Implementing a Technology-Based Instructional Module in An Introduction to Engineering Course: The Impact on Student’s Vocabulary Retention and Attitudes Towards Learning

Robin T. Amick

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IMPLEMENTING A TECHNOLOGY-BASED INSTRUCTIONAL MODULE IN AN INTRODUCTION TO ENGINEERING COURSE: THE IMPACT ON STUDENT’S VOCABULARY RETENTION AND ATTITUDES TOWARDS LEARNING

by

Robin T. Amick

Bachelor of Science
Lander University, 1992

Master of Education
Columbia College, 2006

Master of Education
University of South Carolina, 2008

Submitted in Partial Fulfillment of the Requirements
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University of South Carolina
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Accepted by:

Ismahan Arslan-Ari, Major Professor
Michael Grant, Committee Member
Fatih Ari, Committee Member
Anna C. Clifford, Committee Member
Cheryl L. Addy, Interim Vice Provost and Dean of the Graduate School
DEDICATION

This dissertation is dedicated to my family, both my biological and my work family. You have encouraged me every step of the way, picked me up when I thought I could not continue on, and kicked my tail when needed. This has been a long dream in the making and all of you encouraged me every step of the way.

To my work family, thank you. I am so grateful for a community of professionals who offered advice, proofreading services, and lots and lots of encouragement. There were times that I did not think I could or should go on, and certainly it seemed the end would never come, but you all helped me see the goal and kept me moving forward.

My students – you rock! I never thought teenagers could be so invested in my journey, but you all certainly have been. From counting down the years, to months, to days. I love “my kids” and I am forever grateful for your willingness to take this journey with me.

Lastly, my dear husband, Ashley, you are my rock and biggest supporter. My daughter, Courtney, you are my bestie and such a cheerleader! Thank you for understanding when I needed to be alone to work and when I needed to take a break. Thank you for believing in me. All my love.
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ABSTRACT

The purpose of this study was to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Project Lead the Way (PLTW) Introduction to Engineering course. The goal of the study was to answer two key questions: 1) How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course? and 2) What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course? This study was conducted with Introduction to Engineering students (N=23) during the second semester of a year-long course. Students were instructed during this module through the use of various computer-based learning platforms, providing both imagery and text, allowing for at-will access and review, and creating varied forms of practice.

Data were collected through pre- and posttests, focus group interviews, and surveys. Data were analyzed through paired t-test and inductive analysis. Quantitative analysis revealed significant growth from pre- to post-assessment for engineering vocabulary academic gains. Qualitative analysis revealed increased scores and improved attitudes towards learning from pre- to post-intervention.

The findings of this study indicated that although technology-based instruction had a positive impact on academic gains, relevance of the material and the relationship with the instructor influences both academic gains and attitudes towards learning. The
research has implications for future research with technology-based versus traditional instruction and reevaluation with students who are more than one-year post-Covid virtual learning.
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CHAPTER 1
INTRODUCTION

National Context

It is well known to educators that students need to understand and be able to apply content vocabulary and literacy skills both inside and outside the classroom. In order for students to develop strong lifelong and varied literacy skills, they must develop a strong vocabulary knowledge base (Adlof et al., 2019; Kutner et al., 2007). This instruction must be a continuous component of education from the elementary to the secondary level, and even into post-secondary education (McPherson & Dubé, 2016; Simoneau, 2019). In the fields of science, technology, engineering, and mathematics (STEM), this becomes even more critical as enrollment and successful earning of a degree are defined as areas of national need (Goan et al., 2006). In addition, there are reports of a decline in students pursuing STEM careers in secondary education (Durodolu, 2018; Goan et al., 2006; Gottfried & Plasman, 2018; Mau & Li, 2018; Pollock, 2019).

Due to these concerns, there has been a push to increase student interest in the STEM majors and to pursue post-secondary degrees. The creation of the federal Carl D. Perkins Career and Technical Education Improvement Act (Perkins Act) provided funding for more fully developed academic programs (Simoneau, 2019). Part of this fully developed curriculum was designed to create a solid foundation for students in the STEM fields. This foundation includes a strong understanding of the technical academic vocabulary (McPherson & Dubé, 2016; Simoneau, 2019).
Students must develop the ability to take the taught vocabulary and apply it academically and in real-life scenarios. Students are tested on this ability as they complete teacher created and national/state-standardized tests. In 2018, only 51% of students in the United States who followed the core class requirements, to include 4 secondary English classes, achieved the ACT Benchmark score for Reading, and for students who did not follow the core schedule, only 35% met the minimum score (American College Testing Inc., 2018). This is a direct reflection on a student’s ability to perform on the college level and in the workplace.

Students need a large knowledge base of literacy in order to be truly college and career ready; this includes the ability to deconstruct, critique, analyze, and further apply the vocabulary taught in the k-12 classroom (Adlof et al., 2019; American College Testing Inc., 2018; Haycock, 2010; Hayes & Wilson, 2016). In an additional study, Catts (2012), identified the five components for achieving a strong base of literary skills as: 1) recognizing literary needs, 2) locating and evaluating information, 3) storing and retrieving information, 4) using the information effectively and ethically, and 5) the ability to use the information to communicate knowledge. Further studies support the concept of literacy being less about the ability to read and more about the ability to comprehend and apply knowledge gained through vocabulary and reading (Caldwell & Webster, 2013; Hayes & Wilson, 2016; Song, 2019).

Students are tested on vocabulary and literacy skills as needed within the classroom, but there have been limited tests of the measures of the ability to apply these skills in life situations (Caldwell & Webster, 2013). There have been studies to prove the need for strong information literacy skills, specifically, the ability to comprehend and
apply information to create new knowledge, which is much more than rote memorization (Catts, 2012). It should also never be assumed that students have the skillset to master any literacy task given, these skills must be taught throughout the educational experience in order for students to find success in vocabulary comprehension and application (Durodolu, 2018; Williams & Armstrong, 2017).

Researchers have provided evidence of the value of true learning instead of reviewing for memorization (Grundmeyer, 2015; Jarrett-Thelwell, et al., 2019; Swanson, et al., 2017; Webster & Willett, 2019), especially when technology is a component of the instruction (Kara, 2008; Koretsky & Magana, 2019; Moratelli & Dejarnette, 2014). Technology, when used appropriately, can be an integral part of the instructional process. Maninger (2006) found evidence of a positive link between the integration of technology and academic results for both teachers and students. Teachers noted a greater ability to individualize instruction and students demonstrated increased test scores from the previous year.

Other studies point to the need for teacher monitoring and careful oversight of students’ activities when utilizing technology in a 1:1 device environment (Dreyer, 2014; Koretsky & Magana, 2019; Rashid & Asghar, 2016), especially when students have personal devices, access to social media, or open Internet access (Burnham & Mascenik, 2018; Rashid & Asghar, 2016). Additional reports caution schools in the use of technology for instruction as there must be clear guidelines, timely feedback, and explicitly taught knowledge and skills to avoid the technology becoming a barrier to learning instead of an asset (Green et al., 2015; Lefevre & Cox, 2016).
Local Context

The school within this study was located in South Carolina with approximately 1700 students; 49% white, 36% African-American, and 15% other. For the 2018-2019 school year, the average SAT score was over 1100, the average ACT score was over 20, and AP exams had an average pass rate over 75%.

Within the school system, students had the ability to graduate under an engineering program of study. Students in the program were required to take, and pass with at least an 80, a minimum of four engineering courses in addition to the other requirements for graduation.

Teachers within the school were encouraged to incorporate the 4Cs into instruction: collaboration, communication, creativity, and critical thinking. Teachers received regular professional development training to stay updated on current technology and research-based instructional methods. Students were incentivized to succeed through a school-wide Positive Behavioral and Intervention Supports, or PBIS, system. Any school employee could reward a student with a certificate. Students could redeem PBIS reward certificates for cafeteria purchases, pay school debts, or special privileges.

According to South Carolina report cards, for the 2018-2019 school year, the school had a graduation rate over 80%. The average teacher to student ratio was 25.2:1, and over 77% of the teachers held advanced degrees in their subject area.

Students participating in the Introduction to Engineering course were taking the first course in the mechanical/civil/electrical engineering educational tract. These students were being introduced to the concepts and procedures of the engineering field. For many students, this was their first engineering course and a foundation for following
the engineering pathway in their college and career life. Introduction to Engineering is a Project Lead the Way course, designed by both education and industry professionals. The material in this course served as a baseline for the higher-level engineering courses; thus, this course served as a foundation for success. Students participated in both traditional instruction and project-based learning activities. At the conclusion of the course, students took an End-of-Course exam in an attempt to qualify for college credit. As this test utilized all of the content vocabulary, the researcher sought to define if there was a relation between improved vocabulary knowledge and increased test scores.

**Statement of the Problem**

Students in the Introduction to Engineering class were not retaining the content vocabulary necessary for the successful completion of the engineering program. Sparks (2013) referred to vocabulary as the “key to upward mobility.” Proper vocabulary instruction, and thus full understanding of the terminology being taught and its usage, leads to achieving the highest effect on student learning (Kieschnick & Casap, 2017). Vocabulary instruction has been found to directly impact literacy competency and academic achievement across all disciplines (Adlof et al., 2019). In addition to a consideration of the instruction itself, Clark, Scafidi, and Swinton (2011) pointed to the influence of personal perceptions on student attitudes and outcomes; therefore, it also becomes important to consider how attitudes towards learning academic vocabulary may interfere with learning and academic success.

During the 2018-2019 school year, students were provided the vocabulary for each unit of the Introduction to Engineering course and assessed with vocabulary quizzes with an average score of 60% for the first attempt and 75% for the second attempt. In
order for these students to continue through the engineering coursework and graduate as an engineering program completer, the foundation vocabulary must be mastered in the Introduction to Engineering course.

**Purpose Statement**

The purpose of this study was to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Introduction to Engineering course.

**Research Questions**

The following research questions were explored in this study:

1. How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course?

2. What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course?

**Statement of the Research Subjectivities and Positionality**

Who am I? I am a white, middle class, Christian, educated female teaching in a large high school in South Carolina. I am a supporter and believer in educational technology and the benefits it can provide to students as they learn. I believe educational technology is a tool, that when used properly, can enhance learning. I also see educational technology as a means to bridge the gap for struggling students, offering an alternative method of learning and opportunities to progress at an individual pace. This
can be accomplished as long as the technology is carefully aligned with instructional goals and the needs of the student (Koretsky & Magana, 2019).

In both my personal life and my job as a career and technology teacher, I utilize technology as a key component of my daily life. I believe this enhances my ability to be an ideal educational technology professional. I encourage my students to use the technology available to create, present, and study as we progress through the course units. I also use social media both personally and professionally to celebrate accomplishments and connect with other professionals and friends. In regards to my challenges with becoming an educational technology professional, I have struggled with balancing the large influx of available technology with the proper and full application. I often find myself under-utilizing a program or device because I have not had time to fully understand the capabilities before a new technology is introduced. Therefore, I will also utilize this study to improve my own skills by researching technology options and seeking help from other professionals.

My worldview is best aligned with pragmatism as the current research focuses on allowing both the qualitative and quantitative work together to seek out a solution to a real-world problem (Wahyuni, 2012). Pragmatic researchers often view traditional research as restrictive and limiting of intellectual curiosity (Davies & Fisher, 2018). This aligns with my own thinking as I seek to understand student gains from not only the academic standpoint but the social-emotional as well. The answers to my questions must be more than a number, but more a view of the whole child in relation to learning.

I view my research as falling on the continuum presented by Herr and Anderson (2005) as Insider research. I will be evaluating a program in which I am an active
participant and studying the differences in the motivational and academic outcomes of the students through observations conducted by both myself and school administrators and by evaluating the test scores of the students as a whole. As I am involved with the participants on a daily basis and have established a relationship with them, it will be easy to negotiate my position. The students and I work well together and have a good rapport. It is both expressed and understood that I work to help them achieve success. In addition, I will establish the need for honesty and anonymity in the study. With a healthy conversation, I can establish with the students that the study is for my growth, as well as, for theirs.

Finding a method to improve vocabulary retention was the focus of my study. I wanted to find a way to help my students better obtain, understand, and retain the content vocabulary as it is critical for progressing through the engineering curriculum and major. To me, this meant using common sense and practical thinking in regards to the research. It involved a mixed-method design that sought to find what works best for the problem at hand (Wahyuni, 2012). Pragmatism also best served the study as it lends itself to finding multiple reasons for a problem and developing the solution based on this information, thus the need for quantitative and qualitative data (Creswell & Creswell, 2018). For my research, “pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis” (Creswell, 2014).
Definition of Terms

**Technology-Based Instruction:** Technology-based instruction develops 21st-century skills, builds vocabulary, promotes comprehension development, and includes websites that promote literacy learning (Laverick, 2014). In addition, Rashad and Ashgar (2016) define technology-based instruction as any tool that provides a platform for, “taking notes, participating in discussion forums, access to supplementary resources, software, and applications, and facilitate student-student and student-faculty interactions…” Technology-based instruction, for the purpose of this study, is the use of computer software, websites, and review games readily available through district-issued Chromebooks.

**Traditional Instruction:** Teacher-led instruction with the use of drill and practice to memorize a term (Tan et al., 2019).

**Attitudes Towards Studying Engineering:** During the study, the term attitudes will focus on a student’s mindset in regards to learning and school itself. Student’s personal goals, self-perception, and confidence in the subject will also be a construct of attitude. Studies show that learning is strongly tied to the beliefs, values, and attitudes of learners, (Moyer et al., 2018; Parr & Bonitz, 2015; Shaw et al., 2019), but there are limited studies of instructional methods on affects (Moyer et al., 2018).

**Vocabulary Instruction:** Vocabulary instruction involves the meaningful and explicit learning of content terminology (Fainman & Tokar, 2019) in order to ensure academic and professional success beyond traditional k-12 schooling (Hayes & Wilson, 2016)
CHAPTER 2
LITERATURE REVIEW

The purpose of this study was to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Introduction to Engineering course. The study focused on student academic gains and attitudes towards learning in the Introduction to Engineering class. The review of related literature focused on the following two research questions, (1) How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course? and (2) What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course?

Based on these questions, the initial literature search focused on three main variables: the importance of vocabulary acquisition and retention, the impact of outside influences on student motivation and success, and the impact of instructional methods on academic gains. Upon completion of this initial phase of the study, additional articles were identified using the following keywords and phrases: (a) vocabulary instruction, (b) high school instruction, (c) STEM, (d) engineering education, (e) student motivation, and (f) teacher impact. Searches were also conducted by utilizing a combination of keywords, often in conjunction with the initial variables revealing additional relevant research studies with potential impact on the current study. Electronic databases, such as
ERIC, JSTOR, Education Source, and Academic Search Complete, were used to search for published articles. Based on the articles found using these databases, additional resources were located by mining the reference sections of other articles. In addition, recommendations by colleagues led to a number of useful resources. Google Scholar was also utilized as a means to locate and cross-reference resources.

The review of literature was organized into four sections, (a) the importance of and the relationship between Engineering education and STEM education, (b) the critical importance of vocabulary acquisition and comprehension in all subject areas (c) the various factors that can impact a student’s motivation to learn, both external and internal factors, (d) cognitive load theory and cognitivism, and (e) the definition and importance of technology-based instruction.

STEM and Engineering Education

Engineering education is considered a critical component of both STEM education and preparation for skills beyond the classroom (McComas & Burgin, 2020; Xie et al., 2015). As students engage in STEM education, they develop skills that are valuable both across the curriculum and for college and career readiness (English, 2016; Phelps et al., 2018). The exploration of STEM and engineering education will be divided into two parts, (a) the definition and role of STEM education and its importance as a component of secondary school, and (b) the particular importance of Engineering in the STEM curriculum and its impact on the learner.

