The Use of Vocabulary Learning Strategies in High School Science Classrooms

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Abstract

This capstone project explores various strategies that can be used in the science classroom to improve student’s vocabulary acquisition. As teachers will encounter students of varying reading levels, it’s important to find ways to best support these students in acquiring science content. Science teachers may not always think about the importance of teaching vocabulary and providing plentiful opportunities for students to practice with the vocabulary. One of the greatest difficulties that students encounter in science classes is the amount of Tier 3 vocabulary words they must learn, understand, and apply. It is recommended that science teachers explore various methods of explicit vocabulary instruction and the creation of activities that further support their students in gaining vocabulary knowledge.

Keywords: vocabulary strategies, science classroom, ELLs, vocabulary instruction
# Table of Contents

A capstone project submitted to the Department of Education and Human Development, State University of New York (SUNY) Brockport in partial fulfillment of the requirements for the degree of Master of Science in Education

Chapter I: Introduction

Significance of the Problem

Purpose

Chapter II: Literature Review

English Language Learners

Students with Learning Disabilities

Teacher Preparedness

Content Acquisition Podcasts for Teachers (CAP-TS, CAP-TV, CAP-PD)

The Teacher Study Group (TSG) Professional Development Program

Science Intervention Support (SVS) Intervention Program

Creating Habits that Accelerate Academic Language of Students (CHAAOS)

Students’ Perceptions on Vocabulary Strategies They Use

Students’ Perceptions of Strategies Used by Teachers

Motivation

Group Collaboration

Competition

Using Games to Practice Vocabulary

Quizlet

Visuals to Support Vocabulary Learning

Content Acquisition Podcasts for Students (CAP-S)

Interactive Word Walls

Frayer Model Graphic Organizer

Concept Maps and Mind Maps

Implications for Classroom Instruction

Conclusion

Chapter III: Project Work
Purpose ........................................................................................................................................... 32
Student Demographics ......................................................................................................................... 32
Semi-Structured Interviews – Teachers .................................................................................................. 32
The Use of Visuals ................................................................................................................................. 35
Word Walls with Visuals ....................................................................................................................... 36
Students Find Word Walls Beneficial .................................................................................................... 37
Gamification, Motivation and Vocabulary Practice ............................................................................... 38
Modified Frayer Model ......................................................................................................................... 40
Chapter IV: Conclusion ....................................................................................................................... 42
  Conclusions ........................................................................................................................................ 42
  Implications for Practice ..................................................................................................................... 43
  Recommendations ............................................................................................................................. 45
  Final Thoughts ................................................................................................................................. 46
References ............................................................................................................................................. 48
Appendix A .......................................................................................................................................... 52
Appendix B .......................................................................................................................................... 53
Appendix C .......................................................................................................................................... 54
Appendix D .......................................................................................................................................... 56
Appendix E .......................................................................................................................................... 58
Chapter I: Introduction

Learning academic vocabulary is imperative when it comes to understanding science content. Mastering academic vocabulary can be especially difficult for English Language Learners (ELLs) and students with low reading levels. Science courses are heavy with Tier 3 vocabulary words that students do not encounter in everyday life. Thus, vocabulary strategies that can be implemented in the classroom must be carefully considered in order to help students in mastering science content.

There has been literature on several different strategies that have proven to be effective based on studies. Based on research, the use of games and media have been proven to be effective in not only helping students learn vocabulary but also provide an element of entertainment, enjoyment, establish real-world connections, and the use of vocabulary in different contexts. Studies have also been conducted on how the Frayer model, concept mapping, and reading interventions such as the Science Vocabulary Supports (SVS) program can benefit students by having them use, apply, and make connections with vocabulary.

Significance of the Problem

Teachers will continue to encounter many students that are learning English as a second language and students that have Lexile scores below the minimum needed to read and understand science text. This means that teachers must be equipped with strategies that will first help these students identify, recall, and apply science-specific vocabulary terms. The inability to have vocabulary knowledge in science will make it near impossible to truly understand the meaning of texts in order to successfully answer multiple choice and free-response questions.
As students begin taking standardized tests like the Regents exams in New York, vocabulary acquisition is a must. These exams contain essential scientific vocabulary within questions and passages that students may not be able to understand even with the use of context clues. Providing students with the tools to better learn these science vocabulary terms may increase the probability that they can pass these tests needed for graduation. Students can then build on their vocabulary knowledge to gain knowledge, motivation, confidence, and enjoyment for science.

**Purpose**

The purpose for this project is to increase my students’ vocabulary knowledge in order for them to increase their understanding of science content. This can be especially difficult for any students I have that are learning English as a second language and those with very low Lexile levels. By providing these students with the proper tools that help them I can improve their chances of passing the high stakes Regents exam in June, as well as provide them with skills and knowledge they can apply to other subjects or even to their own lives outside of school.

**Chapter II: Literature Review**

Vocabulary learning should be emphasized in content area classrooms as lack of vocabulary knowledge can negatively affect a student’s understanding when reading a text or listening to peer or teacher explanations. In order for learners to listen, speak, read, and write they must continuously increase the size of their vocabulary (Kruawong, 2021). Integrating effective vocabulary strategies can help students learn new vocabulary words. Vocabulary is essential for communication, reading comprehension, and achievement in school. The inability to
fill gaps in vocabulary can make it difficult for the most vulnerable students to reach their highest potential in their academic career and post-secondary life.

It is important to examine the different issues surrounding vocabulary teaching in science classrooms and possible implications on how to address these issues. As general education science teachers experience an increase in English Language Learners and students with disabilities (SWD), research-based strategies must be investigated and implemented to help these students achieve in science class. There is minimal literature and research about vocabulary instruction within science classrooms. With the increasing number of students with disabilities who may also be ELLs, educators must find ways to fill in gaps that vulnerable students face due to language barriers and/or learning disabilities.

Students in the United States of America are struggling with science achievement, especially SWD. According to the National Assessment of Educational Progress (NAEP) science assessment data, 41% of fourth-grade students and 37% of eighth-grade students achieved proficiency (National Center for Education Statistics, 2015; Kennedy et al., 2018). Science data from this 2015 assessment also showed that SWD performed much lower than other students with only 18% of fourth-graders and 11% of eighth-graders meeting science proficiency. In order to close this gap teachers must be prepared with meaningful and researched vocabulary teaching strategies and any other supplemental materials that can help students grasp the complexity of scientific vocabulary terms.

**English Language Learners**

A demographic of students that faces the greatest difficulty learning vocabulary in science is English Language Learners. ELLs have to not only grasp Tier 3 content-specific vocabulary, but also Tier 1 and Tier 2 words that do not require direct instruction for most
students. This lack of vocabulary knowledge makes it difficult for these students to learn content-specific vocabulary terms as they must build upon prior word knowledge to make connections to new words (Kruawong, 2021). Additional vocabulary instruction and support in science class can be beneficial to this demographic of students in their science reading comprehension and vocabulary. Students that are at the high school level are expected to take high stakes standardized tests that heavily contain vocabulary words they’ve never seen before. However, they are expected to pass these tests despite their deficits in vocabulary and reading levels. Failure to do so can result in their inability to graduate high school.

It is important to find ways to bridge the gaps in ELLs vocabulary deficits in order to reduce the inequities these students may face with regards to economic and educational opportunities. While students may learn vocabulary through incidental vocabulary acquisition it should not be solely relied on for these students’ vocabulary knowledge. This means that ELLs must receive much explicit instruction, word-learning strategies, and reading comprehension skills (Carlo et al., 2004).

**Students with Learning Disabilities**

Students with learning disabilities may also find it very difficult to understand science content because the scientific vocabulary used in class is often not used in daily conversation. Repeated exposure to vocabulary words can help students better understand and apply the vocabulary, however, scientific vocabulary may only be seen in scientific text (O’Connor et al., 2020). If a student has a learning disability or low Lexile score, they may not be able to access even the basic meaning of the text, let alone the meanings of complex scientific words. As these students’ progress through school the volume of academic vocabulary that they should have
learned is enormous, which only widens the gap between what they know and what they need to know.

