely the most beneficial vocabulary strategy; however, when teaching specific vocabulary in a content area subject such as science, direct instruction is also necessary for maximum benefits (The Texas Education Agency, 2000).

A second method that has been proven to support students in vocabulary acquisition is that of using both linguistic and nonlinguistic methods to support student learning. The more we use both linguistic and nonlinguistic representation, the more we "are able to think about and recall knowledge" (Marzano, et al., 2001). When students represent information through visualization, they create stronger psychological systems for learning new information (Garner, 2007). In fact, in one study nonlinguistic strategies have an average gain of 34 percentile points (Marzano, 2004). Another study has shown that students who draw words remember them better and longer than those who use any other method (Burke, 1999). Having students engage

in creating nonlinguistic representations increases activity in the brain and allows students to see content in a new way (Marzano, et al., 2001).

Nonlinguistic methods come in many forms including graphic organizers, pictures, and pictographs (symbolic pictures) (Marzano, et al., 2001). Students who use graphic organizers that require them to work with the word multiple times remember more words than those who just memorize the definitions because graphic organizers help all students (especially dependent readers) organize information and see relationships between concepts (Beers, 2003). In addition, having students use pictures and pictographs allow students to become more engaged in creating their own meaning for the words, and the more engages students are, the more they learn (Garner, 2007). Finally drawing their own pictures and pictographs helps students draw from language and experiences that they are already familiar with and is, thus, more effective than memorizing dictionary definitions (The Texas Education Agency, 2000). Also, according to Holiday (2011) the complexity of scientific vocabulary lends itself well to nonlinguistic representation as can be seen in the heavy emphasis that science textbooks put on visuals in helping to communicate important concepts to students.

A third successful vocabulary-building strategy is that of comparison-contrast. When using a comparison-contrast method, students are asked to think of examples of a term as well as non-examples. Requiring students to provide similar ideas and examples helps them to make connections in what they are learning (The Texas Education Agency, 2000). As mentioned before, scientific text is often very interrelated and making these connections can be quite beneficial. Thinking of opposites or non-examples is also helpful to student learning because it forces students to think about the important elements of a word and requires critical thinking and creativity (Allen, 1999). Using comparison-contrast can also be highly effective if students

are allowed to use nonlinguistic answers as well as linguistic (Allen, 1999). For example, students can draw or cut out pictures of items that are similar or different to the concept they are studying.

The use of root words is the final research-based strategy for vocabulary instruction covered in this study. Focusing on bases, prefixes, and suffixes allows students to determine the meaning of the unknown words (Marzano, 2004). This breaking words into parts is an extremely valuable tool, especially in content-area subjects—however, many students do not know how to do this, which is why it is important to provide multiple lessons on the proper way to use root words to effectively decode unfamiliar vocabulary (The Texas Education Agency, 2000). One way of teaching this strategy is to show students the vocabulary word and definition, then break it into parts and show how the meaning of all the parts makes up the definition (The Texas Education Agency, 2000). Although this strategy is most beneficial with experienced readers, it can be adapted and used with readers at all levels (Marzano, 2004). Since many science words consist of Greek and Latin bases, this strategy can work well in a science classroom.

## Concept-Based Vocabulary Instruction

Traditional vocabulary instruction teaches new labels for familiar concepts. For example, knowing the concept fair/unfair helps when teaching new vocabulary labels like the word bias (Allen, 1999). Researchers believe that a concept-based method of instruction has the most lasting impact on vocabulary development (Allen, 1999). The majority of science words students must learn represent conceptually complex ideas that require more than traditional vocabulary instruction (Cervetti & Hiebert, 2011). In fact, science vocabulary is considered "higher-level academic language" and poor literacy becomes detrimental to the secondary

science classroom (Allen, 2007). Students need tools to help them with literacy and content at the same time. These tools can be found in the effective practice of content-area vocabulary instruction-- the study of concepts rather than words. Focusing on concepts that will have the biggest impact on comprehension of content rather than covering many words superficially will improve overall vocabulary acquisition and retention (Allen, 1999).