STEM Education

STEM education is an established field of education making a tremendous impact on the college and career readiness of elementary, secondary, and college-level students
(McComas & Burgin, 2020; Xie et al., 2015). Xie et al. (2015) also characterize STEM education “as a channel for individual social mobility, allowing socially disadvantaged persons to succeed through objectively measured criteria accepted by STEM educators and scientists” (p. 333). The exploration of STEM and engineering education will be divided into two parts, (a) the definition and role of STEM education and its importance as a component of secondary school.

**Definition of STEM**

STEM is an acronym for Science, Technology, Engineering and Mathematics. A definition for the term STEM is dependent on the setting in which it is implemented. For the elementary level, this is defined as the science and math curriculum required by all students, for the secondary level, students have the opportunity to not only explore the opportunities within the tracks of STEM but to expand their knowledgebase with courses in the social sciences (Xie et al., 2015). McComas and Burgin (2020) assert the idea of confusion with the definition of STEM with the accepted belief that teaching or implementing any one aspect of STEM makes the instructional model a STEM model. The more widely accepted definition was best described by Thibaut (2018) as an environment in which teams of students are exposed to integrated research and engineering throughout their courses resulting in meaningful learning experiences. This definition both aligns with and defines the scope of the current study.

**STEM in the Secondary School and Cross-curricular Impact**

There are five key principles of integrated STEM education that can be integrated into any content: (1) integration of STEM content, (2) problem-centered learning, (3) inquiry-based learning, (4) design-based learning, and (5) cooperative learning (Thibaut,
Bruce-Davis et al. (2014), and Wright (2018) expand upon the significance of STEM as both a foundation of skills to promote higher-order thinking and developing a change in student beliefs regarding equality and problem-solving ability. Studies have also shown students involved with an integrated STEM curriculum perform even better than their peers (Thibaut, 2018). As students are exposed to STEM education, and it is implemented in a cross-curricular format, the ability to apply skills from multiple contents to develop a solution to a real-world problem grows (Bruce-Davis et al., 2014).

**Engineering Education**

Engineering education includes the study of mechanical, civil, electrical, and biomedical engineering, just to name a few (Carl D. Perkins Career and Technical Education Act, 2006) and was federally funded by the Carl D. Perkins Act (Gottfried & Plasman, 2018). Further push for engineering societies and other organizations to encourage interest in STEM careers, which includes informal learning with engineering camps to draw underserved populations into the 21st Century career fields, was established by President Obama with the creation of *Educate to Innovate* (Sahin et al., 2015). Government programs and plans were designed to ensure accessibility for all students and to impart skills and knowledge that have direct currency to the daily challenges and problems students will face should they pursue a college degree or career in engineering (Gottfried & Plasman, 2018). Engineering education serves as a platform for fostering creativity, collaboration, communication, and problem-solving, as well as, cultivating the use of technology to design solutions to real-world problems (Chien & Chu, 2018). Malkiewich and Chase (2019) assert the importance of engineering education with two important arguments: (a) learning abstraction allows students to learn
to problem-solve, and (b) students need content goals not just task goals. As schools implement engineering education programs, studies have shown two positive connections, (a) college and career readiness, and (b) critical thinking skills.

**Engineering education and college and career readiness**

Engineering education in secondary education has been found to positively influence college and career readiness (Chien & Chu, 2018; Gottfried & Plasman, 2018; Malkiewich & Chase, 2019). Malkiewich and Chase (2019) state “Many scholars have touted the benefits of these curricula for teaching valuable engineering practices, developing broader twenty-first-century skills, and raising interest in engineering careers” (p. 552). Engineering education allows students to discover future careers, motivating them to learn and integrate STEM into other curricula (Chien & Chu, 2018). Additionally, the high school engineering curriculum increases exposure to underrepresented populations and provides opportunities for diverse educational and work environments which foster creativity, innovation, communication, teamwork, and productivity (Gottfried & Plasman, 2018).

**Engineering education and critical thinking skills**

Typical school instruction does not promote critical thinking skills (Bećirović, et al., 2019) but rather utilizes the dissemination and memorization of information (Webster & Willett, 2019). It is not for a lack of understanding, as most academic institutions do understand the need for critical thinking, but lack training on instructional activities which facilitate critical thinking (Song, 2019; Webster & Willett, 2019). The importance of critical thinking is best described by Cetin et al. (2019) with the notation “On the other hand, in our world, which constantly changes and evolves thanks to what technology
brings into our lives, there is an increased need to raise individuals who are able to renew themselves, learn autonomously, and have higher-order thinking skills such as critical thinking and deducing” (p. 192).

The literature provided evidence of the benefits of STEM education and engineering education in both their independent setting and across the curriculum. While the definition and importance of both STEM education and engineering education have been explored, it is critical to understand the ties to a basic construct of integration of information and the importance of vocabulary acquisition and comprehension.

**Vocabulary Acquisition and Comprehension**

Vocabulary comprehension and acquisition are critical for academic success in all courses, including engineering. (Buran, et al., 2019; Durodolu, 2018; Harmon, et al., 2018; Hooley & Thorpe, 2017; Laverick, 2014; Sedita, 2005). When discussing vocabulary acquisition, three important factors must be explored, (a) vocabulary acquisition is vital in all levels of education and subject matter, (b) there are multiple methods of vocabulary instruction, and (c) learners should hold a vast lexical knowledge to speak, read, write, and gain rich knowledge.

**Vocabulary Acquisition**

Researchers have shown a decrease in reading proficiency since 1992 (Hooley & Thorpe, 2017). Yet, other researchers have also shown the importance of vocabulary skills (Harmon et al., 2018; Hooley & Thorpe, 2017; Vintinner, et al., 2015) in order to speak, read, write and gain knowledge as students progress through their educational and professional careers (Harmon et al., 2018; Touti & Maleki, 2016). Vintinner et al. (2015) noted a shortfall in literacy skills in a study where only 6% of seventeen-year-olds read at
a level that allowed for the higher-order thinking skills required to understand complicated texts and documents. It is, therefore, important for students to develop a vast lexical knowledge (Touti & Maleki, 2016) to include domain-specific and generalized academic vocabulary (Harmon et al., 2018). Buran et al. (2019) cite the importance of vocabulary instruction in the engineering classroom. Their study noted the importance of including the use of synonyms, collocations, and creative reading tasks to increase student understanding of technical texts.

**Vocabulary Instruction**

Traditional vocabulary instruction includes guided reading and is tracked through summative assessments, but rarely taught directly past early childhood education (Hooley & Thorpe, 2017). Multiple researchers have shown both the importance of direct and indirect vocabulary instruction (Durodolu, 2018; Sedita, 2005) and the relationship between the written word and spoken language (Sedita, 2005). Traditional methods of vocabulary instruction include semantic mapping, semantic prosody (Douglas, 2016), fill-in-the-blanks, task type instruction (Touti & Maleki, 2016), word walls, and drill and practice (Vintinner et al., 2015). Douglas (2016) noted the importance of semantic prosody for vocabulary acquisition as the connotation and intonation of a term is directly related to the imbued meaning. Furthermore, this study notes the value of semantic mapping to allow the reader to develop a visual relationship of the term and any related terms.

The majority of vocabulary instruction is through drill and practice or incidental learning through reading tasks (Vintinner et al., 2015). In addition, Touti and Maleki (2016) note the lack of dedicated class time for vocabulary instruction. Their study found
the higher the involvement load of the student, the greater the vocabulary acquisition and comprehension. In the field of engineering, this would prove invaluable as the baseline vocabulary is continually built upon through the course of study. Research by Vintinner et al. (2015) notes the benefits of interactive vocabulary instruction, specifically word walls, allow for immediate feedback, formal assessment, and as a visual reinforcement for key vocabulary terms. The development of digital flashcards, as planned in the current study, provides similar consequences in vocabulary instruction.

**Lexical Knowledge**

A strong base of lexical knowledge allows a reader to facilitate the discovery of new words as they explore texts (Palmer et al., 2019). Students need this base as they progress through school and face new material (Hooley & Thorpe, 2017) in order to have the capacity to learn and expand their content and daily vocabulary (Hooley & Thorpe, 2017; Vintinner et al., 2015). A strong lexical knowledge base allows the reader to understand unknown words as “the identification of known words in connected speech allows the edges of adjacent (novel) words to be inferred” (Palmer et al., 2019, p. 139).

As much as the research has shown the importance of vocabulary acquisition, it has also shown that it is only as effective as the method of instruction. Despite the research and proven methodologies, studies have also shown that student success relies on student response to factors outside the scope of instructional strategies to include (a) social influence, (b) distractors, and (c) external and internal motivation.

**Student Attitude and Motivation**

Research has shown that many factors impact student attitude and motivation towards learning and thus greatly impact student success. (Fan & Wolters, 2014; Tan et
This myriad of factors may be either a positive or negative influence on student success including, (a) social influence, (b) distractors, and (c) external and internal motivation.

**Social Influence**

As students navigate through school, they can be strongly influenced by peers, homelife, and parental involvement. These influences have the potential for both positive and negative impacts. Social influence on student success has been widely studied (Balkıs, et al., 2016; Clark, et al., 2011; Parr & Bonitz, 2015). Balkis, Arslan, and Duru (2016) note the top reason for student failure was absenteeism, specifically due to boredom, negative encouragement of friends, lack of educational expectations, or general dislike for school. In addition, socioeconomic status and the educational level of the parent have been found to impact both student performance and beliefs about the importance of education (Balkıs et al., 2016; Parr & Bonitz, 2015). A final social impact that may lead students away from academic success comes from socio-cultural influences (Cantrell et al., 2018).

**Peer influence**

Clark, Scafidi, and Swinton (2011) note the tremendous influence of peers on educational outcomes. The influence may be positive or negative (Balkıs et al., 2016) and includes not only the student’s social group but class peers, as well (Clark et al., 2011). As with many influences, the negative implications can be targeted and overcome (Parr & Bonitz, 2015). Class placement with high achieving peers has been found to increase student achievement and placement with low achieving peers has been found to decrease achievement (Clark et al., 2011).
Homelife and parental involvement

The first influential factors impacting student success are homelife and parental involvement and have been found to be the most difficult to overcome (Parr & Bonitz, 2015). Homelessness or home instability can easily outweigh the desire for academic success (Uretsky & Stone, 2016). Students from lower-income households have been found to have higher absenteeism, lower expectations of academic success, and a greater focus on meeting basic needs (Cantrell et al., 2018; Parr & Bonitz, 2015). Researchers Uretsky and Stone (2016) reported lower grades, lower standardized test scores, increased absenteeism, and increased behavior issues for students dealing with homelessness or home instability.

Students who have parents with low educational levels or parental involvement have been found to have increased absenteeism and lower educational expectations (Balkış et al., 2016). On the opposite end, students who have highly educated parents are found to have greater expectations, especially relative to the level of involvement of the parent (Balkış et al., 2016; Parr & Bonitz, 2015).

Distractors

Today’s students are faced with multiple distractors that may negatively impact the academic success (Cantrell et al., 2018; Heflin et al., 2017; Uretsky & Stone, 2016; Wernette & Emory, 2017). Many activities, which are often considered positive, can also be distractors for students. These activities can include social events, sports, and even the mobile technology that schools often depend on for student communication and engagement. There is evidence to support both positive and negative connections between outside activities and academic success (Fredricks, 2012). In addition, students
may have stress outside of school from the need to be either emotionally or financially supportive of their family.

**Mobile technology**

Most schools utilize some form of mobile technology. These devices, as well as student personal devices, can be as much of a distraction to students as it is an enhancement (Heflin et al., 2017). According to *6 Pros & Cons of Technology in the Classroom 2021* (2021), technology may not only be a distraction from school but cause the disengagement of students from social interactions. This may lead to a reduced ability to verbally communicate (6 Pros & Cons of Technology in the Classroom 2021, 2021; Taneja et al., 2015). A study by Taneja et al. (2015) noted the ease with which students use technology and high expectations for classroom use. If students are not fully engaged, there is an increased risk of “cyber-slacking” (p. 141) or utilizing the technology for off-task activities. It is therefore imperative to develop instruction that utilizes the best skills of the educator, student, and the technology for the greatest outcome (Henrie et al., 2015).

**Extrinsic and Intrinsic Motivation**

Both extrinsic and intrinsic factors have an impact on student’s motivation towards academics (Borovay et al., 2019; Bouras, 2019; Cukurbasi & Kiyici, 2018; Fan & Wolters, 2014; Kavandi & Kavandi, 2016; Khodadady & Dastgahian, 2015; Tan et al., 2019). Intrinsic factors are those in which the student finds value, meaning, and joy. Extrinsic factors are those in which the student seeks a positive consequence (Taneja et al., 2015). Recent studies have shown that the personal goals and beliefs of the student
have a direct impact on academic success. Other factors that can affect academic success are instructional methods of the teacher and personal interactions.

**Personal goals and beliefs**

By the time a student reaches the secondary level many of their personal goals and beliefs about academic ability have been established (Song, 2019). Tan et al. (2019) asserts the tendency of high school-age students to view ability as more constant and intelligence as more stable. This is further explained as students’ perception of ability never changing. A students’ intelligence, though, is deemed stable as it is continually growing with new knowledge. This concept is supported by Fan and Wolters (2014) in the following:

“This model states that students’ perceived academic competence (i.e., ability belief) and students’ interest in learning (i.e., intrinsic value) play important roles in shaping their expectations regarding how they will perform in school tasks, which in turn influence their achievement-related choices and behaviours. That is, students who feel confident about their learning abilities and view school activities as interesting are likely to have higher expectations of their performance on upcoming tasks and make more positive achievement-related choices.” (p. 23-24)

Perception of ability is further impacted by student absenteeism (Balkıs et al., 2016). The stress created by absence leads the student to a self-perception of inability, while full engagement in school activities leads to internal motivation and self-perception of achievement towards an external goal (Cukurbasi & Kiyici, 2018).
The polarity of intrinsic versus extrinsic motivation is best defined in research conducted by Beerenwinkel and von Arx (2017) as “based on the assumption that humans tend to internalise socially-given values or requests into personal ones” (p. 240). The study goes further to explain this idea as students develop their intrinsic motivators based on the input from external motivators.

**Teacher interactions**

Teacher interactions and relationships have been found to strongly influence student success (Bouras, 2019; Khodadady & Dastgahian, 2015; Song, 2019) as well as teacher efficacy (Kim & Seo, 2018). Questioning (Song, 2019), regulated learning, regular feedback (Sherwood & Kwak, 2017), and inquiry-based teaching (Borovay et al., 2019) have all been found to have a positive effect on student engagement. Cukurbasi and Kiyici (2018) noted increased student engagement in learning activities when objects and activities are attractive to students. These researchers went on to explain the importance of interactive and engaging activities as a platform to improve teacher-student and student-student correspondence.

A number of studies have shown that student engagement and motivation increase when classroom instruction moves away from traditional methodology (Dreyer, 2014; Varier et al., 2017; Wright, 2018). When non-fiction engineering literature replaces traditional readings, students developed a greater sense of gender equality and an increased ability to problem solve (Wright, 2018). Further, allowing students the freedom of the use of technology to submit assignments, allowing for typing instead of writing, and flexibility in the use of free time at school increased student efficiency and engagement (Varier et al., 2017). Finally, moving away from traditional “drill and
practice” to a gamification type of study removed the affective filter and improved student test scores (Dreyer, 2014). These studies provide evidence that non-traditional methods of instruction can increase a student’s problem-solving skills, increase efficiency and engagement, and improve test scores.