**Teacher Preparedness**

While science teachers feel prepared to teach scientific content in their area of certification or expertise, vocabulary instruction may be an area of concern. Unlike ELA teachers, science teachers may not emphasize explicit vocabulary teaching or know how to effectively teach vocabulary. Providing science teachers with professional development opportunities and resources on how to effectively teach vocabulary is a must in order to help the students struggling with a language barrier or a learning disability. As many students with disabilities and ELLs receive science instruction in a general education classroom, teachers in the room must have a strong foundation on how to help these students achieve. In 2017, the National Science Teachers Association (NSTA), recognized the problem that many science educators report feeling unprepared to teach SWD, as well as feeling unsupported in effective instructional strategies.

**Content Acquisition Podcasts for Teachers (CAP-TS, CAP-TV, CAP-PD)**

Content Acquisition Podcasts are not only a tool that can be used by students. Teachers can also benefit from CAPs (Content Acquisition Podcasts) to enhance their professional development. Studies have been done on the use of CAPs to enhance the learning of pre-service and in-service teachers. Former studies have shown that CAPs have been used to help teachers learn how to provide vocabulary instruction (Ely et al., 2015), how to use and apply curriculum-based measures (Kennedy et al., 2016), and behavior management strategies (Kennedy et al., 2017). These podcasts provide a level of inclusivity to help teachers gain professional development using the cognitive apprenticeship framework as its foundation (Collins, Brown, &
Newman, 1989). By using this framework in the creation of these CAPs, instructors are presented with multimedia professional development that uses a model-coach-scaffold cycle (Kennedy et al., 2018). Modeling allows teachers to see how to execute an instructional strategy while coaching helps provide guidance and feedback.

The CAP-PD (Content Acquisition Podcasts for Professional Development) process was investigated by Kennedy et al. (2018), with the goal to create a professional development intervention that supports teachers to meet the vocabulary needs of their students. The CAP-PD intervention involves the following: 1. CAPs with modeling videos (CAP-TV), 2. instructional slides that can be used or adapted for teacher use (CAP-TS), 3. Feedback and coaching on the implementation of practices. The PowerPoint slides (CAP-TS) can be downloaded and provide the following for each vocabulary term: (a) slides for reviewing background knowledge, (b) providing student-friendly definitions, (c) example and non-examples, (d) morphological features, (e) comparing and contrasting the term with similar terms, and (f) repeating the definition. (Kennedy et al., 2018). These professional development podcasts can prove to be valuable for preservice and in-service science teachers that may not feel prepared in supporting their SWDs and ELLs with vocabulary instruction.

**The Teacher Study Group (TSG) Professional Development Program**

The Teacher Study Group (TSG) is a professional development program shares many features with professional learning communities (PLC) and lesson study groups. These professional developments provide opportunities for active learning, teacher participation in relevant activities, teachers implement planned lessons in their classroom, and is facilitated by someone with a strong content and pedagogical knowledge. TSG uses effective, researched
vocabulary instructional strategies to help teachers enhance their curriculum. This is especially useful for teachers as it does not require them to create entirely new curriculum or lesson plans.

The study by Jayanthi et al. (2015) consisted of 10 professional development sessions that followed a five-phase recursive process. Teachers would collaboratively plan a lesson that they would then execute in their classrooms. The next session had the teachers debrief on how the lesson went and any modifications they made. Each session involved teachers selecting words to teach, developing student-friendly definition, creating examples and non-examples, and creating activities in which students can practice using the words. Educators in the TSG program received coaching from teacher researchers and/or administrators and provided with feedback (Jayanthi et al., 2015). This professional development program provides teachers with meaningful time to collaborate, learn from one another, and apply relevant strategies to their own practice.

**Science Intervention Support (SVS) Intervention Program**

A study by Van Orman et al. (2021) studied the effectiveness of the SVS intervention program in helping ELLs learn scientific terms from an Earth Science unit. This program uses the three principles of integration, repetition, and meaningful use from the *powerful vocabulary instruction* framework (Nagy, 1988). Integration requires students to link vocabulary words to other knowledge through the use of visuals, real world scenarios, and discussion. Next, the principle of repetition provides learners with multiple opportunities to learn and practice using the word in low stakes ways. Once a student is able to quickly access the meaning of the word, they will then be able to apply that word to more complex tasks (Van Orman et al., 2021). Lastly, students must use the new vocabulary words “for multiple learning purposes and across contexts and modalities… [as this] requires meaningful, contextual use of the targeted words” (Van
Orman et al., 2021). Students must use these newly learned words throughout a variety of tasks as it will lead to a greater depth of understanding because they are actively involved in thinking, discussing, and applying the meaning of the word (Van Orman et al., 2021).

**Creating Habits that Accelerate Academic Language of Students (CHAAOS)**

Explicit vocabulary instruction is imperative to help bridge the academic gaps that English Language Learners and students with learning disabilities may have when entering the science classroom. In order to explicitly teach vocabulary to students, teachers must teach students the definition of words, provide them with examples and non-examples, provide multiple exposure, and have students practice using the vocabulary words (O’Connor et al., 2020). In addition, teachers should provide opportunities for students to interact with their peers in order to use vocabulary in various contexts. Creating Habits that Accelerate Academic Language of Students (CHAAOS) is a vocabulary intervention aimed to support students with disabilities.

The effects of the CHAAOS intervention on learning vocabulary, using the vocabulary in contexts, retaining the vocabulary knowledge, and how it is impacted by students’ first languages, was investigated by O’Connor et al. (2020). In this study students were taught 48 vocabulary words over the course of 12 weeks. The CHAAOS intervention instruction included: 4 new vocabulary words per week, student friendly definitions, vocabulary activities (teacher guided, peer-practice, and independent practice) that involved images, real-world scenarios, and graphic organizers, and providing immediate feedback (O’Connor et al., 2020). Results from this study showed that the classes that used the CHAAOS intervention were able to better retain the vocabulary words four weeks after the end of the intervention. These students also showed substantial gains on multiple choice vocabulary questions.
Students’ Perceptions on Vocabulary Strategies They Use

Student input can help guide teacher decisions on certain activities. Student input can be in the form of surveys in which students can rank their satisfaction with certain strategies and provide feedback on ways that the teacher can change the activity to better meet their needs. A study by Avarind & Rajasekaran (2020), showed that the most commonly used vocabulary strategies by students were media (91.7%), verbal repetition (88.9%), taking notes in class (88.9%), wordlists (86.1%), testing oneself with word tests (83.3%), and written repetition (83.3%). This information is useful as it can help teachers decide which strategies their students may be most comfortable using that they perceive to be effective.

An additional study by Tamimi Sa’d and Rajabi (2018) was conducted for the purpose of not only learning the strategies students preferred, but also the most common strategies they observed their teachers using in the classroom. Data was also collected on whether gender played any role in students’ preferred vocabulary strategies. Based on the results from the questionnaire, they were able to identify that the most common vocabulary learning strategies the learners utilized were using the vocabulary words in a sentence, mental repetition, and translating the words into their native language (Tamimi Sa'd & Rajabi, 2018). They also found that the least common vocabulary learning strategies students used were writing, copying down words from television shows and movies, using dictionaries, and Leitner’s boxes (Tamimi Sa'd & Rajabi, 2018). According to the independent samples t-test used to identify any significant differences in vocabulary learning strategies based on gender, it was found that female learners were more likely to memorize words by saying them out loud, while male learners would learn words from the internet (Tamimi Sa'd & Rajabi, 2018).
Students’ Perceptions of Strategies Used by Teachers

Educators can decide to conduct student surveys or questionnaires periodically in order to collect data on their own teaching. In a study conducted by Brown and Concannon (2019), a student questionnaire was conducted for the purpose of collecting data on students’ perceptions of different vocabulary strategies used in class. Data was collected on students from traditional classes and advanced classes. Results from the vocabulary perception assessment showed that students in the advanced classes had more positive perceptions of their own vocabulary knowledge. More students in the advanced classes said they enjoyed taking notes to learn vocabulary when compared to the students in the traditional classes. More students in the traditional classes were in favor of learning more vocabulary strategies in the future and look forward to vocabulary activities in class compared to the advanced classes. Information collected from this study could drive decisions on how to differentiate material for varying student-ability levels.