In her book *Getting to "Got It!"*, Garner (2007) states that learning is a creative act and students need to "make connections with prior knowledge and experiences, find patterns, identify predictable rules, and abstract general principles that can be applied to new and different situations" on their own (p. xiii). This can be done through a concept-based method of vocabulary instruction. Although this involves more time and deeper discussion in the classroom in order to develop meaning for concepts that are largely unfamiliar to students, it is an effective way of storing new words in long-term memory (Allen, 1999). Getting concepts stored in long-term memory is accomplished by using multiple strategies in a concept-based graphic organizer to enhance students' chances of storing and retrieving these new terms from permanent memory. By processing information in linguistic and nonlinguistic forms in working memory and providing multiple exposures to the new concept, students are more likely to understand and retain concept meanings (Marzano, 2004).

Even though the focus in education has become more scientific and research-based, teaching, like learning, is still a creative act (Burke, 1999). As part of this creative act of teaching, I have modified a concept map found in Stephanie Macceca's (2008) book *Reading Strategies for Social Studies*. This concept map uses research-based strategies and methods to provide students with a different way to access new vocabulary in the science classroom. Many encounters with a new word are needed for students to truly have a lasting understanding of the

word (Allen, 1999). Therefore, this concept map focuses on four main areas: reading text, linguistic and nonlinguistic representation, comparison/contrast, and root words. The use of this concept map provides students with the opportunity to break down individual words and study them by looking at them through different lenses. By having multiple exposures to the word's meaning and examining it in this dynamic way, students are able to gain a clearer understanding of the concept (Macceca, 2008).

## Purpose and Research Questions

After reviewing the above research on the importance of vocabulary study and effective vocabulary development strategies, I developed a research study to see how these strategies can be used as a concept map in a science classroom. The purpose of this study is to determine the effect of implementing a concept map for studying new vocabulary words in an integrated classroom. The focus of this study will be on the acquisition and retention of content-area vocabulary—specifically biology vocabulary. This study will research the following questions: (1) What effect does the use of a concept map have on biology vocabulary acquisition? (2) What effect does the use of a concept map have on biology vocabulary retention?

# METHODOLOGY

## Participants and Setting

The participants of this study will be the students of two different BioLit classes at Adams Central High School. Each BioLit class will have approximately 44 students who are around 14-15 years of age. These students will all be freshmen of mixed ability. There are no advanced or remediation classes offered at Adams Central High School at the freshmen level, so students will range from low to high-ability. There will be approximately six special education students included in the study. Approximately half of the students are female and half male. The ethnic makeup of the students is predominately Caucasian, with few (if any) exceptions. Most students pay in full for lunches (82%), while some (18%) are in the free or reduced lunch program (IDOE, 2010b). This is the students' first experience in an integrated classroom, so the combination of biology and English is new to them.

This study will be performed at Adams Central Jet Tech High School. Adams Central became a New Tech high school during the 2010-2011 school year. New Tech has changed Adams Central from a traditional high school in several significant ways: one-to-one computers

for all students, wall-to-wall project based learning, strong use of cooperative learning groups, integration of core classes, and assessment on 21st Century Skills as well as traditional content.

Adams Central High School has 404 students, and there are approximately 100 students per graduating class (IDOE, 2010b). At 89 students, this class is slightly smaller than the traditional group. The two classes involved in this study are the only two BioLit classes in the school. Adams Central has an attendance rate of 96.94% and a graduation rate of 96.7% (IDOE, 2010b). Adams Central houses a very stable population of students, with few students transitioning in or out of the school system in any given year.

## Action Plan Design

This study is designed to answer the following questions: "What effect does the use of a concept map have on biology vocabulary acquisition?" and "What effect does the use of a concept map have on biology vocabulary retention?" In order to accomplish this, I will introduce my concept map to both of my BioLit courses during the project-based unit on vocabulary. I will introduce the concept map after my students have already completed two vocabulary quizzes with no concept-map instruction. These initial quizzes will serve as a control for the study. Students will then be given a "pop" follow-up quiz three weeks after completion of the concept maps to check vocabulary retention. During this follow-up quiz, students will be tested on two lists (one control list, one concept-map list). The entire study will be completed during one nine-weeks grading period.