Students face a myriad of influences on their educational success. These influences stem from family, friends, society, teacher interactions, and even from within themselves. In planning instruction with the outcome of learner success, teachers and instructional designers must take these factors into account. One theory that focuses on avoiding an overload of information for the student is cognitivism, specifically cognitive load theory. To ensure reliable data, the literature also supports the need for the study to be conducted under a pragmatism paradigm.

**Learning Theory**

There is a quote by Johann Wolfgang von Goethe which says, “The limits of my language are the limits of my universe.” This is very true in the many aspects of life, and the high school engineering pathway is no exception. Students at this high school begin this pathway in the Project Lead the Way program with Introduction to Engineering. In this class, students are exposed to the basics of engineering and the vocabulary used in the profession. Fully understanding vocabulary is critical for successful advancement through engineering. Since students must take in so much information in any given day, and any given class period, it is vital to make instruction as efficient and meaningful as possible without overloading the learner. The literature and previous studies provide support for this research under the theory of cognitivism, specifically, cognitive load theory, and the support for the study to be conducted under the pragmatism paradigm.
Cognitivism

The theory of cognitivism focuses on how we take in, process, store and use information (Brieger & Mclean, 2020; Clark, 2018). The cognitivist is looking at the student as a processor and the teacher as a guide to maximizing the learning. The learner is actively participating in the process by asking questions, researching phenomena, conducting experiments, and conducting their own informal learning outside of the formal setting (Yilmaz, 2011). The cognitive movement started as researchers began to question behaviorism. Psychologists such as Piaget and Vygotsky, along with theorists Bruner, Weiner, and Tolman saw learning as not only the observable behaviors but also a process within the mind. The limitations of behaviorists fall in an incomplete explanation for how we learn, rather than just how we respond to stimuli, and this deficiency led to the development of cognitive research and the theory of cognitivism (Clark, 2018; Morrison et al., 2013; Yilmaz, 2011).

Cognitive Load Theory

Under the umbrella of cognitivism is the cognitive load theory. Cognitive load is the stress placed on the brain when a person is learning something new (Lewis, 2020). Cognitive load theory suggests the learner’s brain has limited short-term memory, but an extensive long-term memory schema, the categorical chunks of long-term memory in the brain. This long-term memory must be activated to make new material long-lasting and meaningful to the learner (Poffenbarger, 2017). The design for cognitive load theory was presented by Sweller in the 1980s. He proposed a short-term working memory of three to five items at a time and long-term memory of limitless capacity where knowledge is grouped and stored (Poffenbarger, 2017; Schilling, 2017). In cognitive load theory, the
basic rule is that learners can absorb between five to nine items at a time. It is the task of the instructional designer and instructor to develop and implement strategies that reduce the cognitive load of materials (Morrison et al., 2013). Cognitive load can be divided into three categories: (a) intrinsic cognitive load, (b) extraneous cognitive load, and (c) germane cognitive load (Bentley & Sieben, 2019; de Jong, 2010; Sweller, 1994, 2020).

Intrinsic cognitive load refers to the material which is to be learned and its characteristics, i.e., the testable information and level of difficulty. Extraneous cognitive load refers to the load created by the instructional material used to teach the lesson - the method of presentation. Germane cognitive load refers to load created by the learning process itself – sorting and classifying the information (de Jong, 2010; Schilling, 2017; Sweller, 2020). For example, if a high school engineering student is learning about calculating gear ratios and the teacher is using a PowerPoint to provide the information, then the understanding of the process of calculating gear ratios is the intrinsic cognitive load, the presentation method is the extraneous cognitive load, and processing and organizing the material to the long-term memory schema creates the germane cognitive load.

**Intrinsic cognitive load**

The intrinsic cognitive load of material is different for every learner. How quickly do they understand the material? How much past experience does the learner have with the material? The input of the individual components determines the intrinsic cognitive load (Morrison et al., 2013). In short, instructional design cannot influence intrinsic cognitive load as much as personal background. What can impact intrinsic cognitive load is the learner’s ability to relate the new material to background knowledge, problem-solving skills, or the complexity of the material itself (Martin, 2012).
Extraneous cognitive load

The presentation of information, including the platform, verbiage, images, interaction, and sounds all work together to develop the extraneous cognitive load (Bentley & Sieben, 2019; de Jong, 2010; Martin, 2012). When the design of the instruction causes unnecessary processing, the extraneous cognitive load is increased (Martin, 2012). There is evidence of the importance of careful design and utilization of multimedia presentation of material. Chapter four of *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning* by Clark and Mayer (2016) depicts the multimedia principle. This principle cites the importance of words and graphics to provide the necessary words and images for learners to fully engage in active learning. However, the selection of both components must be intentional and thought out. The careful compilation of words and images, although increasing extraneous cognitive load, provides the learner the opportunity to make meaningful connections between written vocabulary and visual imagery.

Germane cognitive load

Germane cognitive load is the brain’s filing system of learning. This load is created by learners as they work to organize and store the new material in relation to the schemata already existing in their memory database (de Jong, 2010). Germane cognitive load is directly influenced by the instruction and is related to the presentation and learning activities of the lesson (Paas et al., 2003). Germane load is the working memory of the learner as it activates schema to learn (Brieger & Mclean, 2020).
Reducing extraneous cognitive load

In order to allow learners to retain the most information possible, the extraneous cognitive load must be reduced. If not, the learner will suffer from cognitive overload, which leads to the ability to process being slowed and a loss of information (Lewis, 2020). So, how do instructional designers and instructors help students reach the highest capacity of cognitive load? This can be accomplished by teaching students in a way that activates the long-term memory and a relation between the student’s current schemata and the new material. This is done by teaching them problem-solving skills, making lectures more effective, engaging the past knowledge of the student, and using dual-modality presentation methods (Lewis, 2020; Mousavi et al., 1995; Paas et al., 2003). In addition, it is critical to reduce the extraneous cognitive load by avoiding distracting fonts or an overload of information (Lewis, 2020). Other research on cognitive load theory suggests making the presentation fit the audience. The design of the instruction should be the best for the intended learner and their ability and background (de Jong, 2010; Lewis, 2020). In addition, the physical learning environment must be conducive to learning (Choi et al., 2014). Simply stated, a familiar platform and environment reduce the extraneous load and allow for the learner to focus on the content integration.

Cognitive Theory of Multimedia

The methodology for presentation of material is also critical and may be directed by the Cognitive Theory of Multimedia Learning (Mayer, 2017). This theory, and the related Multimedia Principles, indicate that people learn better from a combination of pictures and words than words alone, as long as the tools do not create unnecessary cognitive load (Mahajan, 2020; Mayer, 2008, 2017; Sorden, 2005). In the theory of
multimedia learning, the learner has the information enter through the ears and eyes, where it is briefly held. The material is then transferred to the working memory, if it is processed before being lost. Finally, the learner activates prior knowledge in conjunction with the new knowledge to develop a new long-term, working memory (Mayer, 2017). Under the Cognitive Theory of Multimedia Learning are also three fundamental assumptions, 1) Dual Channels, 2) Limited Capacity, and 3) Active Processing (Mayer & Moreno, 2003; Sorden, 2005). Dual channels refers to the intake of information through the combined format of pictures and words, limited capacity refers to the ability to organize the words and pictures, and active processing allows the user to integrate the information by building connections (Mayer, 2008). This connection of images and text is ideal for use within the Engineering classroom for vocabulary instruction as it bridges the gap between abstract ideas and the related physical models.

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Multimedia Principle</strong></td>
<td>The Multimedia Principle is tied to the dual channels and states that words and pictures in combination are more effective than words alone (Mahajan et al., 2020; Mayer, 2017). The presentation of words and related images allows the learner to activate prior knowledge and integrate the new material (Issa et al., 2011).</td>
</tr>
<tr>
<td><strong>Coherence Principle</strong></td>
<td>Learning is more effective with limited extraneous or distracting material. The presentation of material should have limited words, sounds and images to avoid creating unnecessary extraneous cognitive load (Issa et al., 2011; Kirschner, 2002).</td>
</tr>
<tr>
<td><strong>Signaling Principle</strong></td>
<td>The learner clearly sees the focus of the material through highlighting, emphasis, or placement. The keywords or phrases are emphasized to avoid being lost in the other material (Issa et al., 2011; Liu et al., 2018).</td>
</tr>
<tr>
<td><strong>Image Principle</strong></td>
<td>Learners process information better from images and graphics that a person speaking. Information is better conveyed by allowing the learner to see relevant imagery than having a video of a person conducting a lecture (DeBell, 2020).</td>
</tr>
<tr>
<td><strong>Redundancy Principle</strong></td>
<td>Learners gain more from animation and narration than from animation, narration and on-screen text (Ari et al., 2014; Kirschner, 2002). The use of redundant material, specifically narration and text, can increase cognitive load and limit the integration of the material (Mayer, 2008).</td>
</tr>
<tr>
<td><strong>Spatial Contiguity Principle</strong></td>
<td>The display of any graphics and corresponding text should also be presented in close proximity to provide the learner with relevance and relation.</td>
</tr>
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29
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<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporal Contiguity Principle</td>
<td>Learners take in information better when visual and audio information is presented at the same time. This may include text an narration or text and GIFs (DeBell, 2020).</td>
</tr>
<tr>
<td>Pre-Training Principle</td>
<td>People learn better when they have pre-training on key concepts before starting new material (Mayer, 2017).</td>
</tr>
<tr>
<td>Segmenting Principle</td>
<td>Learners have greater success when material is provided in segments instead of a continuous stream (Mayer, 2008).</td>
</tr>
<tr>
<td>Modality Principle</td>
<td>People learn better from graphics and audio than from graphics and text. The combination of graphics and text may lead to a visual-channel overload (Liu et al., 2018).</td>
</tr>
<tr>
<td>Personalization Principle</td>
<td>Learners receive and process information better when delivered through informal discussions and dialogue (Almasseri, 2019; DeBell, 2020).</td>
</tr>
<tr>
<td>Voice Principle</td>
<td>Material should be presented with human voice and not a computer generated voice (Mahajan et al., 2020).</td>
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**Pragmatism**

My plan for research aligned with the pragmatism paradigm. Pragmatists utilize both quantitative and qualitative data to determine understanding (Wahyuni, 2012). As my research sought to understand the numeric impact of implementing a technology-based instruction and the social-emotional impact of this intervention and outside influences on academic gains, this paradigm was of the best accord. According to Creswell (2014), pragmatists look at what and how to research and where they want to go.
with it. The knowledge gained from this research was driven by what I wanted to learn, how I wanted to research, and how I planned to use the information provided as a result. Finding a method to improve vocabulary retention was the focus of my study. I wanted to find a way to help my students better obtain, understand, and retain the content vocabulary as a critical component for progressing through the engineering curriculum and major. It involved a mixed-method design that sought to find what worked best for the problem at hand (Wahyuni, 2012). Pragmatism also best served the study as it lent itself to finding multiple reasons for a problem and developing the solution based on this information, thus the need for quantitative and qualitative data (Creswell & Creswell, 2018). For my research, “pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis” (Creswell, 2014).

As cognitivism looks to how we take in and process information, cognitive load explores how the information is divided in order to allow the instructor to avoid a cognitive overload with the learner. Pragmatism explains the need for a mixed-methods design in order to provide the instruction in methods that allow the learner, and the researcher, to see the complete picture of the learning process. As part of the research, technology-based instruction was used to convey material. The plan was to present the material in a manner familiar to the twenty-first-century learner. Technology can be both a positive and negative component of the learner’s environment. It was critical to explore technology by evaluating (a) the definition of technology-based education, (b) the involved platforms and devices (c) implementation of technology within flipped classrooms, but also (d) reveal the digital divide that can occur.
Technology-Based Instruction

Technology-based instruction may play a key role in educational settings with today’s learners (Cetin et al., 2019; Chang et al., 2014; Henrie et al., 2015; Koretsky & Magana, 2019). Technology-based instruction can only be fully explored by reviewing the key elements of (a) the definition of technology-based education, (b) the involved platforms and devices, and (c) the digital divide that may occur for learners.

Definition of Technology-Based Instruction

The information age has pushed forward a society built on information, communication, and computational technology (Koretsky & Magana, 2019). This growth in technology has produced a myriad of platforms described as technology-based education. Within these educational frameworks, the definition of technology-based instruction varies from researcher to researcher. Technology-based instruction may include logging into a computer site, learning platform, or online classroom (Chang et al., 2014). Specific to engineering, and the basis of this research, technology is best described by Koretsky and Magana (2019) with the three categories of learning innovations, technology use in engineering practice, and technology with a capital “T.”

Learning innovations refers to computer technology designed for use in classroom settings. Fishman et al. (2004) referred to this as cognitively oriented technology innovations. No matter the title, the concept is the same; to develop material to stimulate thoughtful and meaningful learning. This concept is rooted deeply in the constructivist learning theory and supports consideration and understanding of cognitive load theory (Bentley & Sieben, 2019). This modality allows for instruction to be delivered through
both computer-led and computer-supported methods with the teacher and peer support (Mazur, 1997).

True and effective technology in engineering involves “real-world activities, actions, or applied skills where individuals must think and act in the modes of a particular discipline” (Koretsky & Magana, 2019, p. 5). This allows for the student to focus more on the project at hand and allows the teacher to be a resource and guide (Xu & Shi, 2018). Engineering-based technology may include devices, but also key software to provide design tools, high-level computations and programming, and analysis and simulations (Koretsky & Magana, 2019).

Technology with a capital “T” represents the impacts, both positive and negative, on the engineering instructional environment (Koretsky & Magana, 2019). The positive impacts include expanded resources, while negative impacts include decreased personal interactions and inability to access solution manuals (Demosthenous et al., 2020; Koretsky & Magana, 2019).

Technology should not replace instruction, but rather serve as a tool to enhance instruction (Adams & Strickland, 2011; Chang et al., 2014; Dinov et al., 2009). A properly created technology-enhanced learning environment embedded with a computer-assisted feedback strategy will achieve two tasks, (a) deliver content more effectively, and (b) serve as an instructional strategy to improve student academic outcomes (Adams & Strickland, 2011). In addition, if technology is properly utilized within the classroom, it can be a valuable tool to provide “dynamic, linked and interactive learning content with heterogeneous points-of-access to educational materials” (Dinov et al., 2009, p. 2).
Platforms and Devices

The ability to implement technology-based educational activities is completely dependent on the platforms and devices available. The general definition was best stated by Schipper and Yocum (2016) as any device which provides multimodal learning. Educational devices may include, but are not limited to, any information and communication technologies (Dreyer, 2014), handheld and mobile devices (Heflin et al., 2017), tablets, Kindles, laptops (Veira et al., 2014), interactive whiteboards and projectors (Schipper & Yocum, 2016). Depending on the devices available, age of the students, and desired purpose, schools may utilize several different platforms. Educational platforms for dissemination of information include social networks, Google tools (Veira et al., 2014), audio-visuals, test-banks, and educational blogs (Dinov et al., 2009). In addition, mobile applications and classroom response systems permit student interactions with the instructor and material, often with instant feedback (Heflin et al., 2017).

Access and the Digital Divide

Technological devices and platforms are only as effective for students as the level of access available for their use. In 2014, Vigdor et al. exposed a digital divide from school to school and house to house. The divide can fall under two categories, (a) lack of access, or (b) lack of knowledge of use (Reynolds & Chiu, 2010). Lack of access can refer to equipment or platforms, and the lack of knowledge of use applies to teachers and students. The COVID-19 pandemic further exposed the digital divide among students in both the United States and other countries (Correia, 2020; Hassan & Daniel, 2020). A 2020 study showed 35% of households with school-age children and incomes below
$30,000 per year did not have access to the high-speed internet required by many platforms (Correia, 2020). Disparities in access exist between race, socioeconomic status, and parental education (Vigdor et al., 2014).