Students’ opinions and preferences regarding vocabulary teaching strategies can help teachers make decisions on which strategies to continue to use and which they may need to remove or revise. Administering a questionnaire on whether students preferred vocabulary pre-teaching or post-teaching instruction as well as their thoughts on visual-aided dialogues (Alamri & Rogers, 2018). Results showed that overall students favored explicit vocabulary being pre-taught. Based on the questionnaire, students believed that pre-taught vocabulary helped them notice target words throughout the unit, improved their understanding of readings, helped them memorize the words when they encountered the word again, and their pre-teaching vocabulary was helpful in introducing the unit (Alamri & Rogers, 2018).
Motivation

A study by Lee, Ahn, & Lee (2022), investigated the relationships between motivation and vocabulary size and depth, as well as, the differences extrinsic and intrinsic motivation had on vocabulary knowledge. The results from this study showed that there was a correlation between motivation and vocabulary knowledge. Intrinsic motivation was a better predictor than extrinsic motivation for the use of vocabulary learning strategy and L2 vocabulary knowledge (Lee, Ahn, & Lee, 2022). Students are more inclined to participate and complete work to the best of their ability if they are intrinsically and extrinsically motivated. There are various ways that motivate students so a teacher may experiment to see which activities and tools help improve their own students’ motivation to learn.

Group Collaboration

Group work is often used in classrooms for the purpose of student engagement, collaboration skills, learning from peers, and student ownership. Student collaboration can also be useful for vocabulary acquisition. In a recent study by Park et al. (2021) students were asked to draw a group diagram regarding the scientific concept of sound. Each group contained 3 students. The students had worked collaboratively many times before so they were familiar with group discourse as well as scientific drawings. Students first planned what they were going to draw. Groups then drew what they planned, and lastly, students that were not part of the drawing process, evaluated the drawing. This 3-step process occurred several times throughout the activity. Students would ask a question or ask for suggestions, and other students would contribute. The completion of the group drawings also involved negotiations and reaching consensus among group members. This process helped students practice using academic
vocabulary through discourse and writing in order to achieve a final scientific drawing of an abstract concept.

**Competition**

Student collaboration improves student vocabulary knowledge through applying vocabulary in various ways. As students engage in group work, they practice their reading, listening, and speaking skills. This can not only be useful to improve student participation and socioemotional learning, but can provide students with the opportunity to use vocabulary in various contexts. A study by Araffin (2021), the effectiveness of collaboration in improving ESL students through vocabulary knowledge was conducted through the adaptation of a peer-tutoring method called Student Teams – Achievement Divisions (STAD), developed by Slavin (1986). This group method involved grouping students into heterogeneous groups after teaching the content. Students worked in their groups to complete worksheets related to the content. Assessments are given to individual students after the group work is complete and their scores are calculated into a final group score. These scores are then compared to other groups’ scores and the winning group receives a reward. This provided students in the group with an incentive and the need to ensure all members of the group mastered the content as their scores will all count towards a group score. Quantitative data collected showed a statistically significant difference in the mean score of 8.82 (mean pretest score) compared to 11.53 (mean posttest score) (Araffin, 2021). This evidence suggests that group collaboration led to an improvement in vocabulary knowledge.

**Using Games to Practice Vocabulary**

Students are more likely to complete an activity if they are engaged and motivated. Teachers should find activities that are not only effective in helping students learn content and
skills, but also enjoyable. The activities should be purposeful in that they help students meet an objective(s) and provide meaningful engagement opportunities. Games that embed vocabulary give students many opportunities to spell and pronounce vocabulary as well as entertain and challenge them (Kruawong & Soontornwipast, 2021).

Gamifying activities can help increase student motivation and participation. These activities can be used to help students retain vocabulary through repetition, collaboration, discussion, and application. Traditional or digital games can be utilized to improve students’ proficiency. Research studies have shown an increase in students’ vocabulary test scores when they learned through different vocabulary games, such as handman, flashcard memory games, bingo, and odd man out (Masoumeh, 2014). Games provide students with multiple ways to interact with content in ways that are more memorable and enjoyable.

Students may find the competitive aspect of certain games to be appealing and engaging. Competition can intrinsically motivate students to want to do well, so they may decide to pay more attention in class or increase their studying in order to see results. These results can be rewards of better grades, beating their peers’ scores, or a reward. Online review websites such as Kahoot or Quizizz have students compete through answering questions and acquiring points for every right answer. The competitive nature of Quizizz can motivate students to want to do well enough that they end up on the leadership board (Huei et al., 2021). Similarly, the study by Araffin (2021) resulted in groups of students competing with others to achieve the highest quiz score. In order to achieve this, group members did their best to ensure all members of the group knew the content well in order to give their group the best chance to score the highest test score, since all group members' grades were averaged into a final score. The group with the highest
group score received a reward and recognition. Through motivation and competition students are able to learn while also having fun.

A study by Kesgin and Kartal (2022) studied the effectiveness of a game-based teaching method and story-based teaching method. The students participated in several activities after reading each story, such as “answering reading comprehension questions, answering true-false questions, filling in the blanks in a story, writing short paragraphs about the animals given in the pictures, writing a story about a visit to the zoo, writing a letter to a pen friend about national festivals in Turkey, etc.” (Kesgin & Kartal, 2022). These 27 students participated in matching words to pictures, bingo, scrambled-words game, hangman, crossword puzzles, etc. (Kesgin & Kartal, 2022). Results showed a significant difference in pretest and posttest scores in the group that learned through the story-based vocabulary method. Similarly, the group that was taught through the game-based vocabulary method also showed significant growth in test scores.

Crossword puzzles are often found in newspapers, magazines, or in books dedicated solely to these puzzles. They can be done as a leisurely activity, to provide a form of entertainment and even as a mental challenge. Educators have used crossword puzzles with the goal to help their students review content while having fun. Kruawong and Soontornwipast (2021) wanted to investigate the effect of using Science Vocabulary Crossword Puzzle (SVCP) practices on students’ science vocabulary knowledge in English. Their two research questions were to identify how effective the Science Vocabulary Crossword Puzzles (SVCP) practices were at improving students’ science vocabulary knowledge, as well as the students’ opinions towards the use of these puzzles in helping them develop their science vocabulary knowledge. Quantitative results showed a statistically significant difference in pretest and posttest scores. The pretest scores were an average of 28.9% while the posttest scores showed a mean score of
79.16%. Students’ opinions regarding the practices were analyzed based on frequency and compiled into a bar graph. The students had an overall positive view towards the use of SVCP practices in helping them develop their vocabulary knowledge. Crossword puzzles enable students to practice writing vocabulary words by using a description to figure out and write the vocabulary word.

The use of childhood games that many students (e.g., ESL students) may already be familiar with and the incorporation of vocabulary learning may provide a level of entertainment, collaboration, and competition. Orejuela et al. (2022), conducted a study that investigated how gamifying instructions would impact ESL students' proficiency in English. This study was conducted on 44 grade 8 ESL students in the Philippines. Different types of games were examined to see if certain games (cup games, board games, card games) were more effective than others in helping ESL students with vocabulary, reading comprehension, and grammar (Orejuela et al., 2022). Results showed that the cup games and board games improved students’ proficiency due to their increased gain score on the posttest of 7 points and 5 points respectively. The majority of the ESL students ranked as Approaching Proficient in language, reading comprehension, grammar and vocabulary.

**Quizlet**

As the use of technology increases in the lives of students, gamified online websites and applications may be beneficial to engage students in vocabulary learning. Popular websites used in and outside the classroom to help students retain content are Kahoot, Quizizz, and Quizlet. These types of websites bring computer-assisted language learning (CALL) and mobile assisted language learning (MALL) into the student learning process. An application like Quizizz can
help students stay entertained while learning as well as adding a competitive component that may motivate students to want to do well (Huei et al., 2021).

The process of learning vocabulary should involve repeated exposure and use of vocabulary words in small sets over a period of time. This provides learners with ample time to learn the word and practice using each word. There is greater success in learning new information when taught in small amounts over a period of time (Nguyen & Le, 2023). A study by Pham (2022) interviewed university students that had experience using Quizlet for vocabulary practice. The study collected data on how often they used Quizlet, what features they used most frequently, and the pros and cons of using Quizlet. 95% of the students thought Quizlet was a good tool for learning vocabulary due to its several features, ease of use, and free cost. (Pham, 2022). Quizlet provides users with features such as: Test, Flashcards, Learn, Write, Spell, Match, and Gravity. This allows students to apply their vocabulary words in a variety of different ways besides the traditional writing and memorizing the meaning of the words.