I will begin the experiment by creating three lists of ten vocabulary words each of similar complexity. Over the course of several days, I will give students the first two lists of vocabulary words as separate quizzes. Students will be told the dates of the quizzes and a recommendation will be made that they prepare for these quizzes by studying. These scores

will serve as a control. Next, I will introduce the concept map to the class. We will use the concept map on the next list of vocabulary words. Students will then be given a quiz over these words. Once again, they will be informed of the date for the quiz and a recommendation will be made to study. The scores from this test will provide the information for the effect of the concept map on vocabulary acquisition (research question one). Three weeks later, students will be given a "pop" quiz over words from list two (control list) and three (concept map list) to test the effect of the concept map on vocabulary retention (research question two).

Students will be introduced to the concept map by following a modified version of the procedure recommended in *Building Background Knowledge for Academic Achievement* by Marzano (2004). First of all, our Biology teacher, Mr. Hower, will provide a description and explanation of the new term. Students will then be provided with a handout of the concept map in which they will write the term and Mr. Hower's definition and example. Secondly, I will discuss the word parts of the concept and any prefixes, bases, or suffixes and how they help make up the word meaning (root word strategy). Students will then read the textbook section that explains the concept, record the sentence in which the term occurs, and record any additional examples (reading strategy). Next students will create a nonlinguistic representation of the term (nonlinguistic strategy). Students will then work in their groups to compare nonlinguistic representations and come up with other examples and nonexamples of the concept (comparison/contrast strategy). Finally, students will restate the concept's meaning in their own words. As students get used to the process of completing the concept map, there will be a gradual release of responsibility in the completion of the maps from teacher-directed to self-directed.

# Data and Analysis Collection Plan

## Introduction

There can be no doubt that vocabulary acquisition and retention is an important part of BioLit. Providing students with instruction that allows them to learn and remember biology concepts is integral to my goals of meeting the literacy criteria set for me by the Common Core Standards and increasing student scores on the Biology ECA. The purpose of this action research study is to help me become more effective in the area of direct instruction of content-area vocabulary by answering my research questions: (1) What effect does the use of a concept map have on biology vocabulary acquisition? (2) What effect does the use of a concept map have on biology vocabulary retention? In order to answer these questions, I will use a quasiexperimental design.

Several types of data are needed to answer the research questions. For this study, I will be gathering both quantitative and qualitative data. I will use two quantitative methods of data gathering: a student survey and pretest-posttest. In addition, I will also use one method of qualitative data: student interviews conducted through email. I will use triangulation of data in order to ensure that my results are valid and reliable. I will have multiple investigators involved in the data-collecting process (Mr. Hower and myself), collect multiple sources of data, and use multiple methods of data collection.

**Comment [p1]:** To ensure validity and reliability I will provide triangulation using multiple investigators, multiple data sources and use multiple methods of data collection.

## Quantitative Data

### *Student Survey*

The first instrument used to collect data will be that of a closed-ended student survey. The survey will be taken through Survey Monkey and sent to all students participating in the study through a link on their school email accounts. The purpose of the survey is to determine

**Comment [p2]:** since this is occurring after pre-& post test - put it in that order after your description of pre-post

the students' perception of the effectiveness of the concept map, what part(s) of the concept map were perceived as helpful, and compare traditional study methods to the concept map. The students will be asked four closed-ended questions:

1. I felt that using a concept map to learn new biology vocabulary words… (check one)
    a. Helped me *learn* new biology words better than the way I normally study
    b. Helped me *remember* new biology words longer than the way I normally study
    c. Helped me both *learn* and *remember* new biology words better than the way I normally study
    d. Did *not* help me learn or remember new biology words better than the way I normally study
2. I think that these parts of the concept map are helpful…(check all that apply)
    a. Root words
    b. Reading from the textbook
    c. Drawing
    d. Examples/Non-examples
3. In the future, if I need to learn a new concept on my own, I… (check one)
    a. Will definitely use a concept map—they are very helpful
    b. Will possibly use a concept map—they can be helpful
    c. Will not use a concept map—they are not helpful at all
    d. Will not use a concept map—I do not understand how
4. What would be the biggest reason to use a concept map in the future? (check all that apply)
    a. They help me understand new words.
    b. They help me remember words for a longer period of time.
    c. They help me organize information.
    d. Other _____
5. What would be the biggest reason to *not* use a concept map in the future? (check all that apply)
    a. They take too long to complete.
    b. They do not help me learn and/or remember new concepts.
    c. I do not understand how to use a concept map.
    d. Other _____