When technology is fully implemented, students and teachers must be exposed to complete and proper use to reap the benefits (Reynolds & Chiu, 2010). Teachers must have strong digital literacy skills and made aware of and trained on how to use technologies in a manner that enhances curricular content (Kessler, 2018). Teachers must also be aware of the limited resources of students and adapt learning accordingly. It should not be assumed that students have access to printers, web cameras, high-speed internet, or scanners when working outside of school (Correia, 2020). However, proper use of technology can allow teachers and students to attain goals previously thought unattainable. Kessler (2018) summarized the advantage of proper use of technology with the statement “Today’s technologies enable language educators to strive for a more robust and individualized learner centeredness, one that benefits from technological innovations that influence enhanced individualized experiences, social activity, and access to data” (p. 209).

Technology can provide enhancements to the educational setting for students. With a wide variety of platforms and devices, the student can take ownership of learning and have access to the material at any given time. The balance comes, as has been shown during the 2020 pandemic, when ensuring the digital divide does not create advantages for some and disadvantages for others.
Summary

Throughout the literature, the ties between contents have been explored. STEM, engineering, and core curriculums all rely on a base knowledge of vocabulary content. Without this vocabulary base, it is difficult, and often impossible, to gain a full understanding of academic material. As was also supported by the literature, the impact of vocabulary acquisition skills has a cross-curricular impact.

As secondary students prepare to enter post-secondary education or the workforce, skills attained through STEM education and engineering education were found to have a positive connection with success. STEM has been shown to be an immensely impactful program for social and economic growth on all educational levels: elementary, secondary, and post-secondary. The key to this impact lies within the proper implementation of STEM programs and the opportunity to fully explore the potential for STEM careers.

A key component of academic success is a strong base of lexical knowledge. Students must acquire new vocabulary and teachers must learn ways to convey this body of knowledge. Neither the attitude of the student nor the methodology of the instructor can work alone in the drive to achieve academic success. Both parties must work together in order for students to develop the ability to decipher and decode new text as they move through their academic and professional careers. Proven methodologies including the implementation of technology-based instruction and utilization of visual clues with vocabulary have shown to increase content knowledge and the ability to decode new terminology, but only in careful consideration of the cognitive load being created by the instructional material.
Academic achievement is not only impacted by instruction but by many other factors, as well. Peers, homelife, homelessness, social influence, and parental involvement may all generate positive and negative influences on student attitudes towards school and self-efficacy. In addition, student-teacher interactions have been found to influence student engagement. The development of a solid relationship between the teacher and the student allows for conversations leading to solutions to overcome distractions and obstacles.

Technology has been integrated into many curriculums to enhance learning and create new platforms for instruction. Although many schools have implemented technology for this purpose, research has also shown it to be a distraction. Texting, email, social media, and online games have been found to draw the student away from the educational purposes for which it was designed. The COVID-19 pandemic also revealed a tremendous digital divide for sections of the country and from household to household. The role of the instructor is to delineate the proper use of technology resources, whether devices or platforms, to allow equal access and opportunity for all learners.

From the literature review, there is a need for further study on the combination of technology integration and vocabulary acquisition. Specifically, a study with consideration of cognitive load theory and student engagement. This supports the current research based on the following two questions, (1) How does implementing a technology-based instructional module impact students’ content vocabulary test scores in the Introduction to Engineering course? and (2) How does implementing a technology-based
instructional module impact students’ attitudes towards learning in the Introduction to Engineering?
CHAPTER 3

METHODS

The purpose of this study was to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Introduction to Engineering course. The goal of the study was to answer two key questions: 1) How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course? and 2) What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course?

Research Design

Action research was used to evaluate a technology-based instructional module on the attitudes towards studying Engineering vocabulary and the academic impact for students in the Introduction to Engineering class. As I was both the Engineering teacher for these students during their first year and their subsequent years, my personal involvement and vested interest made action research the best choice.

Action research, as described by Mills (2011), is, “any systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interest in the teaching and learning process or environment for the purpose of gathering information about how their particular schools operate, how they teach, and how their students learn” (p.4). This definition describes my research and its purpose: to understand how my
students learn and adjust how I teach to reach an optimum learning environment. The information obtained from this research will not only be used to develop and modify curriculum but also to educate all stakeholders involved with the student’s education to include administrators, technology staff, and parents. Action research was appropriate for this study as it placed the researcher in the environment directly. Unlike other types of research, action research is done to self-evaluate the practice of the teacher (Mertler, 2019). Action research in education is a cyclical process that aims to improve instruction, assessment tools, and student outcomes. Action research promotes 1) understanding of teaching and learning; 2) teaching and management expertise; and 3) confidence to effect positive change in classrooms and schools (Lari et al., 2019, p. 24).

Quantitative and qualitative data was be collected to answer the research questions. Mixed-methods was designed to not only evaluate an overall quantitative difference between pre-test and post-test vocabulary scores but also to evaluate the influence of student attitude towards academic gains. The design of the mixed-methods research was a mixed-method experimental which seeks to understand the participant views within the context of an experimental intervention (Creswell, 2014). Quantitative data included measures of academic achievement and attitude surveys before and at the conclusion of the study. The data collected through test scores in combination with attitude surveys was evaluated for trends. The data allowed me to adjust my curriculum and methods to meet the needs of the student whether purely academic or social-emotional.

This convergent mixed-methods research design (Creswell, 2014), specifically using triangulation (Mertler, 2019), used the intervention of technology-based instruction
in order to assess the effect on post-test vocabulary achievement scores. In addition, surveys were given to gauge the student’s attitude towards the instruction prior to and at the conclusion of the study. The researcher collected field notes and conducted focus group interviews in order to collect the data necessary to accurately display the impact and outcome of the study.

**Setting and Participants**

**Setting**

The outlined research took place in an Introduction to Engineering class. Introduction to Engineering was the first Project Lead the Way course taken in the Engineering course of study. Students enrolled in this class were focused on the basics of Engineering to include the design process, CAD modeling, documentation, reverse Engineering, and basic mechanics. The setting of this class was a modified traditional classroom with work stations through the middle of the classroom and computer stations along the walls. Each student was provided with access to a printer and a district issued computer. The classroom was also enhanced with a Smart Board, 27 student desktop computers with course specific software, six group work stations, a color printer, and two 3D printers. Students were provided with access to the course curriculum on the Project Lead the Way site, Google Classroom, and various computer-generated learning systems. Although students were provided with a device by the school district, they were also allowed to use a personal device. Any device connected to the school district network was restricted by the district’s monitoring program.
Participants

There were 77 students taking the Introduction to Engineering class. Students were required to have a passing score in Algebra 1 before being allowed to enroll. This prerequisite was necessary in order to be successful with the computational activities within the course. The class met for 90 minutes every other day, as the school operated on an A-B schedule. This meant the class met three times one week and two times the next week. The classes consisted of mostly males with a small number of females, and the majority of the students were white.

For the purpose of the study, students were presented the information regarding participation and parents were sent an electronic consent/assent form. Out of the 77 students, 23 returned the consent/assent form. From the 23 participants, 20 volunteered to participate in the focus group interviews. The students were then grouped based on creating an equal number of male and female participants, as much as was possible. The participant descriptions are in Table 3.1.

Table 3.1 Participant Demographics

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Gender</th>
<th>Age</th>
<th>Grade</th>
<th>Race</th>
<th>Focus Group Participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mary</td>
<td>Female</td>
<td>14</td>
<td>9</td>
<td>Black</td>
<td>Yes</td>
</tr>
<tr>
<td>Bobby</td>
<td>Male</td>
<td>15</td>
<td>9</td>
<td>White</td>
<td>Yes</td>
</tr>
<tr>
<td>John</td>
<td>Male</td>
<td>15</td>
<td>10</td>
<td>White</td>
<td>Yes</td>
</tr>
<tr>
<td>Susie</td>
<td>Female</td>
<td>14</td>
<td>9</td>
<td>White</td>
<td>Yes</td>
</tr>
<tr>
<td>Billy</td>
<td>Male</td>
<td>16</td>
<td>11</td>
<td>White</td>
<td>Yes</td>
</tr>
<tr>
<td>Tim</td>
<td>Male</td>
<td>15</td>
<td>9</td>
<td>Black</td>
<td>Yes</td>
</tr>
<tr>
<td>Lou</td>
<td>Male</td>
<td>15</td>
<td>9</td>
<td>White</td>
<td>Yes</td>
</tr>
</tbody>
</table>
I have been a teacher at the school for three years and previously served as a PLTW teacher within the associated middle school. During this time, I participated in regular data meetings with other PLTW instructors and discussed the need for improved vocabulary instruction. I was the only teacher for the class at this location and have been trained in Smart Technology and all programs used within the curriculum. I was also a technology trainer for the district and taught professional development sessions on
classroom technology. Within the school, I served an additional support role in which I offered technology support to other staff members.

Within the study, I performed both the roles of researcher and teacher. As the researcher, I worked to collect relevant, accurate, and reliable data. I then reviewed and analyzed the data and made every effort to remain unbiased and to protect the participant’s identity. The role of the teacher involved providing proper instruction to both groups involved, be a mentor to the students, and offered appropriate academic reinforcement as needed.

**Action/Innovation**

This convergent mixed-methods research design (Creswell, 2014), specifically using triangulation (Mertler, 2019), included the intervention of technology-based instruction in order to assess the effect on post-test vocabulary achievement scores. A survey of Attitudes Towards Learning Vocabulary was given before and upon conclusion of the study. Student focus groups and field notes were also utilized to gather data.

**Innovation**

The students received instruction and practice through computer-based activities, online games, and digital presentations of vocabulary applications. The group was taught vocabulary over the course of 5 weeks (13 classes). Definitions were provided in the context of the instructional material. To begin their study, students received a teacher-created Quizlet digital flashcard set for the content vocabulary. Students were provided with a web quest applying the vocabulary created by the teacher. Students participated in weekly computer-based review activities utilizing Quizizz, Pear Deck, and other digital
resources. Students completed a survey of Attitudes Towards Learning Engineering Vocabulary prior to the research and upon conclusion.

**Justification for the Innovation**

Technology-based instruction was chosen for the intervention as several studies have shown the positive impact of integrating technology to include increased learner inquiry and embedded instructional scaffolding (Koretsky & Magana, 2019; Maeng, 2017). The technology implemented in this study provided learners with varied modalities of learning and included visual and auditory cues. This dual-modality has been found to increase the effect size of working memory (Mousavi et al., 1995). The technologies chosen for this study were specifically selected to reduce the cognitive load for the learners, specifically through implementation of the Multimedia Design Principles. The platforms were all familiar to the students as they had been applied in various formats in other classes. This familiarity with the technology allowed the student to focus on the material to be learned and not be distracted by the instructional method (Lewis, 2020; Sweller, 1994).

The components chosen for the innovation were selected based on Mayer’s Cognitive Theory of Multimedia Learning (Mayer, 2017). Although the components made use of multiple technology-based platforms, the research still took into consideration the cognitive load of the student. The platforms were all familiar to the students and had been utilized independently in various classes. They had not, however, been used in unison to achieve an end result of increased academic vocabulary knowledge. Because of the pre-established familiarity with the platforms, the student
was able to focus on the material and information and not on the platform itself (Mayer & Moreno, 2003).

**Innovation Components**

The study consisted of the implementation of multiple technology components. Students played review games in class throughout the study utilizing the Quizlet platform. These games reinforced the baseline definitions of the Engineering content vocabulary in both text and visual formats. This program provided the student computer-based practice tests, flashcards, and review games. The program offered both visual and auditory support as the program presents and reads the text. The Quizlet flashcards are displayed in Appendix A.

The next component consisted of the presentation of material to students through the Pear Deck platform. This allowed the presenter to control the advancement of the material, provide interactive response prompts, and collect instant feedback from the students. Utilizing this platform allowed the teacher to maintain the attention of the students and keep them actively involved in the learning process. Students answered questions and provided other forms of feedback throughout the lesson. This allowed the teacher to provide support and additional information as needed to ensure the student understood the material before moving forward.

Students completed a teacher-created web quest in week two in order to research the application of the term in various Engineering scenarios. The web quest provided an opportunity for students to seek out the vocabulary on various sites and in various settings. This activity provided the student with the opportunity to see the Engineering term in a real-world scenario. This platform allowed the students to integrate the new
knowledge and find a relationship between what was learned and what the student
already knows. This relationship helped the student develop a stronger understanding of
the term and to see a real-world implication.

Quizizz was utilized on weeks two and four to gauge student mastery of the terms
in both definition and context. Quizizz is an online gaming platform. Students answered
multiple choice questions, received feedback in the form of memes and sounds, and
competed for rank on a leaderboard. The Quizizz was created by the teacher, ensuring
the questions were accurately comparable to the term meanings in context. Presentation
through the Quizizz platform both engaged the students as a game and provided another
resource for dual-mode presentation as the site allowed for both text and imagery.

On week three, students created a slide within a group Google Slide with imagery
to represent an assigned term. Each term had its own slide and each student was directed
to their vocabulary word. Students sought out images to add to their slide which they
best felt represented the word. Students were paired with a partner to check each other’s
work before returning to a whole group setting. The class then went through the slides
and allowed the creator to explain their image choice.

On week four students completed a Wordle with terms and phrases related to the
vocabulary words. Wordle is a program that creates a word cloud when related terms are
entered.

Technology tools and the assigned purpose for each are defined in Table 3.2.

Table 3.2 Technology Tools and Purpose

<table>
<thead>
<tr>
<th>Technology Tool</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizlet (Non-Log in edition to</td>
<td>This online flashcard system was used to allow students to study and</td>
</tr>
<tr>
<td>prevent collection of student</td>
<td>review vocabulary. Activities included games,</td>
</tr>
<tr>
<td>data)</td>
<td></td>
</tr>
</tbody>
</table>
practice tests, and multiple-modality presentation.

Quizizz

The game-based review was used to provide review through instructor-led gaming sessions.

Wordle

Wordle is an online platform to create a visual image of a word and the related terminology. This helped develop a deeper understanding of the terms as the student worked to find synonyms.

Google Slides

Google Slides is a Google presentation platform. Utilizing this tool added another visual component to the understanding and application of the Engineering terminology.

Pear Deck

Pear Deck is a presentation add-on that allowed the teacher to lead instruction in a controlled manner. The students were able to interact with the instruction and received immediate feedback. Use of this tool also allowed the instructor to conduct formative checkpoints as the lesson progressed.

Web Quest on Chrome

A web quest furthered the student’s understanding of the Engineering terms as they conducted research based on teacher-created prompts.

Google Forms

Google Forms allowed for controlled assessment. This platform was used to conduct the assessments and the survey. Use of this tool allowed for the collected data to be downloaded to a spreadsheet for analysis.

The standards for this unit of study were: (1) CCRA.L.6 Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level;
demonstrate independence in gathering vocabulary knowledge when encountering an
unknown term important to comprehension or expression, and (2) RST.9-10.4 Determine
the meaning of symbols, key terms, and other domain-specific words and phrases as they
are used in a specific scientific or technical context relevant to grades 9-10 texts and
topics. An alignment of the timeline and associated standards and assignments are
defined in Table 3.3.