Research has been done on the effectiveness of Quizlet on students’ vocabulary retention. A study by Nguyen and Le (2023) looked to answer the following research questions: “Is Quizlet effective in improving learners’ lexical retention?” and “To what extent is lexical retention of learners using Quizlet different from that of those who do not?”. In this study the experimental group used Quizlet to help them learn vocabulary in addition to traditional vocabulary instruction. Findings from this study showed that the experimental group had a significantly higher mean gain than the control group that did not use Quizlet to supplement their vocabulary learning. Quizlet provided students with the opportunity to practice their vocabulary words in a variety of different ways using the Quizlet features.
Visuals to Support Vocabulary Learning

Visuals can be a valuable component in helping students make connections to real-world situations which can provide a meaning to a scientific term. For example, when teaching an abstract science word like mitochondria, that cannot easily be visualized, providing students with images can help them begin to make sense of the word’s definition. Visuals should be embedded in scientific texts to help students make connections between images and texts, in order to store the information into their long-term memory (Wright et al., 2014). Science has many visuals in text that may or may not provide students with a better understanding of information from the text.

There is no doubt that students will encounter visuals in some way, shape, or form throughout their academic career and in the real-world. Visuals can include images, photographs, diagrams, graphs, data tables, etc. Visuals can stand alone, be embedded in a reading, or part of a question(s). While vocabulary words may be specific to a language, many visuals can span over several languages. For example, if a student is shown an image of a sun, plant, and rain when learning the word “photosynthesis”, they may gain a better understanding of the word as those objects are universally known, and they can make a connection between the images and the words' meaning in their native language. A study by Alamri & Rogers (2018), investigated how different explicit teaching instruction impacts students’ vocabulary retention. In this study visual-aided dialogues were used in the experimental group while the control group only received written-aided dialogue only. Mean scores from the post-test showed that the experimental group had a score of 47.8% and the control group scored 16.4%. A delayed post-test was also administered in which the experimental group had a mean score of 43.4% while the control group had a mean score of 18.7% (Alamri & Rogers, 2018). Findings from the results show that
the use of visual-aided dialogue during explicit vocabulary instruction not only showed an increase in vocabulary knowledge, but also vocabulary retention as shown by the delayed post-test results.

Graphics should be strategically designed in such a way that the reader is able to develop vocabulary and depth of content knowledge. A study by Wright et al. (2014), assessed the quality of graphics that were found in science textbooks. Images that are used to help students enhance their vocabulary should include captions that help the students connect the visual to a definition or word(s) in the text. When images do not help show the meaning of the text or a vocabulary word it may confuse readers, especially ELLs, associate the content with a real-world connection (Wright et al., 2014). Additionally, visuals glosses can be used as a learning tool to help students learn difficult vocabulary. A study by Sato & Suzuki (2012) focused on schematic, pictorial, and live-action images as visual glosses to help students learn prepositions, L2 vocabulary, and improve their reading comprehension.

It is not only English Language Learners that may benefit from the use of visual materials when learning vocabulary. A study by Birinci and Saricoban (2021) studied the effectiveness visual materials had when it came to teaching vocabulary to EFL deaf students. This study found that the experimental group that was provided with visual aids to supplement their vocabulary instruction scored higher on their posttest and delayed posttest, compared to the control group that was provided no visual aids. The testing material had students first match words to the corresponding picture. The next section of the test asked students to unscramble letters to spell out one of the target words. Lastly, participants were to write out the words underneath an image of the word (Birinci & Saricoban, 2021). Additionally, the group that was taught using visual aids was able to better retain the vocabulary words 6 weeks after the study was completed.
Another study by Tahir et al. (2020) had similar results with an increase in vocabulary acquisition through the use of visual vocabulary worksheets. These findings suggest that visual materials when used to supplement vocabulary instruction, may provide short term and long-term memory retention.

**Content Acquisition Podcasts for Students (CAP-S)**

Images have been used as effective learning tools to help students make real-world connections to academic vocabulary words. Additionally, the use of content acquisition podcasts for students (CAP-S) has been investigated as a possible effective tool to help students learn vocabulary. A study by VanUitert et al. (2020), investigated the effectiveness of CAP-S in helping students with learning disabilities to learn science vocabulary. These CAP-S contained effective vocabulary practices and cognitive theory of multimedia learning (CTML). The students in this study utilized the multimedia website Ed Puzzle in order to track students’ views. CAP-S were utilized both for asynchronous and synchronous instruction. Results from this study showed that students that had access to CAP-S outperformed students that did not have access to CAP-S. CAPs use explicit visual and auditory cues to help focus students and limit cognitive load. An effective CAP would use the following sequence: introduction and rationale for video, name the term, review critical background knowledge, provide student-friendly definition, provide example, provide non-example (if clear non-example exists, otherwise skip), highlight morphological features of word (if clear elements exist, otherwise skip), repeat definition (VanUitert et al., 2020)

**Interactive Word Walls**

An interactive word wall is a vocabulary tool educators display in their classroom so that it is readily available to students every day. The word wall is updated as new words are
introduced to students throughout a unit. A word wall is considered interactive as it requires students to engage with the vocabulary words by participating in adding to the wall. This can be in the form of having some students place new words on the wall while other students use resources to find the meaning of the words (Purnamasari, Katemba, & Panjaitan, 2018). A study by Jackson (2013) researched the use of interactive word walls in a diverse, low-income middle school. An interactive word wall organizes academic vocabulary words to show relationships, contains student-generated materials, is aligned with current instruction and uses visual supports alongside the words. The use of visuals helps students gain an additional understanding of the word’s meaning, which can be especially helpful for ELL students. Results from the Jackson (2013) study showed that students found the word wall helpful because it helped them better understand and remember the vocabulary. One student said that the interactive word wall ‘helps remind us of what we have learned’ and ‘since it is always up there, I always remember’. The use of a visible interactive word wall with strong images can help many students get repeated exposure to essential vocabulary.

**Frayer Model Graphic Organizer**

The Frayer Model is a technique that uses a graphic organizer that provides an opportunity for students to gain an in-depth understanding of vocabulary. The Frayer method is a strategy that has students interact with vocabulary in multiple ways, beyond just writing the term and the definition (Estacio & Martinez, 2017). This graphic organizer requires students to not only define the vocabulary term, but also provide characteristics, examples, and nonexamples regarding the term (Wati et al., 2022). Utilizing the Frayer method when learning or reviewing vocabulary places more student ownership on learning, while the teacher is there to help guide student-thinking.
Findings from Wati et al. (2022), showed that the implementation of the Frayer model resulted in significant improvements in vocabulary achievement. Students in this study scored a mean of 37.96 on the pretest and a mean score of 79.52 on the posttest, with an increase of 34.76. Another study by Estacio and Martinez (2017) showed similar results in which their experimental group that used a modified Frayer model had a higher posttest score when compared to the control group that did not use the Frayer model to learn vocabulary. Lastly, a comparative study by Panjaitan and Sihotang (2020) investigated the difference in effectiveness between the Frayer model and concept-mapping when it came to learning vocabulary. While both strategies proved to be effective, results showed that the group that used the Frayer model had a higher gain in score when comparing their pretest and posttest gains to the group that used concept-mapping. This is not to say that concept-mapping should not be used to teach vocabulary.

**Concept Maps and Mind Maps**

Concept mapping has students place the vocabulary word at the center of the map and related words, ideas, or concepts are linked to the word and to one another. A concept map forces learners to make important connections, visualize relationships, and engage in in-depth thinking around a vocabulary term (Panjaitan & Sihotang, 2020). When students create concept maps, they must use both metacognitive and cognitive strategies, resulting in more meaningful learning experiences (Khoshima et al., 2015). By having students create concept maps using academic vocabulary, they are not only gaining a storing of these vocabulary terms into their long-term memory, but also deepening their understanding of the science concepts they are learning.

In a study by Tarkashvand (2015), students were taught how to create concept maps every time they learned a new vocabulary word. These students needed to have a teacher model
how to make these maps and eventually they were expected to create their own maps. Students were encouraged to create their own maps by using the map made in class as a guide. The other experimental group in this study used mind-mapping as a means for learning new vocabulary words. The mind maps included an image in the middle with some complete and incomplete words surrounding the image. In order to organize their maps, they were provided with numerical order, radial hierarchy or outlines (Tarkashvand, 2015). Results from the 40-item posttest showed that both mapping strategies proved to be effective for the English Language Learners (EFL). While both strategies were proven effective, the mind-mapping group had a higher mean score of 35.57 compared to the 24.97 scored by the concept-mapping group (Tarkashvand, 2015). As both maps are shown to be effective, teachers may decide which to use based on student needs or specific goals.