I will give this survey one time at the end of the study. The data gained from this survey will be numerical, which I will organize in a Microsoft Excel file. I will use the mean scores of the student survey to determine the students' perception of the use of the concept map and how it compared to traditional methods. I will present this information in multiple graphs: one graph per question.

*Pretest-Posttest*

A second instrument I will use to collect data is vocabulary pretests and posttests. The purpose of this instrument is to measure student achievement on vocabulary quizzes with and without the use of concept maps. These quizzes will be given four times. The first two quizzes will be given for two different biology vocabulary lists in which students do not use a concept map in order to provide a control. The third quiz will be given after a list of vocabulary words has been learned using the concept map. The final quiz will be given three weeks later with one control list and one concept-map list in order to test vocabulary retention.

I will organize the data by putting all quiz scores in a Microsoft Excel spreadsheet. I will have a different spreadsheet for each quiz. Once I have collected all of the data, I will organize it by comparing student scores on the control lists to those of the concept-map list. First, I will get the mean score of the two control lists. Then I will compare this score to the mean score of the concept-map list. This will show me how the concept mapping affected student acquisition of biology vocabulary words. I will then do the same procedure for the fourth quiz in order to measure the effect of concept mapping on student retention of the biology vocabulary words. I will present this information in bar graphs: one to represent vocabulary acquisition and one for vocabulary retention.

Qualitative Data

*Student Email Interview*

The final instrument I will use to collect data is student interviews that will be conducted through email. For this instrument, I will need to send emails to my students through their school email accounts. I will send emails out on three different occasions. First of all, I will email students immediately after taking the two quizzes they complete on their own. The email

question will be, "Describe your experience in learning the vocabulary words you were quizzed on over the past couple of days. Think about the following to help you answer the question: when, where, how you studied; how long you spent studying; what you did to help you learn the words; the effects of your studying; etc." I will send out the second interview question after students have learned how to use the concept map and have taken their quiz over the concept-map words. This question will read as follows: "Describe your experience in learning the vocabulary words you were quizzed on yesterday. Think about the following to help you answer the question: when, where, how you studied; how long you spent studying; what you did to help you learn the words; the effects of your studying; etc." I will send out the final interview question after students have take the "pop" quiz three weeks after learning all sets of words. This question will ask students to compare and contrast the study methods in helping them learn and remember biology concepts and their overall perceptions of concept mapping. It will read as follows: "Think about your vocabulary experiences over the past several weeks. How do you think concept mapping affects the way you learned and remembered biology vocabulary words compared to the way you normally studied? Discuss your experience with concept mapping and its effects (good and bad) on the way you both *learned* and *remembered* vocabulary words."

After I have collected student responses to the email interview questions, I will organize my raw data by putting all responses in a Microsoft Word document. I will have a different document for each question. I will then read through the responses and code any patterns I see. By the end of the research, I will have three typed and coded documents of student responses to my interview questions. The information from these responses will be presented in narrative form in my action research findings.

## Significance and Conclusion

There are several potential outcomes of my research. First of all, it will directly affect my own instruction. If the use of vocabulary concept maps proves beneficial, it will be included with all of the projects included in the BioLit course. A second potential outcome is transference of the concept map to other content-area teachers in our school. This could be especially useful to the other New Tech integrated classrooms: Global Studies (World Geography and English 10) and American Studies (U.S. History and English 11). Finally, if the study shows strong benefits of the use of vocabulary concept maps, this could be used in the New Tech Network. My team teacher and I are both New Tech Certified Teachers and are already presenting twice at the New Tech Network this summer on other strategies that we have found beneficial in our classroom. The use of vocabulary concept maps to help students learn and retain unfamiliar content-area vocabulary words could be another topic for us to take to the Network.

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