Table 3.3 Timeline of Action/Innovation for the Visualization and Solid Modeling Unit

<table>
<thead>
<tr>
<th>Week</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1 (2 Days)</td>
<td>Quizlet List</td>
<td>Quizlet Review-</td>
<td>Quizlet Review-</td>
</tr>
<tr>
<td>Standard</td>
<td>Provided</td>
<td>whole group</td>
<td>whole group</td>
</tr>
<tr>
<td>CCRA.L.6</td>
<td>Pear Deck</td>
<td>and individual</td>
<td>and individual</td>
</tr>
<tr>
<td>Visualization and solid modeling unit- introduction of terms</td>
<td>Presentation of Terms in Context</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 2 (3 Days)</td>
<td>Web Quest</td>
<td>Web Quest</td>
<td>Quizizz Review</td>
</tr>
<tr>
<td>Standards</td>
<td></td>
<td>Results Sharing</td>
<td></td>
</tr>
<tr>
<td>CCRA.L.6 &amp; RST.9-10.4</td>
<td></td>
<td>Quizizz Review</td>
<td></td>
</tr>
<tr>
<td>Visualization and solid modeling unit- terms in context</td>
<td></td>
<td></td>
<td>Quizizz Review</td>
</tr>
<tr>
<td>Week 3 (2 days)</td>
<td>Google Slides</td>
<td>Share and</td>
<td>Final Quizlet Review</td>
</tr>
<tr>
<td>Visualization and solid modeling unit-application of terms</td>
<td></td>
<td>Discuss Google Slides</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quizlet Review-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>whole group</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>only</td>
<td></td>
</tr>
<tr>
<td>Week 4 (3 days)</td>
<td>Quizizz Review</td>
<td>Wordle Creation</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCRA.L.6 &amp; RST.9-10.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visualization and solid modeling unit-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Collection

Three data sources were planned to assess the impact of technology-based instruction on academic gains for students taking the Introduction to Engineering course. Each of the three data collection methods were used to develop an understanding of student needs, student engagement, and teaching strategies. This understanding was invaluable to the teacher and administration in planning future curricular designs. As shown in Table 3.3, the four data sources included (a) pre- and posttests, (b) Attitudes Towards Learning Content Vocabulary survey, and (c) focus group interviews. The alignment of the questions, methods, and instruments are displayed in Table 3.4 below.

Table 3.4 Research Question Alignment with Data Collection Sources

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Collection Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Question #1: How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering?</td>
<td>• Pretests and Posttests</td>
</tr>
<tr>
<td></td>
<td>• Focus Group Interviews</td>
</tr>
<tr>
<td>Research Question #2: What is the effect of implementing a technology-based instructional model on attitudes towards</td>
<td>• Student Surveys</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
learning Engineering vocabulary for students taking the Introduction to Engineering course?

- Focus Group Interviews

**Pretests and Posttests**

In order to accurately measure the academic benefits of integrating technology into vocabulary instruction, students completed researcher created pre and post assessment for the vocabulary unit. This assessment was administered through the Google Forms platform and provided an academic baseline for the students before instruction began which was then compared to a post assessment score at the conclusion of the study. The assessments focused on measuring the student’s understanding of the vocabulary definitions and the application of the key terminology. Understanding of key definitions aligned with standard CCRA.L.6 and the application of terms aligned with standard RST.9-10.4. Students were able to earn a total of 39 points on the assessment, with the majority of the points acquired in the definitions section using a multiple-choice platform with the student being first provided the definition and then selecting the correct term. The second section of the assessment allowed the student to identify the terms as components of an image. The assessment was validated by three other teachers of the same subject within the district. The complete assessment can be found in Appendix B.

**Student Surveys**

Surveys are a valuable tool as they provide a wealth of information about the student as an individual and not just a score (Tutuianu et al., 2013). The student participants completed the survey of Attitudes Towards Learning Vocabulary before starting the study and at the conclusion. The Student Attitudes Towards Learning
Engineering Vocabulary Survey was adapted from the Learning Attitude Questionnaire developed by Sung et al. (2015) and modified to provide a series of Likert-scale questions gauging a student’s attitude towards learning Engineering content vocabulary. Sung et al. (2015) reported the Cronbach’s alpha value of the original questionnaire as .91. As the survey was modified from its original format, I conducted an analysis of reliability for the new version.

A 5-point Likert-type scale was chosen as it is found to offer a measure of student opinions (Hartley, 2013). The survey included eighteen questions and offered a range of answers from *strongly disagree* (1) to *strongly agree* (5). The survey included a series of questions to gauge student attitudes towards learning the content vocabulary, application of the content vocabulary, and study habits. The completed survey is displayed in Appendix C, and survey modifications from the original survey are displayed in Appendix D. Modifications to the original survey included deletion of five non-relevant questions and the addition of wording to other questions. Examples included changing, “I think the learning content is very useful to me,” to “I think learning vocabulary is very useful to me.” Deleted questions included, “The course helps me learn to deal with problems in my own way.” The final survey consisted of 21 items.

The validity of the teacher made assessment and the student survey were verified utilizing a review by three other Introduction to Engineering teachers, the Director for Career and Technology, the Assistant Principal for Instruction, and the researcher’s department head. The reliability was verified by testing students in other IED classes.
Focus Group Interviews

At the conclusion of the study, the researcher conducted focus group interviews with four groups of volunteers in order to gain further feedback and insight from the participants and enrich the findings of the study. Focus groups have been found to be beneficial when utilized in conjunction with field notes and feedback received during a unit of study (Edgar & Gibson, 2016). The focus groups ideally each consist of 6 students, three male and three female. This configuration was due to the limited number of females in the class and a desire by the researcher to have equal representation in each group. The groups met for approximately thirty minutes during the normal class period, but outside of the classroom and free from peer distractions. Questions were designed to elicit conversations about how the students normally study content vocabulary and their thoughts about implementing the technology tools. The interviews were recorded, and notes transcribed from the recording after the interview. The complete interview protocol is located in Appendix E.

Data Analysis

By comparing the pretest and posttest assessment data for the study group versus historical gains, in combination with student attitude surveys and field notes, this research was able to explicate the more effective instructional strategy for teaching the content vocabulary. The study also provided insight into the effect of the technology-based instructional module on student attitudes. Scores were converted from a points-based score of 39 to a percentage score. The converted scores were used for quantitative analysis. As shown in Table 3.5, the analysis was conducted using paired sample $t$-tests and inductive analysis.
Table 3.5 Research Question Alignment with Data Source and Analysis

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Source</th>
<th>Data Analysis Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Question #1: How does implementing a technology-based instructional module impact content vocabulary test scores for students taking the Introduction to Engineering course?</td>
<td>• Pretest and Posttest</td>
<td>• Paired sample t-test</td>
</tr>
<tr>
<td></td>
<td>• Focus Group Interviews</td>
<td>• Inductive Analysis</td>
</tr>
<tr>
<td>Research Question #2: What is the effect of implementing a technology-based instructional module on attitudes towards learning for students taking the Introduction to Engineering course?</td>
<td>• Student Surveys</td>
<td>• Paired sample t-test</td>
</tr>
<tr>
<td></td>
<td>• Focus Group Interviews</td>
<td>• Inductive Analysis</td>
</tr>
</tbody>
</table>

**Quantitative Data Analysis**

Quantitative data was analyzed using both the results of the Attitudes Towards Learning Vocabulary survey and the Engineering Vocabulary Assessment. The quantitative data was first evaluated using pre and post study student survey results. Construct scores for student attitudes, specifically towards learning Engineering content vocabulary, were computed based on the survey. As a measure of reliability, Cronbach’s alpha was calculated for the survey.

The quantitative data was then evaluated using content vocabulary assessment means from student pre- and post-tests. The content assessment measured for two specific skills: a) ability to correctly identify the definition of a term, and b) ability to correctly use the term in an Engineering setting. Content area scores were calculated as the total number of items scored as correct. Paired-sample t-tests were conducted to
evaluate the effect of the integration of technology on each competency. In addition, descriptive statistics was used to present results and demographic information.

**Qualitative Data Analysis**

Qualitative data was used to augment the quantitative data analysis. The qualitative data was derived from field notes collected by the teacher and through focus group interviews conducted at the conclusion of the survey. The field notes and interview transcripts were studied for themes. The qualitative data was obtained through the interview process and recorded using a digital recorder was then transcribed and formatted into a Word document. The transcription was analyzed using inductive analysis through a coding scheme (Mertler, 2019) to develop categories and themes by grouping data with similar information.

The qualitative data was evaluated through inductive analysis using a coding scheme (Mertler, 2019). Inductive analysis is the conventional approach of analyzing qualitative data (Armat et al., 2018). In this approach, the researcher sought to support pre-disposed theories and assumptions regarding the data (Elo & Kyngäs, 2008; Hsieh & Shannon, 2005). The researcher achieved this task by reading and rereading the transcripts, creating categories, and grouping information under headings. Once higher order headings were established, the researcher then began to look for patterns or relationships between headings. The final product was designed to develop a reasoning for any identified trends or phenomena discovered as a result of the study (Armat et al., 2018; Hsieh & Shannon, 2005; Katz, 2015).

The identity of the school, course, and students was protected through the use of pseudonyms. The material was organized into chunks according to a common word or
phrase (Rossman & Rallis, 2012). This method allowed the material to be explained using identified themes. Once subcategories were created to represent related data, the themes emerged. The subcategories included field notes, quotes from students, and anecdotal data. Components were reviewed until reaching saturation. Delve online qualitative analysis tool was used to complete this process. The qualitative and quantitative data was then compared using triangulation to present any relation or contradiction of results (Creswell, 2014).

**Procedures and Timeline**

This study consisted of three phases completed in a high school freshmen and sophomore Engineering class during the course of twelve weeks. Prior to the first phase of the study, IRB approval was received from the University of South Carolina (Appendix G) and the school district (Appendix H). The first phase of the study included identifying participants, a vocabulary pre-test, and pre-intervention completion of the survey. Phase 2 was the implementation of the intervention and data collection, and phase 3 was the data analysis. Table 3.6 provides a detailed timeline of the study.

Table 3.6 Timeline of Participant Identification, Data Collection, and Analysis

<table>
<thead>
<tr>
<th>Phase</th>
<th>Procedure</th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Collect Consent and Assent Forms</td>
<td>2 weeks</td>
</tr>
<tr>
<td></td>
<td>Collect Demographics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assign Numeric Identifiers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vocabulary Pretest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pre-Intervention Survey</td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td>Introduce New Vocabulary</td>
<td>5 Weeks</td>
</tr>
<tr>
<td></td>
<td>Introduce Digital Study Platform 1 - Quizlet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quizizz</td>
<td></td>
</tr>
</tbody>
</table>
Phase 1: Participant Identification

Participants for this study were identified from a high school Introduction to Engineering class. As the participants were minors, digital consent and assent forms (Appendix F) were sent home to parents through email and printed copies were provided through the students upon request. Identified participants were then assigned a numeric identifier and pseudonym for the purpose of anonymity. The week prior to the beginning of the study, participants took a pretest on the vocabulary and completed the Attitudes Towards Learning Vocabulary survey.

Each student completed a vocabulary pre-assessment (Appendix A) delivered electronically utilizing Google Forms as the test platform. The students completed the pre-assessment on their district issued Chromebook. The teacher was able to monitor all the computer screens through the use of Hapara, a computer monitoring system that can be viewed directly from the teacher’s laptop. This allowed the teacher to monitor the activity on the student Chromebook and prevented the student from opening any additional tabs.
Phase 2: Innovation and Data Collection

Over the course of the five weeks, the researcher met with the group for a total of thirteen sessions. Each session was for a 90-minute block on alternating days of the week. With this schedule, students either received 3 hours or 4.5 hours of instruction per week. The researcher collected field notes during each class and compiled them at the conclusion of each meeting. In the first meeting the researcher provided the vocabulary in the form of a Quizlet for the students. The class reviewed the vocabulary and the related definitions at the beginning of each class by utilizing Quizlet Live sessions.

Students then began to complete the related activities for the given vocabulary to gain a contextual understanding. On week two students completed a teacher-made web quest to develop a deeper understanding of the terminology in context. Upon completion of the web quest, students played a teacher created Quizizz on the vocabulary which included both definition and application of the terminology. The next step in this phase involved participants creating a digital image of the term. Students were assigned a slide in a shared Google Slides presentation. The students then added their imagery to the assigned slide. The final component consisted of students creating a Wordle for an assigned term. The Wordle was comprised of related contextual terminology.

Week five concluded with participants completing a vocabulary posttest and post-intervention survey. Students took the post-assessment electronically utilizing Google Forms as the test platform. This test was identical to the pre-assessment. Students completed a retake of the Attitudes Towards Learning Vocabulary survey which provided a comparison to the pre-intervention data. Focus group interviews were also conducted with four focus groups.
consisting of six students each. These focus groups were designed to ideally be evenly split by gender and comprised of both college prep and honors-level students.

**Phase 3: Data Analysis**

Pre and post vocabulary test data was analyzed with a paired $t$-test. A paired $t$-test was also used to analyze any change in the results of the pre and post innovation survey. Triangulation was used to look for commonalities between change in vocabulary test data and survey data.

**Rigor and Trustworthiness**

Quality research requires a study that upholds standards of rigor and trustworthiness. The study must be sound with evidence of validity and reliability for quantitative data, and accuracy, dependability, and credibility for qualitative data (Creswell & Creswell, 2018; Mertler, 2019). Since the current study used a mixed-methods approach, the quantitative data was verified initially and then triangulation was used to evaluate the findings as a whole. This study collected quantitative data through teacher made assessments and attitude surveys. The qualitative data was through teacher focus group interviews. Triangulation is a method to enhance the rigor and trustworthiness of the research by gathering multiple types of data through multiple means (Tracy, 2020). The researcher used triangulation as a comparative analysis of the qualitative data against the quantitative data for the purpose of verifying the results of the study. The researcher worked to ensure rigor and trustworthiness of the qualitative data through the implementation of an audit trail, peer debriefing, and member checking.

The surveys provided tremendous insight into student attitudes towards learning content vocabulary, which was then either corroborated or contradicted through focus
group interviews. The process of creating clusters to form themes from survey results was reviewed with the researcher’s dissertation chair to verify the analysis of material followed a logical path. The focus group transcripts were reviewed with the researcher’s dissertation chair. This allowed for development of any questions needing to be asked of the participants to clarify noted statements or actions.

Peer debriefing was also implemented to ensure data collection rigor and trustworthiness (Cetin et al., 2019; Watson & Watson, 2011) and involved reviewing the data and interpretations with the participants and the researcher’s dissertation chair. The combination of the data and peer review discussions could lead to questions for further research.

Member checking was implemented to ensure rigor and trustworthiness of the qualitative data. Member checking, or member validation, is a process of taking material back to the participants to validate ideas and perceptions, and to gather additional ideas in order to elaborate on themes and categories (Birt, 2016; Harvey, 2015). Member checking was conducted in two ways. First, the transcription of the focus group interviews was shared with the group members. Members were asked to provide feedback on the transcript to ensure accuracy. Second, after analysis and the development of themes, focus group members were asked to ensure the interpreted meanings and ideas were correct.

Plan for Sharing and Communicating Findings

The findings of this research were compiled and shared with the appropriate administration within the school district through a slide presentation. The researcher scheduled a presentation meeting with the district stakeholders to include the Assistant
Superintendent of Instruction, the site Principal, the site Assistant Principal for Instruction, and the Director of Career and Technology Education. The involved parties discussed the data and developed the next actions based on the findings that are in the best interest of the students. The planned action may include modifications and adaptations to the instructional method for both the CTE program and other programs in an effort to strengthen academic content vocabulary.