**Implications for Classroom Instruction**

As various vocabulary learning strategies have been researched, educators must make informed decisions on which strategies would be the most beneficial in their classroom. A teacher does not have to just choose one strategy but may decide to implement a variety of strategies throughout the year based on student strengths and deficits. As science educators may not have formal or vast training in vocabulary and literacy training like English Language Arts teachers, it’s imperative to find supports.

Teaching students how to effectively use literacy strategies can help them build more confidence in their abilities to approach texts. Integrated vocabulary strategies can also help students learn complex and abstract vocabulary. Lastly, close reading strategies can be beneficial for students to analyze texts and extract important information and scientific concepts. As data showed both advanced and traditional classes outperformed AAAS scores, there could be
benefits in teaching students’ literacy strategies in science classes (Brown & Concannon, 2019). Classroom educators could decide on a few literacy strategies that they believe their students would benefit from, and consistently work these strategies into their curriculum. In regards to science education, there is a lack of studies involving literacy strategies. Future research on the effect specific literacy strategies have on student learning and achievement in science should be done.

Providing science educators with meaningful and rich professional development experiences can help bridge gaps they may have in vocabulary acquisition strategies. Schools should provide their science educators with professional development on how to implement effective vocabulary teaching in their classrooms. These professional development sessions should be facilitated by educators who have formal training in explicit vocabulary teaching and use evidence-based research as their framework. The Teaching Study Group (TSG), lesson studies, and professional learning circles are professional development programs that can help teachers support their students with disabilities and English Language Learners (Jayanthi et al., 2015). Alternatively, teachers can benefit from multimedia professional development, such as Content Acquisition Podcasts (Kennedy et al., 2018). By watching these podcasts teachers can learn effective strategies by being provided focused, relevant, and useful materials that they can implement in their classrooms.

Teachers may consider the implementation of the game-based teaching method and/or the story-based teaching method. Based on data, either teaching technique may be implemented with the goal of improving students’ vocabulary knowledge. As both strategies proved to be effective, a teacher may decide to use both strategies depending on the vocabulary that is being taught. A teacher may also decide to use both strategies than have students provide feedback in order to
revise or use one method over the other. As there is an increase in gaming technology, using this in the classroom can help increase motivation and engagement. Teachers can explore various game-based educational games like Quizizz, Blooket, Gimkit, and Kahoot to play in class with students or to assign as asynchronous work. These websites provide a fun, interactive and competitive aspect to the learning process.

Many studies have been conducted on students’ perceptions of vocabulary learning, so it may be beneficial for classroom teachers to collect data on their students’ preferred learning styles, as well as, receive feedback on their teaching. These questionnaires or surveys can be in paper or electronic format for the purpose of collecting data on students’ opinions of the lesson or activity (Alamri, 2018; Huei et al., 2021; Kruawong & Soontornwipast, 2021). Students are more likely to do something they are accustomed to doing and enjoy doing. By taking into consideration students’ ideas, they can modify lessons, incorporate new strategies, or even model for students how to improve the strategies they prefer.

Studies have been done that researched the use of visuals in helping students learn academic vocabulary. A teacher may decide to construct a word wall as a tool students can reference during class. While traditional word walls have a list of academic terms for the topic or unit, the implementation of an interactive word wall may be more beneficial to their students. Teachers can construct an interactive word wall with their students where students make connections between various words. By having students create the word wall with the teacher, they are able to make meaningful connections and may be more likely to remember the words. An interactive word wall should also include visual support to help students see the word. For example, when teaching about plate tectonics it would be beneficial for the students to see an image of two tectonic plates separating alongside the words “plate tectonics” and “divergent
boundaries”. Using visuals can be especially helpful to ELLs as the image used can help them associate a visual to the meaning and the word.

As visuals provide students with an additional way to interact with a word and its meaning, taking careful consideration as to what visuals are used is a must. Visuals can become distracting especially to ELLs if they do not provide a clue to the word’s meaning (Wright et al., 2014). A science teacher can especially benefit from using visuals to show abstract concepts or processes that cannot be easily visualized by students in the classroom. An educator should identify the key vocabulary terms and provide meaningful images to accompany those terms either as standalone images, as part of a glossary tool, or embedded into text. Getting students accustomed to seeing scientific images as well can help them make connections to different concepts or key terms as they encounter visuals and diagrams in standardized science tests.

Graphic organizers are beneficial tools that can help students organize information and make connections. Studies have been conducted on the effectiveness of the Frayer Model organizer to help students learn vocabulary words, and results from the studies have shown positive vocabulary gains (Estacio & Martinez, 2017; Panjaitan & Sihotang, 2020; Wati et al., 2022). So, the Frayer Model organizer or a modified version of it can be introduced into science classrooms or assigned as homework for students. This organizer can help all students gain a deeper understanding to the meaning of a scientific word, but can be especially helpful for students that have difficulty making sense of abstract scientific vocabulary words or words that they do not encounter in everyday conversation.

**Conclusion**

Teaching students’ vocabulary in addition to teaching students’ vocabulary learning skills is imperative for their success in learning a new language and learning science content. If
students are not given adequate opportunities to strengthen and build on their vocabulary knowledge, it will be extremely difficult for them to truly master science concepts. Science courses require students to be able to read and comprehend science texts, analyze diagrams, synthesize responses, and pass standardized assessments. Scientific texts may include words that a student has never encountered before in their second language or even their native language. Diagrams in science often include labels of scientific words and multiple-choice questions in standardized assessments include academic vocabulary in their questions and answer choices. If teachers do not emphasize vocabulary teaching in their curriculum, it may widen the gaps in learning for the most vulnerable students.

There are various vocabulary acquisition strategies that educators can implement in their classroom. Strategies can include the use of the Frayer model or other graphic organizers that prompt students to engage with vocabulary words in various contexts. The Frayer model has been successful for building vocabulary because it has students define words, provide examples, and non-examples, which creates multiple avenues for understanding a word's true meaning. Studies on the Frayer Model are plentiful with research that shows it is an effective tool for vocabulary teaching. Other studies have supported the use of concept-mapping and mind-mapping as effective strategies in building students’ vocabulary knowledge (Khoshsima et al., 2015; Panjaitan & Sihotang, 2020). Whether the organizer is a template like the Frayer model or an organizer that students must create, like concept-maps or mind-maps, they all achieve the same goal of increasing students’ vocabulary.

It is important to note that vocabulary instruction must include ways to motivate and engage students. As studies have shown, vocabulary teaching must include methods that will provide vocabulary learning in fun and engaging ways. Students are more likely to learn and
want to learn when they are stimulated through the use of games and/or online activities. These games can include crossword puzzles, card games, hangman, and competitive online games (Kruawong & Soontornwipast, 2021; Masoumeh, 2014). Group collaboration and discussion will not only help build social connections within the classroom but help students practice applying scientific vocabulary terms through verbal contexts, which can be especially beneficial to ELLs.

There is a lack of literature on vocabulary development in science. Many studies have been conducted on how to effectively teach students basic words or concepts in a new language. As science curriculum requires students to understand complex concepts within various units of life science and physical sciences, a great deal of vocabulary knowledge is needed. How can teachers bridge the gaps in vocabulary and content knowledge, especially for ELLs and students with disabilities? Future research should study vocabulary strategies within high school science classrooms. Many studies on vocabulary learning deal with ELL students at the elementary level or university students. It would be beneficial to have researched information on how vocabulary learning strategies can help high school students that are learning English as a second language and students that are behind several reading levels.

**Chapter III: Project Work**

In this chapter I will be discussing the implementation of a few vocabulary teaching strategies in a high school science class. As a teacher in New York City, I encounter a diverse group of learners. As my school has seen an influx of English Language Learners and students reading several grades below grade level, I believe it’s important to find ways to better support these students in learning science content. These students are expected to all take the same exam in June that is supposed to gauge their understanding of the science content, however, this can be especially difficult when students lack the vocabulary knowledge. While there are many ways to
help students learn vocabulary words, I chose a handful that were mentioned in several journals. The strategies I will be discussing are: the Frayer Model, word walls, visual aids, videos, and interactive web applications.

**Purpose**

The purpose of this capstone is to inform science teachers on the importance of vocabulary instruction in the science classroom. Towards the end of the 22-23 school year, the science department at my school began to focus on ways to implement more explicit vocabulary instruction into our lessons. This year I brought up the importance of continuing our work with vocabulary for the entire 23-24 school year. Many of our students are reading below grade level, which can make it difficult for them to understand science texts. This year I have implemented various strategies in order to provide my students with as much exposure and practice with tier 3 vocabulary words.

**Student Demographics**

The strategies used in this capstone project were used with 3 Living Environment class periods. I teach 3 ELLs that attend an ENL class for one hour every day. The ELLs are Spanish speakers classified as Beginners with very little knowledge of the English language. Additionally, many of my English-speaking students are enrolled in a reading intervention class every other day with the goal of increasing their reading levels. This means that the majority of my 9th grade students read below grade level which makes it imperative that vocabulary becomes a focus to help them acquire the content knowledge.

**Semi-Structured Interviews – Teachers**

I conducted semi-structure interviews from other teachers and students. A google form was given to teachers at my school pertaining to vocabulary instruction in their classrooms. The
The purpose of this Google Form was to get an idea of how other teachers in my school are teaching vocabulary to their students. This form also provided information on difficulties other teachers are having and possible strategies they have found successful. I have compiled some of their responses in the data table below.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Teacher Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do you teach vocabulary in your classroom?</td>
<td>• In context based on the novels or assigned text we are reading&lt;br&gt;• By association. Having students fill in blanks in the definition. Having them write it out in their own understanding&lt;br&gt;• Word wall, post a math dictionary in google classroom&lt;br&gt;• Students receive vocabulary terms for each unit that are interspersed throughout readings. Students use Quizlet to interact with the terms and take a multiple-choice vocabulary quiz. Writing assignments often include required vocabulary terms. Students also are required to use a specific system of annotating readings which includes circling unknown words and asking for definitions.&lt;br&gt;• I pull words from our class texts and words that fit the thematic unit, usually 10-15 a unit. Then, I introduce them on reading days. Students write the definition in their notebooks. We locate the words in the text, I put them on the word wall, and I try to intentionally incorporate them into discussions and questions.</td>
</tr>
<tr>
<td>2. What strategies have you seen work best with students?</td>
<td>• Pre-reading vocab list; with definition, when possible, vocab contests&lt;br&gt;• By association. For example, substitution. Have the students understand how it works in real life and then bring it into mathematics definition&lt;br&gt;• word wall&lt;br&gt;• Word walls that are frequently referenced, constant exposure to vocabulary and writing assignments that require the use of certain vocabulary words.&lt;br&gt;• When I use vocabulary words over and over and make some connection between their life and the word.</td>
</tr>
</tbody>
</table>
| 3. How do you support SWD’s and ELLs? | • SWD receive the vocab before reading, identified in the pages, and with definitions; ELLs receive the translation  
• The skills above work for all students with English as their dominant language. I have not found an effective way to teach it to ELL students other than typing it out on the translator  
• use of a graphic organizer  
• They receive vocabulary anchor charts that include language translation and English. Words also include any words used throughout the unit that I anticipate students may not be familiar with. Sometimes there are pictures that accompany the words.  
• I use visuals with the words and allow students time to use them in very short story writing. |
| 4. Do you have anything you would like to implement in your classroom? | • Having them find the meaning and definitions but that takes a significant amount of time  
• Yes. A math vocabulary book with math examples. We are working on it now but it is challenging to do A for absolute value, without doing V for variables.  
• have a worksheet that has the vocab words on it ahead of lesson  
• I wish I could dedicate more time to working with meaningful vocabulary but there is not enough time in the curriculum.  
• I want to do more with drawing and maybe games. |
| 5. How much time do you spend a week teaching kids vocabulary or having them practice with vocabulary? | • At least once a week.  
• I incorporate it into the lesson. Usually at the beginning before they begin to use it and emphasizing the definition each time, we use it.  
• not much  
• Appx 20 minutes  
• I am not sure. Maybe 30 minutes or so, but this is more than I have ever done in the past. |

After reviewing the teacher responses, I noticed is that the teachers that responded to the survey spend 30 minutes or less a week teaching students vocabulary or having them practice vocabulary. Teachers found the following strategies to be most useful this year: word walls, real-world connections, and repetition. Teachers have found it difficult to dedicate more time to vocabulary as they try to get through their whole curriculum.
The Use of Visuals

Students are provided with visuals and also expected to create their own visuals that they must connect to vocabulary words. There was a vocabulary word wall in English and Spanish, at the front of the classroom, seen in Figure 2, that was updated every 1-2 weeks with relevant terms. This week students were instructed to watch a BrainPOP video on Cellular Respiration to gain some knowledge before going over it in more detail next week. The video was provided in English and Spanish and had great visuals that accompanied vocabulary words. As students watched the video at their own pace, they had to fill out a vocabulary graphic organizer, seen in Figure 3.

The visuals and word walls around the room were utilized by half of the students consistently in class. While teaching, I could see students looking around the room at key words or concepts that come up in a question. When students were unable to watch the video independently, the video was projected on the board and played twice. The first-time students watched the video without taking notes or answering questions. The second watch, students were instructed to answer questions or take notes. The videos allowed students to interact with vocabulary words in a different context. Videos provided students with a better visualization of a word or process that they would not have been able to obtain through text or a picture.

In this unit students were required to create models that illustrate the different processes that occur in the body of a soccer player during a game. As seen in Figure 5, students were required to make models that used specific vocabulary words to show two complex processes in the human body. The first model required students to show the process of gas exchange on an organ level and cellular level. Students had to include the following words in their models: CO2, O2, mitochondria, ATP energy, cellular respiration. The second model required students to
create a model showing glucose regulation with three additional vocabulary words. This activity gave students a chance to interact with these words beyond a definition. Students had to figure out how to illustrate the word and connect it to a bigger process.

**Word Walls with Visuals**

The use of word walls must move beyond just having a list of words and definitions. Over the years when I would enter other classrooms, I would notice that some rooms had word walls and each word wall varied in appearance and complexity. I found that some word walls provided just vocabulary terms from the unit without any other context to accompany the term. Other word walls had vocabulary terms and definitions, but the wall was rarely ever referenced and some students would not have been able to see the word wall because it was too small or they were too far away. So, while word walls were not a new strategy in my school, I tried to make the use of my word wall more intentional.

A word wall was present at the front and the back of the class. The word wall was updated as students learned new words. After major concepts were completed, words were replaced. The word walls were split down the middle to include English and Spanish words and definitions. Drawings were also added to provide visual context to vocabulary words. I noticed that many students would look around the room during the Do Now when they encountered vocabulary words. When a question was asked to the whole group, students would look around as well or point a classmate to the location of the word.

Based on student observation, students recognized the word wall as a resource they could use during learning activities. When they encountered vocabulary in a lesson that they were not familiar with or had seen but were unsure of the definition, I would instruct students to look around the room. After reminding them to use the resources available to them, some began doing
this on their own. By week 4 other students were advising their classmates to look at the word wall board. I had asked the class, “if glucose is now able to enter the cell, where will that glucose go and what process will happen?” One student I called on had confidently raised his hand and replied, “to the mitochondria.” I wrote mitochondria and drew the mitochondria and the glucose entering. I then asked the class, “That’s correct. What is this process called?” I called on a student and they replied, “cellular respiration.” I asked the class if they agreed and the majority nodded. For the students that had not raised their hand or left their papers blank, I asked one of the students that was confident in their answer, “How did you know it was called cellular respiration? What if you weren’t sure of the name?” The male student replied, “I just knew it. But it’s also written on the board.” He pointed to the board and I instructed all students to look and reminded them to always look around for any clues instead of leaving an answer blank.

**Students Find Word Walls Beneficial**

I believe that it is important for science teachers to provide readily available resources for students in the classroom. I have seen word walls in classrooms that are just a wall of words with no accompanying definition or visual. However, there are many students that need to interact with a word through more than just text. Providing a visual to accompany the word helps them put additional context into that word and its meaning. My classroom has a word wall, as seen in Figure 2, with visuals in both English and Spanish for the purpose of assisting not only my English-speaking students, but English Language Learners of various levels. My ELLs are purposely sat at the front so they have constant access to the word wall if needed.