In addition, participants and parents of the study received documentation of the results of the study to include graphical and anecdotal descriptions of the conducted research and results. The identity of the student participants was kept anonymous throughout the discussions with the use of pseudonyms or numeric identifiers. Original identifiers were kept separately and securely by the researcher and destroyed upon completion of the study. Additionally, the results and planned modifications may be shared with Project Lead the Way (PLTW) curriculum developers and fellow PLTW instructors at the national PLTW Summit.
CHAPTER 4

ANALYSIS AND FINDINGS

The purpose of this study was to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Introduction to Engineering course. Both quantitative and qualitative data were collected in order to answer two key questions: (1) How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course? and (2) What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course? This chapter presents the analysis and findings of data collected in the study based on the results of pre- and posttest data, pre- and post-surveys, and focus group interviews with students. This chapter includes (a) quantitative analysis and findings and (b) qualitative analysis and findings.

Quantitative Analysis and Findings

Quantitative data were collected from two sources: (1) pretest and posttest Engineering vocabulary assessments and (2) pre- and post-surveys. This section includes the methods of analysis and findings for each instrument. The findings include descriptive statistics.
Pretests and Posttests

The teacher-made pre- and posttest was designed to measure student mastery of content vocabulary at the conclusion of five weeks. The assessment was checked by a colleague PLTW teacher to affirm the content vocabulary and adherence to standards and desired outcome. Additionally, the test was shared with PLTW instructors in other districts to determine content validity. The assessment provided quantitative data designed to measure students’ mastery of content vocabulary over 5 weeks of instruction. The test was composed of two sections with the first part being multiple choice and the second part requiring application of the content vocabulary. The tests were administered 5 weeks apart. The pretest was administered before the intervention and the posttest was administered immediately upon conclusion of the intervention. Twenty-four students completed both the pre- and posttests, but one student was not included in the data analysis due to excessive absences during the intervention. The highest a student could score on the assessment was 39 points which was then converted to a percentage score with a maximum of 100%. This converted score was used for the analysis. The test was evaluated using the Kuder Richardson Formula 20 (KR-20) to measure the internal consistency of the test with a KR-20 value of .87. This value indicates a strong internal consistency (Miciak et al., 2015; Zach, 2022).

Descriptive Statistics

The mean and standard deviation of the pretests and posttests are displayed in Table 4.1. The pretest mean was 53.26 ($SD = 16.25$), and the posttest mean was 96.48 ($SD = 4.56$), an 81% increase. When looking at student assessments individually, 35% of the students ($n = 8$), scored a pretest grade of 60 or better. Of the remaining 15 students,
47% (n = 7) showed a gain greater than 50 points from pretest to posttest. When viewed as a whole, only 30% (n = 7) of the students achieved a net increase greater than 50 points, and of the remaining participants, 47% (n = 10) produced a gain of less than 40 points.

The test was also evaluated for gains in each of the two sections. Section one, Vocabulary Understanding, focused on term definitions, and section two, Application, focused on the application of the term. When evaluated for each section, the Vocabulary Understanding a paired t-test revealed a pretest mean of 53.39 (SD = 17.64) and a posttest mean of 96.61 (SD = 4.37), an 81% increase. The second part of the assessment, Application, revealed a pretest mean of 53.04 (SD = 17.69) and a posttest mean of 93.91 (SD = 12.70), a 77% increase. Findings for the two sections are displayed in Table 4.1. More about these findings will be discussed in chapter five.

**Inferential Statistics**

A paired-samples t-test was used to determine the impact of technology-based instruction on students’ Engineering vocabulary academic gains and is reported in Table 4.1. To test the assumptions of normality, a Shapiro-Wilk normality test was checked and did not show evidence of non-normality (W (22) = .97, p = .59). The paired-sample t-test revealed a significant increase in the posttest scores (M = 96.48, SD = 4.56) in relation to the pretest scores (M = 53.26, SD = 16.25), t (22) = -13.25, p < .001. When evaluated for each section, the Vocabulary Understanding a paired t-test revealed a significant increase in the scores with a pretest mean of 53.39 (SD = 17.64) and a posttest mean of 96.61 (SD = 4.37), an 81% increase. The second part of the assessment, Application, also revealed significant gains with a pretest mean of 53.04 (SD = 17.69)
and a posttest mean of 93.91 (SD = 12.70), a 77% increase. The effect size, Cohen’s d, was 2.68 indicating a large effect of the implementation of technology-based instruction on students’ academic gains (Cohen, 1977).

Table 4.1 Paired Sample t-test Results (N=23)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Pretest</td>
<td>53.26</td>
<td>16.25</td>
<td>-13.25</td>
<td>22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total Posttest</td>
<td>96.48</td>
<td>4.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary Understanding Pretest</td>
<td>53.39</td>
<td>17.64</td>
<td>-10.53</td>
<td>22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Vocabulary Understanding Posttest</td>
<td>96.48</td>
<td>4.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application Pretest</td>
<td>53.04</td>
<td>17.69</td>
<td>-8.26</td>
<td>22</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Application Posttest</td>
<td>93.91</td>
<td>12.70</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Student Surveys**

A pre- and post-survey was adapted from the Learning Attitude Questionnaire developed by Sung et al. (2015) and modified to provide a series of Likert-scale questions gauging a student’s attitude towards learning Engineering content vocabulary. The survey included 18 questions and offered a range of answers from (1) *strongly disagree* to (5) *strongly agree*. The survey included a series of questions to gauge student attitudes towards learning the content vocabulary, application of the content vocabulary, and study habits.

The Likert-scale produced a numeric value from which the mean and median were determined. The mean of the survey responses was used to evaluate for any significant change in attitudes from pre- to post-intervention. As the survey was a modification of an existing survey, a reliability analysis was run in Jasp. Reliability
analysis revealed a Cronbach’s alpha score of $\alpha = .71$ which is within an acceptable range (Nunnally, 1978).

**Descriptive Statistics**

Survey analysis results are displayed in Table 4.2. An aggregate score for the survey data was developed by first finding the mean score for each student and then using these scores to establish the class mean. The class pre-survey mean was 2.85 ($SD = 0.45$) and the class post-survey mean was 3.34 ($SD = 0.37$). In evaluating the individual items within the survey, questions 4, 13, and 15 showed the greatest increase and referenced to an interest in learning Engineering vocabulary and other content vocabulary. Questions 10, 16, and 18 produced the least increase and these referenced the student taking initiative to learn the Engineering vocabulary and ask questions without prompting. Questions 5 and 8, both of which evaluated learning Engineering vocabulary as a negative activity, showed a decrease in mean score from pre-intervention to post-intervention.

**Inferential Statistics**

A paired-samples $t$-test was used to determine the impact of the intervention on the students’ attitudes towards learning Engineering vocabulary. Results from the survey analysis is displayed in Table 4.4. The paired-sample $t$-test revealed a significant increase in the post-survey scores ($M = 3.34, SD = 0.37$) in relation to the pre-survey scores ($M = 2.85, SD = 0.45$), $t (21) = -3.57$, $p = .002$. The effect size, Cohen’s d, was 0.76 indicating a moderate effect of the implementation of technology-based instruction on students’ attitudes towards learning Engineering vocabulary (Cohen, 1977).
Table 4.2 Survey Data Analysis (N=22)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Survey</td>
<td>2.85</td>
<td>0.45</td>
<td>-3.57</td>
<td>21</td>
<td>0.002</td>
</tr>
<tr>
<td>Post-Survey</td>
<td>3.34</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Qualitative Analysis and Findings**

Qualitative data was collected from a series of four focus group interviews. This section includes the method of analysis and findings for the interviews. Interview questions focused on allowing students to express honest thoughts and opinions regarding several areas of context related to the study, the technology implemented, and school in general. Participants were reminded that the transcription of the conversation would be kept confidential and names would be replaced with pseudonyms. A discussion of the methods of analysis of the focus group transcripts will be followed by a description of the coding process, which revealed categories that formed themes while employing a constant comparison method.

**Focus Group Interviews**

The focus group interviews were conducted in a relaxed, small-group setting and recorded. Participants volunteered to be a part of the focus group and were a mixture of honors level and college prep students. Each group was made up of male and female students, was representative of the class population, and reduced anxiety as they were volunteers for the interview. Each interview lasted approximately 30 minutes and were conducted in the high school media center classroom. After the conclusion of the interviews, the recordings were transcribed verbatim and the transcriptions were checked against the recordings for accuracy. The researcher then shared the transcriptions electronically with participants for validation through member checking. The researcher
was unable to provide hard copies to the students as school was out for summer break. Of the participating students, six responded to verify the transcription. This form of member checking was important part of the process as it ensured transcription accuracy before beginning analysis. The transcripts were then loaded into Delve, an online qualitative analysis software. The use of Delve allowed the researcher to analyze the focus group interviews through the application of codes.

The researcher began the first cycle coding for the focus group interviews with structural coding followed by in vivo coding. The application of these two methods allowed for the line-by-line inductive analysis. Inductive analysis, a form of content analysis, is a method to organize qualitative data through open coding, creating categories, and abstraction (Elo & Kyngäs, 2008). This form of analysis allows the researcher to move from very specific to more generalized views, allowing the researcher to note individual instances and combine them to a generalized statement, and has analysis guided by the research questions (Armat et al., 2018; Elo & Kyngäs, 2008). After further analysis and discussion with the researcher’s dissertation chair, descriptive coding was added as a third component of first cycle coding. Once initial codes were established, the researcher assimilated, distilled and relinquished codes in the process of blending by physically displaying the codes. This physical display allowed the researcher to establish groupings and develop categories. Analysis and synthesis of these categories led to themes, and outcome of coding, categorizing, and analytic reflection (Nowell et al., 2017). Table 4.3 displays the qualitative sources.
Table 4.3 Qualitative Sources

<table>
<thead>
<tr>
<th>Type of Qualitative Data Source</th>
<th>Number</th>
<th>Codes Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus Group Interviews</td>
<td>4</td>
<td>298</td>
</tr>
</tbody>
</table>

**Method of Analysis**

The transcripts were coded in several steps, beginning with structural coding during the first cycle. Structural coding allowed the researcher to create main codes related to specific research questions and build a foundation for future coding (Saldana, 2021). The structural coding led the researcher to identify some common codes as the transcript was analyzed line by line. The next step in the first cycle coding process involved the implementation of in vivo coding. In vivo coding is a word or short phrase from the actual data record (Saldana, 2021). As a new researcher, using the words of the participants, rather than inferring their meaning, seemed a more reliable and effective method of coding, therefore in vivo coding was used as the second step of the first round of coding. As a third step of the first round of coding, the researcher implemented descriptive coding. These combined basic coding processes allowed the researcher to organize the large quantity of text into usable and organized categories (Hsieh & Shannon, 2005). After the first cycle coding, 298 codes emerged from the data. Figure 4.1 shows an example of the codes that emerged from Delve and figure 4.2 shows examples of in vivo codes for stress.
Figure 4.1 Sample Codes After First Round Coding in Delve

- self-image (13)
- grades (10)
- relationship (3)
- stress (2)
- Perception (23)
- presentation (11)
- technology (7)
- Emotional Impact (3)

Figure 4.2 Example of Specific In Vivo Codes for Stress

**stress (24)**

Appears in 4/4 transcripts

| Interview Group 1A | Interview Group 1B | Interview Group 2A | Interview Group 2B |

Feeling stress over grades or studying.

Sort By Most Recent

**Interview Group 2B**

Like I have to make sure it’s all done before I like get to school next day or once I’ll be stressed out.

**Interview Group 2B**

And like, I feel like you get so stressed about it.
Table 4.4 demonstrates examples of the structural and in vivo coding.

Table 4.4 Examples of Structural and In Vivo Coding

<table>
<thead>
<tr>
<th>Sample Structural Coding</th>
<th>Sample In Vivo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitudes Towards Learning</td>
<td>It's just something I have to do to get, uh, to where I want to be.</td>
</tr>
<tr>
<td>Technology-Based Impact</td>
<td>my experience Quizlet has definitely been a giant help</td>
</tr>
<tr>
<td>Study Habits</td>
<td>I don't study at all outside of school</td>
</tr>
<tr>
<td>Positive View of Vocabulary</td>
<td>You need the vocab to understand what the material is telling</td>
</tr>
<tr>
<td>Negative View of Vocabulary</td>
<td>We don't ever talk about the words.</td>
</tr>
<tr>
<td>Relevance of Vocabulary</td>
<td>she does make the test to where it's applied to a real-world scenario.</td>
</tr>
<tr>
<td>How You View Yourself</td>
<td>I'm good academically</td>
</tr>
<tr>
<td>Stress</td>
<td>I have to make sure it's all done before I like get to school next day</td>
</tr>
</tbody>
</table>

After conducting first round coding, the researcher used a physical coding to begin to look for relationships and common categories within the existing codes. Existing codes were printed out and cut apart. They were then separated out by research questions and descriptive codes. This physical display of the coding allowed the researcher to reduce the 298 first round codes into 15 categories. The 15 categories were reinforced by creating an Excel spreadsheet of the first-round codes and comparing the similarities of the spreadsheet to the conclusions of the physical coding. The 15 categories were then analyzed and integrated into 3 themes. Figure 4.3 displays the
physical coding and Table 4.5 displays the themes, categories, and supporting evidence derived from the analysis of the qualitative data.

![Figure 4.3 Physical Coding](image)

**Table 4.5 Themes That Emerged from Qualitative Data**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Categories</th>
<th>Supporting Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Relationship with the teacher</td>
<td>a. Personal interactions</td>
<td>a. I feel like personality has a lot to do with it.</td>
</tr>
<tr>
<td></td>
<td>b. Positive relationship increases student view of material relevance.</td>
<td>b. As soon as we talked a bit, everything turned around.</td>
</tr>
<tr>
<td></td>
<td>c. Positive relationship increases engagement.</td>
<td>c. Personality has a lot to do with it.</td>
</tr>
<tr>
<td>2. Motivation to succeed</td>
<td>a. Value of grades</td>
<td>a. I feel like they are supposed to be important to me.</td>
</tr>
<tr>
<td></td>
<td>b. Perception of self</td>
<td>b. See yourself as a good student</td>
</tr>
<tr>
<td></td>
<td>c. Perception by others</td>
<td>c. Others see you as a good student</td>
</tr>
<tr>
<td></td>
<td>d. Stress</td>
<td>d. Not doing well effects your mood and mental health.</td>
</tr>
<tr>
<td></td>
<td>e. Value of school</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f. Study habits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>g. Parental influence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>h. Magnet program membership</td>
<td></td>
</tr>
</tbody>
</table>
e. You want to be a well-rounded person.
f. Some classes I spend more time than other classes.
g. My parents are on top of me about that.
h. You want to make at least an 80 to get credit for the class.

3. Instructional Approach

<table>
<thead>
<tr>
<th>a. Technology usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. Rote memorization</td>
</tr>
<tr>
<td>c. Classroom application</td>
</tr>
<tr>
<td>d. Engagement</td>
</tr>
<tr>
<td>e. Relevance</td>
</tr>
</tbody>
</table>

| a. I like Quizlet because of test mode and match mode. |
| b. When the assessment is done, I just forget the word. |
| c. It can help you with other classes. |
| d. Not everyone is going to learn the same way. |
| e. She makes it apply to a real-world scenario. |

Upon completion of the creation of codes, categories, and themes, I conducted peer debriefing with my dissertation chair and advisor, Dr. Ismahan Arslan-Ari. In relation to themes, Dr. Arslan-Ari asked me to make clarifications such as, “Please define what you mean by the relationship with the teacher?” and “What is the difference between technology usage and application in other classes?” Answering these questions and discussing my thought process with her helped me clarify my thinking and modify the wording of my categories in order to provide a more precise meaning.