A student interview was conducted to get student opinions on the word wall and visuals around the room. I chose 3 students and recorded their responses below.

**Semi-Structured Interview on Word Walls/Anchor Chart**
<table>
<thead>
<tr>
<th>Question</th>
<th>Student 1</th>
<th>Student 2</th>
<th>Student 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your opinion of the word walls around the room?</td>
<td>I like them. They’re helpful.</td>
<td>I use them sometimes.</td>
<td>They’re good because they have pictures.</td>
</tr>
<tr>
<td>What do you like about the word walls and anchor charts?</td>
<td>I can look at it if I find a word I don’t know or forget.</td>
<td>I like that there are pictures.</td>
<td>I like that they’re in Spanish and English. Even though I speak English pretty good. I like to see the Spanish translation.</td>
</tr>
<tr>
<td>What could I do better to make the word walls and anchor charts beneficial to you?</td>
<td>Just reminding me to look there. I sometimes forget that the definitions are there.</td>
<td>Nothing. I just need to study the words at home. I forget to study or I forget to take home my binder to study.</td>
<td>Nothing.</td>
</tr>
</tbody>
</table>

Based on the student interviews, the students had a positive experience with the word walls and anchor charts in the room. Student 3, an ELL, found the word walls useful because it had their native language and pictures. Student 1, a student with a low reading level found the word walls helpful because they use it whenever they encounter a vocabulary word they don’t know.

**Gamification, Motivation and Vocabulary Practice**

Students were provided with opportunities to practice vocabulary through online games. The site Gimkit was utilized to help increase students’ motivation and participation as they practiced reviewing important vocabulary words and concepts. The students enjoyed playing online games that went beyond answering questions. Gimkit provided students with additional challenges and competition. For example, during one game session, students had to obtain energy by answering questions in order to move their character through the game board. The objective was to find the opposite team’s flag and bring it back to their home base. But walking
reduced their energy levels. When their character ran out of energy, they were forced to answer a question to gain more energy.

After gathering some information, I decided to move away from virtual games because it seemed to only benefit a small group of students that already had a high level of vocabulary knowledge. These games, while they increased student engagement, they did not provide all students with the necessary practice need to learn the vocabulary words. Several students that would have benefited from the practice, were focused on only progressing through the game. While this is a motivating factor for students, many of the students were pressing random buttons and taking little time to really digest the information. Others became unmotivated when they saw other player’s scores progress.

I researched other online platforms that could track student engagement, while also keeping them entertained as they learned. I chose to use Nearpod as it provided various educational materials and activities that allowed students to practice previous material, while also learning new content. My students completed activities in Nearpod that had them engaged with vocabulary and received instant feedback. Some students had used Nearpod before, and had positive experiences. Nearpod allowed me to make interactive slides in which I implemented vocabulary practice. In Figure 4, I included screenshots of a Nearpod activity in which students had to complete several tasks to help them practice vocabulary and make sense of science concepts. First, students played a virtual match-game that gave them a chance to practice vocabulary words. I embedded previous and current vocabulary from the unit in the matching pair activity. Students were instructed to match a vocabulary term to its definition and/or to an image that represented to the term. They were provided with images, readings, video sources, and questions to help them practice applying the vocabulary words.
While Nearpod did not provide the fast-paced game style of platforms like Kahoot, Gimkit or Blooket, it did keep students engaged. This application was especially helpful for students that need various activities to keep them engaged and motivated. A noticing from observing students play competitive quiz games, was that students became distracted, restless, or bored as time passed. Nearpod remedied this issue as each slide had them complete a different activity. This alleviated the chances of students getting bored from competing the same activity for long periods of time.

**Modified Frayer Model**

This school year was the first time that I implemented the use of the Frayer model in my classes. Very few students had any experience with the model so it required a lot of modeling and guidance on my part in order to get them used to the routine. There was little to no resistance in having students complete these models in class. The majority of students filled out each portion of the Frayer model with the exception of 1-2 students per class. The students were able to locate their Frayer model packets, as they were instructed to place them into the front of their binders for easy access.

Every week I provided students with vocabulary words and definitions. The students were instructed to write the word and its definition in a Frayer Model organizer. I provided students with a packet of blank Frayer models that we revisited every time we examined a new Tier 2 or Tier 3 vocabulary word. I modeled how to use the Frayer model with students as many stated that they had never seen it before. Students copied a student-friendly definition of a word and a characteristic(s) of the word that could help them remember the word’s meaning. Students were then instructed to list synonyms or an image that related to the word’s meaning in the box.
labeled “examples”. Lastly, under the box labeled “non-examples”, students were instructed to write antonyms or words that were the opposite of the word’s meaning.

I noticed that the non-example portion of the Frayer model was causing some confusion in students. This became evident when we went over content-specific words such as, mitochondria and osmosis. So, this resulted in a modification of the Frayer model. Instead of having students write non-examples or antonyms, students were instructed to use the vocabulary word in a sentence. The majority of students were able to write a sentence using the word. Students needed a lot of guidance to ensure that their sentences made sense. Reading and listening to their sentences gave me insight on their perceived meaning of the word and what types of real-world experiences they associated with that word. Students that struggled to write a sentence were provided with focusing prompts and check-ins as I circulated. Two students would be called on to share what they wrote, and students were given the option to write down one of their peers’ sentences so that they didn’t leave the box blank.

In week 4, after going over the term pancreas, I had asked for a student volunteer to summarize what they’ve learned so far, using the Frayer model for guidance. I had a few volunteers but chose a student that showed mid-level mastery of content. The student got up to the front of the class and was instructed to teach his classmates what he learned so far about glucose regulation. The student began by introducing the definition of insulin in his own words after he read the definition provided. When it came to the examples part, as a class we had drawn a cell with insulin attached to its receptor, and glucose going in. This visual image was used by the student in order to describe to his classmates what the image was trying to convey. The student had said, “So this is a cell and insulin comes along and hooks onto the receptor you feel me. Insulin tells the cell to open up to let this glucose in. So, the cell opens. Then the glucose
goes in to the cell to my boy the mitochondria. The mitochondria then uses the glucose to make energy. That’s called cellular respiration. It’s that easy.” It was interesting to see this student convey his own understanding of a complex process and tie in previous vocabulary words that were not specifically written on this Frayer model. This showed that the student was able to properly use vocabulary words and create his own understanding in a way that made sense to him and his classmates.

I believe that the continued use of these sheets is beneficial to students. It requires students to spend more time focusing on a word’s definition, distinguishing characteristics of the word, examples, and visuals of the word. While it does take more time to complete a Frayer model on a word, I believe that it will only benefit the student in developing a better understanding of scientific vocabulary. The modification of the model was needed to make it more applicable to highly specific scientific terms where providing non-examples or antonyms were confusing students. When I instructed students to use the word in a sentence instead, I was able to formatively assess their understanding of the word and address any misconceptions at that moment.

Chapter IV: Conclusion

Conclusions

While there are many ways to teach vocabulary to students, this capstone project focused on a few that were mentioned in various pieces of literature. The use of the Frayer Model and Word Wall with visuals were used to help students learn the vocabulary words for the first time. After that, repetition, gamification, collaboration, using and constructing visuals were activities that were used to supplement teaching activities and provide students with additional practice.
Repeated exposure to words is necessary for students to store words into their long-term memory. By providing students with multiple opportunities to see, hear, write, and verbalize words and their meanings, it increases the chances of them understanding the term’s meaning. When a teacher finds routines or activities that work well with students, it’s important to keep that routine on a consistent rotation. This way students will become accustomed to the routine and will also get the repetition they need to acquire skills and content knowledge.

As science terms can feel very abstract to students, the literature has shown that the use of visuals is helpful for students to understand the meaning of words. Visuals can be incorporated into text, anchor charts, word walls, videos, and other learning activities. ELLs and students with low reading levels, can utilize the visuals to make sense of a word’s meaning, beyond just a text definition. Seeing, using and creating visuals can help students make sense of complex processes that they might not be able to see. Often these abstract words or scientific concepts are not encountered in their everyday life. So, it’s imperative that teachers find ways to have students visualize abstract terms.

**Implications for Practice**

As science teachers may not have received formal training on how to best teach vocabulary to their students, it is important for them to incorporate vocabulary learning into their teaching. While there is not one set way to have students learn and practice science vocabulary, teachers can try out different strategies until they find ones that works best for their students. Teachers can research and implement a few strategies and routines that may help their students better acquire science vocabulary and implement them into their lessons. The collection and analysis of data can provide teachers with information on strategies to continue, modify, or remove.
Based on my findings, providing students with time to learn vocabulary words would be beneficial. The Frayer Model provided students with time to engage with individual vocabulary words. Having students use the Frayer Model provides them with extra time to engage with a vocabulary word that they may not normally spend much time learning. Students may require some extra support when first implementing this strategy with them, but the goal is for them to be able to complete all sections on their own. My students required modeling and support in order to complete a handful of vocabulary terms found at the start of Unit 1. As time progressed, they were able to complete the Frayer Model independently. While the Frayer Model can be modified to fit students’ needs, it’s important to at least give students the opportunities to unpack vocabulary terms and practice using them in their own words.

Science content involves the use and creation of visual models to show complex or abstract processes. While there may be diverse levels of learners in a classroom, visuals can be a way to help students make sense of a word’s meaning. Teachers should find opportunities to incorporate meaningful visuals in their lessons when teaching abstract words. This is especially helpful with visual learners as they can associate an image or video clip to a vocabulary word when they encounter it in a reading or question. Students were provided with multiple opportunities to interact with visuals during Unit 1. For example, my students were instructed to create multiple models illustrating feedback mechanisms, which had to include the drawing and labeling of vocabulary words. As students practiced creating and revising these models, they obtained frequent exposure to vocabulary terms and visuals associated with them. The use of visuals can be incorporated through the Frayer Model, videos, readings, questions, and the creation of complex models. It’s imperative that teachers are mindful of visuals that they will present to students or have them create as to avoid any possible confusion in meaning.
Additionally, it’s important for teachers to collect periodic quantitative and qualitative data on their students’ progress and opinions. This data can then be used to drive further instruction and make necessary modifications if needed. This can reduce the amount of time teachers spend on activities or routines that are not beneficial to their students. After reflecting on my students’ behaviors and scores during a few online review games, I had decided to make the shift to an entirely new online application. This shift proved to be more beneficial in helping students learn new words and practice old words, while also keeping them entertained. Collecting and reflecting on data can also reinforce routines and strategies that are benefiting students. My students thought the visual word wall at the front of the room was useful to their learning, so I made sure to regularly maintain and reference the word wall every week. Teachers know their students best, and as they get to learn how their students learn, they can modify activities and resources to best support them in learning science.

**Recommendations**

Preparation programs should consider ways to prepare science teachers for diverse learners with various needs. While these programs may prepare science teachers on ways to create lesson plans and deliver lessons, they lack in providing teachers with proper tools that will benefit ELL students and students with disabilities. Some science teachers may teach classes with a TESOL teacher or special education teacher, that can support in ways to help ELLs and low readers, but this is not always the case. While I only had a few English Language Learners, I spent a great deal of time trying to find ways to support them as well as my students with disabilities (SWD). This is still an obstacle to navigate as ELLs and SWDs face several barriers when trying to learn scientific vocabulary. By providing teachers with opportunities to learn and practice vocabulary strategies before they complete their preparation program, they will be better
prepared to teach diverse learners that struggle with language acquisition and reading comprehension.

Schools should establish PLC’s or Teacher Study Groups (TSG) with the purpose of having teachers learn to better their practice from other teachers. It is important that professional development groups in school collaborate in order to create lessons, relevant activities and apply relevant strategies to help one another teach vocabulary or other necessary skills to their students. I did not have opportunities to collaborate with science teachers or other content teachers, which made it a bit difficult to implement strategies. By getting teacher input on what should be an area of focus, it makes the professional development more relevant and useful. Based on the survey I sent out to teachers, there were strategies that teachers found useful in their classroom that others were not using in their classrooms. Overall, teachers felt that there was not enough opportunity to teach or practice vocabulary with their students and they wished they could find better ways to support their ELLs and SWDs. This dilemma could be remedied through relevant professional developments opportunities that allow teachers to learn from more experienced teachers on best practices for teaching vocabulary to students.

**Final Thoughts**

After completing this capstone project, it is evident that vocabulary instruction is a crucial component of learning science content. Teachers may not know how to successfully teach vocabulary to their students in a way that is efficient while also giving them time to finish their curriculum. However, students cannot understand important concepts if they lack vocabulary knowledge. The literature shows that there are a few ways to help students acquire vocabulary knowledge, however, more research should be done on vocabulary learning strategies in high school science classrooms. Teachers should seek out opportunities to learn from other
professionals on the best way to support their students, especially their English Language Learners and Students with Disabilities, as these groups face more challenges acquiring scientific vocabulary terms.
References


[https://doi.org/10.1080/00220671.2021.1881754](https://doi.org/10.1080/00220671.2021.1881754)

Appendix A

Figure 1

1. Biology is the study of ________ Things

- **Definition:**
- **Characteristics:**
- **Features that help you distinguish or recognize the word:**
- **Examples:**
- **Non-Examples:**

2. La biología es el estudio de ________ cosas.

- **Definición:**
- **Características:**
- **Funciones que te ayudan a distinguir o reconocer la palabra:**
- **Ejemplos:**
- **No ejemplos:**
- **Antónimos o claros ejemplos que son muy diferentes de la palabra:**
Appendix B

Figure 2
Appendix C

Figure 3

¿Qué es la Respiración Celular?

Instrucciones: Mira el video BrainPOP Cellular Respiration (enlace en Google Classroom) y toma notas sobre qué es la respiración celular y cómo funciona.

<table>
<thead>
<tr>
<th>Término</th>
<th>Definición</th>
<th>Imagen (un dibujo que te ayuda reconocer el término)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sistema respiratorio</td>
<td><strong>Para procesar la glucosa para proporcionar energía.</strong></td>
<td></td>
</tr>
<tr>
<td>Respiración Celular</td>
<td><strong>Reacciones químicas que son combiertidas en compuestos como la glucosa que luego se regenera por la respiración celular.</strong></td>
<td></td>
</tr>
<tr>
<td>Glucosa</td>
<td><strong>Es una energía creada por la respiración celular.</strong></td>
<td></td>
</tr>
<tr>
<td>Tema digestivo</td>
<td>Definición</td>
<td>Imagen que te ayudará a recordar</td>
</tr>
<tr>
<td>---------------</td>
<td>------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Se ocupa de descomponer los alimentos todo el día y con bengalitas en glucosa para alimentar a las células</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mitocondrias</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>En la mitocondria se oxida la glucosa en una reacción química llamada respiración celular</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ácido de carbo no</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>El ácido de carbono lo desechan a la sangre que la trasportan a los pulmones donde se oxigena y expulsan los gases</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**¿Qué es ATP?** ¿Qué nos ayuda a hacer el ATP (trifosfato de adenosina) en el cuerpo?

Son el trifosfato de adenosina son como las monedas energéticas del cuerpo, permiten a las células sintetizar moléculas orgánicas complejas como ADN el ARN y proteínas.

**Dibuja** un boceto que resuma lo que aprendiste sobre la respiración celular en el video.
Appendix D

Figure 4
Watch any of these videos if you need some review.
Appendix E

Figure 5

UNIT 1: THE SOCCER PLAYER

Glucose Regulation Models

Directions:
- Create a human body model and a cell model to show what happens when a person is maintaining homeostasis.
- Draw an arrow from the human body to the detailed model showing what part of the body the zoom in is located.
- Include these components: O, CO, ATP, mitochondria, glucose, insulin, pancreas
- Circle or highlight any parts that could model the sick soccer player.

Human Body Model

Detailed _________ Cell Model
UNIT 1: THE SOCCER PLAYER

Glucose Regulation Models

Directions:

☐ Create a human body model and a cell model to show what happens when a person is maintaining homeostasis.

☐ Draw an arrow from the human body to the detailed model showing what part of the body the zoom in is located.

☐ Include these components: O2, CO, ATP, mitochondria, glucose, insulin, pancreas

☐ Circle or highlight any parts that could model the sick soccer player.

Human Body Model

Detailed __________ Cell Model