Theme 1: Relationship with Teacher was supported through the categories of personal interactions, positive relationship increases perception of relevance of the material, and positive relationship increases engagement. These three categories represent the impact that students expressed as a result of the type of relationship they felt
with the instructor. It was important to the researcher to understand the student viewpoint as it related to engagement and ownership of the learning. Analysis showed that the students responded favorably to instruction when the instructor established mutual respect with the student.

*Value of grades, perception of self, perception by others, stress, value of school, study habits, parental influence, and magnet program membership* were all categories incorporated in Theme 2: Motivation to Succeed. For this study, the researcher wished to capture both internal and external influences on a student’s viewpoint of the importance to do well in school. Participants expressed a greater impact on their effort towards a higher grade when they could see value in the grade and saw self-worth in the higher grade. The participants also valued the view of classmates and parents in regards to grades and were greatly stressed when they did not achieve an acceptable score. Finally, members of the magnet program strived for high grades as it impacted their membership in the program.

Theme 3: Instructional Approach was comprised of the categories *technology usage, rote memorization, classroom application, engagement, and relevance*. Students expressed varied opinions on the use of technology to present material in class as they often felt the technology was not used properly. The participants also stated a reduced desire to learn when the vocabulary was more rote memorization with very little application. Finally, participants noted a greater interest when the vocabulary was presented in an engaging way and they were presented with example of the relevance of the material, specifically when related to real-world experiences.
Presentation of Findings

The themes for focus interviews are presented below in Table 4.6. The themes that developed from focus group interviews were: (a) relationship with teacher, (b) motivation to succeed, and (c) instructional approach. Each theme is explained with the aid of direct quotes from participants that are verbatim from the transcripts. Pseudonyms have been used for each participant to protect identities.

Table 4.6 Themes, Assertions, and Categories of Focus Group Interviews

<table>
<thead>
<tr>
<th>Themes</th>
<th>Assertions</th>
<th>Categories</th>
</tr>
</thead>
</table>
| 1. Relationship with teacher | Participants saw greater importance in the classroom activities and content when they developed a relationship with the instructor. | • Personal interactions  
• View of material relevance  
• Engagement |
| 2. Motivation to succeed | Participants expressed varied influences, both external and internal, on their motivation to succeed. These influences were also a source of stress for many participants, particularly perception of self, parental influence, and magnet program membership. | • Value of grades  
• Perception of self  
• Perception by others  
• Stress  
• Value of school  
• Study habits  
• Parental influence  
• Magnet program membership |
| 3. Instructional approach | Most participants enjoyed the technology used for instruction, particularly Quizlet and Quizizz, although a few prefer non-technology instruction. The greatest impact, as expressed by the participants, was on the relevance of the lesson and avoidance of rote memorization. Some | • Technology usage  
• Rote memorization  
• Classroom application  
• Engagement  
• Relevance |
participants noted the use of technology used in the study for application in other classes.

Theme 1: Relationship with Teacher

Participants were more positive towards classroom instruction when there was a favorable relationship with the instructor. Prior research has shown students see value in instruction and a greater understanding of the methods implemented by teachers when collaborative and collegial relationships are developed (Viewland, 2017). For this study, it was important for the researcher to establish the various influences that may impact a student’s classroom performance to weigh against the impact of technology implementation. In the interviews, participants were asked for their thoughts regarding the relationship with the teacher and its impact on their classroom success. The participants indicated factors included (a) personal interactions, (b) view of material relevance, and (c) engagement.

Personal Interactions

Participants in the study were a mixture of ninth, tenth, and eleventh grade students taking their first engineering course in the four-course pathway. Participants were asked various questions to garner information about relationships with the researcher and with other instructors. Research has shown that teacher interactions and relationships have been found to strongly influence student success (Bouras, 2019; Khodadady & Dastgahian, 2015; Song, 2019) as well as teacher efficacy (Kim & Seo, 2018). The participants expressed the influence of the personal interactions on class performance with statements such as this one from Tim, “My math teacher makes sure
you know it [instructional material] and that everyone understands it [instructional material], but my English class on the other hand, everything is kind of thrown at you and it’s just do it [the work]” and, “Yeah, it's [your attitude] just based on the class.” These statements emphasize the direct impact of the teacher’s interactions on the student’s motivation to learn and be an active member of the class. Prior research shows how self-determination theory supports the feeling of competence and belonging that motivates students when they have a strong interpersonal relationship with the educator (Peng & Chen, 2019; Sethi & Scales, 2020), while lacking these relationships can lead to disengagement (Tan et al., 2019). Berry (2019) noted the increased benefits of a sense of belonging to include increased participation and learning.

**View of Material Relevance**

Participants expressed a greater understanding of the relevance of the material with teachers when they felt they had a stronger relationship. Four students stated the desire to work harder in classes when they had collegial conversations that led to an understanding of the material in relation to their future plans and their personal lives. The knowledge the teacher has of the student, and the ability to relate the material to the student, can allow the student to see what is the personal gain and, thus, increase personal engagement (Belet, 2018).

When discussing this concept with the participants, the researcher found eight participants did not see any relevance to their future in the academic matter. For example, Mark stated, “I would've learned this field [Engineering] compared to English where all the vocab words are random feeling and I don't feel like I am going to use them [vocabulary],” and Roger stated, “But like something where you're learning about some
off or far, far away, um, small group of people that applies to like nothing that you're
gonna be learning I just don’t see your point in doing it.” Both of these statements reflect
the disconnect that was present when the teacher did not establish the connection with the
student and allow the student to establish the connection with the material. In contrast,
the other 12 participants did see the relationship and therefore were able to conceptualize
increased understanding of the relevance of the material. Mark went on further to say,
“And she [the teacher] does make the test to where it's applied to a real-world scenario”
in reference to a discussion about why a particular class is interesting. Increasing student
understanding of relevance will not only increase success, but increase overall
engagement.

**Engagement**

When investigating student engagement, one must consider the full behavioral
dimension of engagement. Engagement includes the effort, attention, and persistence of
the learner during an activity (Struyf et al., 2019). Participants in this study were very
vocal regarding the varied engagement in their classes. Five expressed a lack of
engagement in any class, four expressed full engagement in all classes, and the other
eleven had different levels for each class. The majority of the participants (15) were
quick to say they were directly impacted by the relationship with the teacher and the
perceived engagement of the teacher.

Student buy-in can be directly tied to engagement (Shaw et al., 2019). Students in
the study expressed a clear divide between buy-in or not, especially in regards to the use
of web quests. Students were quick to express the negative connotation brought about
when a web quest was assigned because they believed it meant the teacher was not
invested and just wanted to give them busy work. The same assertion was made regarding large quantities of vocabulary note cards. Students remarked that these type assignments lead to boredom and more focus on completing a task than learning the material. Positive academic outcomes are closely related to student engagement (Bernstein et al., 2014) and student engagement is solidified when they feel a sense of belonging (Henrie et al., 2015).

**Theme 2: Motivation to Succeed**

Students find the motivation to be successful from both intrinsic and extrinsic sources. In addition, the measure of success is individual and cannot be compared from one student to another. This research looks to the expectancy-value model of motivation to explain success in adolescents. This model states the academic ability perceived by the student and the student’s general interest in learning will directly impact their belief in their own ability, and, therefore, directly influence their academic choices and behaviors (Fan & Wolters, 2014). When exploring this concept within the parameters of the study, the researcher found several common factors impacting student success including (a) value of grades, (b) perception of self, (c) perception by others, (d) stress, (e) value of school, (f) study habits, (g) parental influence, and (h) magnet program membership.

**Value of Grades**

Participants varied in their view of grades. Thirteen of the students did see value in relation to success and future achievement, but did not see value in obtaining the highest grade. All of the participants expressed more concern in advanced placement classes as they saw this impacting college admittance or class rank more than a college prep class. Bobby provided a clear example of this thinking when he said, “I feel like
they’re [grades] supposed to be important for me and I treat them like they’re important for me, but I feel like they’re [grades] not that important for my future.” This was a common idea throughout the conversation, especially in regards to general core classes. This view of grades, and of the class itself, greatly influences the student’s motivation to succeed, particularly with first year high school students who find grades to be a part of their identity and one of the hardest transitions in high school (Roybal et al., 2014).

Perception of Self

The impact on student scores was often found to be related to their self-perceived ability as a student. When asked the question, “Are you a good student?” answers were vague and included “Yeah,” “I guess so,” “I’m not sure,” and “Sometimes.” Four participants answered with greater confidence but still noted that they felt stronger in some classes than others. This belief in ability, or lack of belief in ability, has also been directly correlated with high school failure and dropout (Parr & Bonitz, 2015), thus impacting a student’s motivation to succeed.

As the students move through the myriad of courses they take in a high school career, there is also a relationship between their perceived ability and the academic content. If students do not believe they will be successful, they will often avoid or disengage from the class. In particular, female participants of the study commented more often a feeling of reduced capability in STEM classes. In a conversation with Ally, she responded that she is a good student “sometimes,” and Carrie responded that she is a “mediocre” student. Both of these responses were given by magnet program students with very high averages. As the STEM classes rely greatly on critical thinking skills, these responses corroborated a previous report noting different abilities in different
genders (Bećirović et al., 2019). These self-beliefs significantly influence personal motivation and carry beyond the classroom into STEM careers where only one in seven engineers is female (Gottfried & Plasman, 2018).

**Perception by Others**

All of the focus group participants noted little regard for the opinion of others in their academic behavior, but did feel it necessary to have good grades as a comparison. Sixteen of the participants wanted to be seen by classmates as smart, but chose their own methods to pursue their grades. When asked how they felt if they made a bad grade, Alvin responded, “I mean, I don't really care, but maybe at first I'm kind of like embarrassed.” This sentiment was echoed six times by other participants. The researcher was unable to determine if this was an actual thought or a defense mechanism.

This is in contrast to a previous studies which found a great influence on academic success due to peer influence (Clark et al., 2011; Livingstone et al., 2014; Uretsky & Stone, 2016). Clark et al., (2011) in particular, notated eight studies implicating the tremendous influence peers have on academic outcomes. This evidence was supported by a few of the students in the study. Amy made the comment, “Um, like I wanna have good like B, As and Bs to show that like I'm not, not, not dumb, but like I care,” and Carrie stated, “I feel like now you've started to learn who makes the best and who makes the worst grades.” Most notably, Billy commented, “Cause, I know how I know who I am and I know how, what I know, what face I show everybody and just whatever face they see me as it's the face they get to see it.” As Billy’s teacher and the researcher, this statement was particularly powerful. Billy often tries to portray the persona of not caring and being very nonchalant about grades, but I have witnessed his
stress and his desire to perform well. To continue his “tough guy” appearance, Billy then stated, “I, me personally, I've just kind of whatever people think of me just doesn't matter to me.” Finally, Mark stated, “I don't really view myself as a very good student just because I don't really enjoy school that much.” Although disturbing as an educator, this statement provided valuable insight as a researcher. As a whole, the students seem to have established academic and social identities and appeared confident in the person they had become. Peer influence can influence to desire to succeed through the discreet impacts of modeling and setting a standard for success (Clark et al., 2011).

**Stress**

All of the participants expressed great stress with school and the impact it plays in some form on their academic gains. The sources of stress included personal stress, being in the freshman year of high school, time management, and handling school and extra-curricular activities. Students also commented on the stress of the non-traditional school year due to the Covid-19 pandemic.

The eighteen high achieving students noted a personal stress as they pushed to complete everything required for their classes. Carrie emphatically stated, “Like I have to make sure it's all done [homework] before I like get to school next day or once I'll be stressed out.” This sentiment was reinforced by Amy who said, “And I like, I think that affects like your mood and like how like your mental health, because like, it definitely like grabs ahold of you [classwork and grade stress].” As these two statements confirm, many students face emotional stress as a result of pursuing academic success.

The ninth-grade students commented on the stress of navigating high school for the first time or in conjunction with outside activities. When asked what was needed to
reduce the stress, the answers included training on time management skills, reduction in homework, and an understanding of the amount of work assigned by several teachers each day. For example, Lou, a male student athlete, commented, “I feel like it's [course work] a lot of stress, especially like for student athletes who do have to like figure out how to manage sports and how to get a whole bunch of work done.” Carrie, a female student athlete, reinforced this comment by saying:

“Like, like I just feel like I have to prioritize my like social life and like my, like I just feel like every time I have like a sports activity, I to come home straight after it and look straight into my Chrome Book and just finish everything I had.”

This increased stress can lead to burnout, poor attitudes towards school, or feelings of inadequacy in adolescents (Williams et al., 2021).

Value of School

This topic produced a wide range of responses and circumstances. Five of the focus group participants were in a virtual school for the previous year and were experiencing high school face to face for the first time. The responses were greatly impacted by the educational circumstances from the prior year. The five former virtual students felt a great need for training on time management and saw little regard for being in class for the entire day. Sharon, a former virtual student, expressed her desire to return to her virtual schedule with, “So that's like also like hard because I'm like, why am I here all day?” This sentiment was shared by the other former virtual students who found virtual school easier and less time consuming. It was recognized by these same participants that the virtual year was middle school and that the difference could be due
to being in high school. Lou, a 9th grade student, stated, “Like teachers think that we have the integrity not to cheat, but nah, everybody.” He went on to talk about the ease of cheating, especially when virtual, and how it became natural and expected. As most of the participant students were in the 9th grade, and most had not experienced a normal school year since 6th grade, there was a general consensus that the school year was harder due to an adjustment period of transitioning to a full year of attending every day. Three did share the thought process of seeing school as a stepping stone to the next phase of life. Mark summed up the sentiment of many students when he stated, “It's just something I have to do to get, uh, to where I want to be.” When students do not see value in school, then they do not see value in succeeding in school.

**Study Habits**

Just as with value of school, study habits were greatly influenced by outside activities and prior school experiences. The participants noted a variety of study habits from last minute cramming of information, to regular study times. Seven students noted the different study habits based on the interest and difficulty of a class. Lisa noted, “Because like human geography, I spend so much time just doing the [vocabulary] flash cards by the time I'm done like I'm not gonna study 'em.” This statement relates back to the engagement and how this can influence the study habits of a student. Alvin reinforced the need to learn how to navigate high school when he stated, “And for high school, I learned like throughout the year that you're gonna have to actually put into your subjects and more time to other subjects that I struggle with.” This was an important comment as it opened up discussions with other students about which classes require more time and which are easier to study. The negative comments regarding study habits
is supported by academic studies showing a decline in academic motivation as students move through the school years (Sethi & Scales, 2020). The researcher was encouraged by the students’ apparent understanding of the core value of school. Well stated by Lisa when the conversation turned negative towards learning, “But also like, you still have to be like a well-rounded person in society.” The focus group conversations strongly support the research showing academic self-belief, combined with study habits, will strongly influence student performance (Bahar, 2016).

**Parental Influence**

“Of the many different relationships peoples form over the course of the life span, the relationship between parent and child is among the most important” (Oberai & Vishwavidyalaya, 2017, p. 37). Parents provide the first and strongest influence on the student. Five participants agreed that parents saw value in an education and that they were expected to do well in school. Four participants also noted the need to make a certain grade in order to receive parent approval. In regards to parental influence, Mark noted, “They never like yell at me about 'em but like, uh, just when they talk to me about it [grades], I almost feel like I've let them down.” Ally then commented, “So my parents, you get paid for like your report card or you lose money for your report card.” These two comments show polar opposite motivators from the parents. The first reflects a need to please and the second a desire to be rewarded as the motivation to be successful.

**Magnet Program Membership**

When asked about magnet program membership, the eighteen students who are part of the program noted the push to do well to maintain their membership status. They
also noted the stress brought on as members of the magnet program and how it pushed some to withdraw.

The magnet program students, who take a rigorous AP schedule, recognized the need to improve their study skills, but also noted the differences between magnet teachers of the same subject. Mark made the following remark regarding the stress of the magnet program in the first year of high school and the first year back after being a virtual student, “Especially being in a magnet program and like your first year of high school and not going to school for two years, it was just like, like big shock.” Lisa followed up with a supporting statement when she said, “I think a part of that is the magnet program and like we joined it to be pushed farther and to be ready to for college, but I wouldn't recommend it for a freshman.” Both students felt tremendous pressure to be successful as members of the magnet program in their drive to succeed in academics.

**Theme 3: Instructional Approach**

Cognitive Load Theory states that different types of resources provided varied teaching and learning activities can make demands on students beyond the learning of material (Martin, 2012). The instructional approach of the researcher was designed to reduce the cognitive load by implementing platforms familiar to the students and on devices familiar to the students. When evaluating instructional approach in this study, several key categories arose to include, (a) technology usage, (b) rote memorization, (c) classroom application, (d) engagement, and (e) relevance.

**Technology Usage**

In this study, students were familiar with the various technology platforms used and had been exposed to it by the researcher prior to the beginning of the intervention.
Students appeared relaxed in regards to the use of each technology and were able to access it without issue. In general, the participants actively participated in the lessons and understood each component also held an academic value in the form of a grade. Students cheered each other on and played the games with vigor. When the discussion of these activities arose in the focus groups, the researcher discovered the mixed feelings of the students and the reasons for these mixed feelings.

The first activity that elicited mixed reactions was the Quizlet. Twelve of the students commented positively and noted the regular use of this platform in several classes. Students provided reasons for liking this platform to include the ability to play review games, take practice tests, and use the flash cards for reviews. Some negative responses regarding the platform included not really learning the terms but instead memorizing a picture, and the inability to cross things out. One important comment made by Tim was, “For me creating it [flash cards], helps you study it more by actually doing it.” This was in reference to vocabulary sets being provided versus having the students create them. The group went on to mention that they knew they would learn it better if they were writing it rather than looking at it on a computer screen.

The students also had very strong opinions about web quests. When first assigned, the researcher heard collective groans from the students. When discussed in the focus groups, participants explained the negative connotation that comes with web quests. Students described it as, “pages of busy work,” or “it’s time consuming and boring.” Participants went on to explain the change of opinion when they saw the design of the web quest for the study. They found value in the research and in the peer teaching that occurred. Mike summarized the value to the group with the statement, “I mean,
they're pretty simplistic words, but like doing the research made it had me a better understanding of 'em.”

Although the other technologies used did not elicit such strong responses, a few student comments were of note as they were valuable insight into the students’ thoughts. First, Amy, who was being particularly quiet, finally spoke up and said, “I, I don't learn well with technology.” This was a powerful statement at the conclusion of a study based on technology. Second, Carrie commented, “I feel like I also am a better test taker when it’s paper. I feel like it is less intimidating.” It is assumed that today’s students are technology-driven, but that is not always the case. Participants of this study acknowledged a desire to study with paper flashcards, implement mnemonic devices, and utilize other non-technology-based methods of learning.

**Rote Memorization**

Rote memorization is surface learning or surface processing and not valuable deep processing of information (Cook, 2006). Participants in the study admitted to frequent rote memorization and noted the ease and lack of value in this process. Participant comments included the statement by Jane, “When it’s done, I just forget the word.” This reinforces the surface learning and the lack of information processing. Participants noted the value in the various applications of the terminology during the study and the rich meaning these activities provided.

**Classroom Application**

When asked if they utilized any of the skills learned in any other classes, all of the students did note the use of Quizlet in other classes. Six also commented on the value of having peer instruction and how it could be helpful in another class. Mary stated, “You
better understand what you're doing” in reference to taking time to really learn the vocabulary. Three students also commented on the desire to move away from technology and utilize paper and pencil methods for studying new vocabulary. This was best expressed by Mike who commented, “Like in Spanish I write down words a lot and that helps with just, I mean, the more you write it [the vocabulary] the more you are going to know how it’s [the vocabulary] written and how to spell it [the vocabulary].”

**Engagement**

Student engagement explores the emotional, physical, and academic responses students supply as they dedicate time and energy to class activities (Rashid & Asghar, 2016). Focus group participants noted different levels of engagement based on the subject and the teacher. Comments by participants included when Tim said, “So like if it's like, not like if I'm not interested, it's hard for me to like, listen, you know, but if it [the instructional material] has my interest I'm engaged,” and when Lou stated, “If you like the class, you will remember it [the instructional material] more than for a class that is boring.” Research has shown a direct relation between engagement and educational outcomes such as persistence in learning, satisfaction and academic achievement (Henrie et al., 2015).

**Relevance**

Course relevance has been described as, “a student’s perception of whether the course instruction/content satisfies personal needs, personal goals, and/or career goals” (Belet, 2018, p. 209). Relevance may refer to the material being presented itself, or it may refer to the manner in which the material is presented, adapted, or matched to student’s interests (Tutuianu et al., 2013). Students in the study were asked if they saw
relevance in learning vocabulary and the responses, in context, were very telling of the importance of relevance. During the four focus group interviews, there were a total of 22 comments related to relevance. For example, Billy, in group Focus Group 1A, stated:

“Cause most of the time when teacher give like what classes cause they know they're not gonna be there in the next class. And so, it's not even most of the time, it's [the web quest material] not even relevant to what we're learning. And it's [the web quest material] some random stuff that you gotta find out that the [web] links are so outdated and stuff like that. They're [the links] either blocked on the website or they don't even exist anymore.”

This one example epitomized the reactions of the students. Other examples included Mark’s statement of, “Cause I would've learned this field [Engineering] compared to English where all the vocab have words are random feeling and I don't feel like I am going to use them [English vocabulary words],” and Sharon’s comment, “Or if it's a class that has something to do with what you want to do in the future, then you're more likely to actually wanna study it [the instructional material] because when you in a class where you don't really care about it [the instructional material], it's [the assignment] just busy work.” When the students do not see value or relevance in the material, they lose the desire to be fully engaged. One student noted the relevance of the material in the engineering class as a result of the problem-based learning and the hands-on experiences, both of which have been shown to increase the relevance of learning (Struyf et al., 2019). John supported this concept with the statement, “This is the only class where they've
[vocabulary] been used in context, like where we openly used them and actively used them.”

Summary

The experience with the technology-based module appeared to be positive for the academic gains of the students. Participants actively interacted with the lessons and each other. As evidenced from the focus group interviews, participants valued the relevance of the material and relationship with the instructor as major factors towards their attitudes towards learning and level of engagement. Students appreciated understanding the impact of the vocabulary in relation to the real-world and their personal futures. They also expressed great significance of influence based on their interactions and relationship with the instructor. Proper implementation of technology (Burnham & Mascenik, 2018; Koretsky & Magana, 2019; Maeng, 2017), clarifying relevance (Belet, 2018; Courey et al., 2013), and strong relationships (Sethi & Scales, 2020) are powerful tools for ensuring student success. In chapter five, discussion will continue about the effectiveness of implementing a technology-based module in this study.
CHAPTER 5
DISCUSSION, RECOMMENDATIONS, IMPLICATIONS, AND LIMITATIONS

The purpose of this study was to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Introduction to Engineering course. This chapter presents the findings in relation to the research questions and literature regarding technology-based instruction and student attitudes towards learning to answer the two research questions: (1) How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course? and (2) What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course? In addition to a full, detailed discussion, recommendations, implications, and, limitations will also be discussed.

Discussion

The quantitative and qualitative data collected and analyzed were combined to answer the two research questions driving this study. The discussion portion is broken into two parts, one for each research question: (1) How does implementing a technology-based instructional module impact Engineering vocabulary academic gains for students taking the Introduction to Engineering course? and (2) What is the effect of implementing
a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course?

**Research Question 1: How Does Implementing a Technology-based Instructional Module Impact Engineering Vocabulary Academic Gains for Students Taking the Introduction to Engineering Course?**

Students in today’s schools are using technology to take notes, complete assignments, and access resources (Henrie et al., 2015; Lowther et al., 2008; Taneja et al., 2015). To determine if participants’ academic gains were impacted by the implementation of a technology-based instructional module, the results from the pre- and posttest scores were analyzed. Technology impacting this innovation included Quizlet, Quizizz, Wordle, Google Forms, a web quest, and Google Slides. The findings from the analysis of this data are presented below.

After examining and comparing the data from the teacher created pre- and posttests, the use of technology did positively impact student academic gains in content vocabulary. A comparison of the pretest ($M = 53.26$) to posttest ($M = 96.48$), completed after the implementation of the technology-based instructional module, revealed a significant increase. Although both sections showed gains, the greatest increase occurred in the Understanding section, pretest ($M = 53.39$) and posttest ($M = 96.61$), versus the Vocabulary Application section, pretest ($M = 53.04$) and posttest ($M = 93.91$), which indicates a need for more focus on applications. Pearson et al.’s (2009) study with fourth and fifth grade students found a significant difference in mean scores between students who used a technology-based learning module and students who did not. Another study by Maeng (2017) evaluated the impact of technology integration in a secondary Biology
classroom. This study provided evidence that suggests technology as a powerful tool for differentiated instruction and to meet the needs of various learning styles. An even earlier study by Maninger (2006) found an increase in state-mandated test scores for high school English 1 students in comparison to the previous year without technology-integrated instruction.

In the current study, the impact varied based on student, as seen by the individual scores for both the assessment and the survey. When comparing the pretest to the posttest, all of the participants saw improvement in their measure of vocabulary understanding, but only 30% saw a gain of 50 points or more. The remaining 70% showed gains between 20 – 49 points, with a majority, 47%, producing gains of less than 40 points. This improvement could be attributed to the students’ familiarity with the platforms used or with the accountability established with the researcher monitoring activity.

When comparing the academic gains to the survey results, a pattern was evident. All of the students with gains of 50 points or more had slight to significant increase in survey means. This data supports the concept that the implementation of technology not only increases academic gains, but has the effect of increasing attitudes towards learning academic vocabulary, specifically Engineering vocabulary.

One significant notation as a result of the study was the students’ desire to move away from technology. Of the 20 students participating in the focus groups, four of them, 20%, commented on the desire to move away from technology. This is in contrast to previous studies in which students preferred technology-enhanced curriculum (Koretsky & Magana, 2019; Lefevre & Cox, 2016). Educators believe their students to be digital
natives with a desire to learn via technology (Staff, 2021). Could it be the excessive amount of technology-based learning during the Covid pandemic has shifted the students from a desire for digital instruction to a preference of tactile methods? Students within this study supported this possible change with statements such as, “I, I don't learn well with technology,” and, “I feel like I also am a better test taker when it's paper it's I feel like it's less intimidating.” These two examples show that although there were increases in academic gains, factors other than technology may be of greater influence.

Focus group discussions brought about important information regarding technology and academic gains. The students repeatedly stated the use of Quizlet and Quizizz in other classes and the benefit of these programs in increasing test scores. The ability to play review games, use various study modes, and have a visual and an auditory prompt providing motivation to study the vocabulary was also found to be an outcome of the study. Students also noted the ability to create tests on the technology platforms to check their understanding and measure the level of preparedness for an assessment. As with the study by Koretsky and Magana (2019), the current study showed increased engagement from the students, a key indicator of increased test scores.

Focus group discussions also brought to light a desire to, at times, move away from technology. Students commented the habit of, “rote memorization,” “clicking the images,” or, “you’re just memorizing what it [vocabulary and related image] looks like.” Additionally, students were very vocal on the negative connotation of a web quest and the “busy work” implication of the term. Students in the focus groups were adamant of the need for proper implementation of technology and the application of the technology
and vocabulary to real-world scenarios. They desired to know the technology being utilized was applicable to a future career and not just inside the confines of the classroom.

**Research Question 2: What is the effect of implementing a technology-based instructional model on attitudes towards learning Engineering vocabulary for students taking the Introduction to Engineering course?**

Students attitudes towards learning have been found to be a predictor of student success (Cetin et al., 2019; Moyer et al., 2018). To determine if participants’ attitudes towards learning were impacted by the implementation of a technology-based instructional module, the results from the pre- and posttest scores, student surveys, and focus group interviews were analyzed and combined. The findings from the analysis of this data can be presented in three sections: (1) vocabulary presentation, (2) relevance of material, and (3) relationship with the instructor.

**Vocabulary Presentation**

The engineering classroom utilizes a very hands-on approach to instruction. Students learn through brainstorming, designing, collaborating, building, and testing of ideas. Content vocabulary is the exception to this approach. Within this study, the content vocabulary was presented using a variety of technology-based platforms. The students expressed both approval and disdain for the programs.

When asked about Quizlet, the students had an overall approval for the platform. They liked the various study methods and the ability to create practice tests. Some students did comment on the need to move away from the platform’s digital flashcards to paper flashcards with comments like, “I feel like writing something down, you get the information a little bit better,” and “Cause writing down makes you remember it.”
Web quests were a source of information that, at first, created a very negative response with the participants. Participants commented on the assumption that a web quest would be a bunch of busy work and of no value. They were very pleased to find the value in the design of the web quest for this study. The focus of a web quest is to use information and not look for it (Grant, 2002). Therefore, this study provided the students with a known vocabulary word (using information) and asked them to find a visual representation of the term. Additionally, the students saw value in having peers teach them about the term when they presented their image of the vocabulary word. One example came from Carrie when she said, “And definitely like when we, it like, um, people explain it [content] in their own way, made it, made it make sense to me because it came from like a student's point of view where some things just don't make sense.”

The last tool used in the study was a word cloud. The teacher provided a term and the students responded with the first word that came to mind. Similar terms created larger words within the cloud. When discussing the word cloud with the students, there was a common appreciation for the visual it created. The students liked that they could see the relative terms and the magnitude of the relevance.

**Relevance of the Material**

Relevance of material is classified as either high relevance, with local and familiar examples, or low relevance, with abstract examples (Belet, 2018). Providing relevance allows the student to see the importance of a lesson and increases authentic understanding (Courey et al., 2013). When relevance was discussed with the students from the study, most participants agreed that relevance had a significant impact on their
study habits and classroom engagement, both of which directly impact attitudes towards learning.

For example, although Mary only had a slight increase in survey score from pre to post intervention, she did discuss in the focus group the relevance of vocabulary as, “You better know it to know what you are doing.” Mary also marked the positive question, “I always actively complete the Engineering vocabulary assignments of this course without being reminded” with a *strongly agree*, while marking the negative questions, “The learning of Engineering vocabulary is irrelevant to my future life,” and, “I actively ask the teacher about the Engineering content vocabulary that interests me in the course” as *disagree* and *strongly disagree*, respectively. Additionally, Kevin commented, “Cause like science at the end of the day is just term definition. But like human geography, you need to know like what's happening, what it is, where it's happening, things like that.”

When survey results were considered for the participants as a whole, the results showed an increased score for relevance question, “I think learning Engineering vocabulary is very useful to me,” thus reflecting a positive impact as a result of vocabulary relevance.

When focus group comments were evaluated as a whole, the class remarked high value for the impact of relevance of vocabulary on engagement. This is similar to the study by Belet (2018) which found that the perceived higher course relevance was associated with higher course satisfaction. Focus group participants noted the importance of understanding the future value of the knowledge being conveyed. They also found greater motivation with material which would impact their future careers, is relevant to a real-world scenario, or is applicable in cross-curricular implementation.
Relationship with the Instructor

Student engagement can be seen from two perspectives. The first perspective focuses on disengagement and the need to build relationships in order to correct this concern (Quin, 2017). The second perspective focuses on the positive connotation as seeing students actively engaged in school activities and engage with positive relationships with teachers (Xuan et al., 2019). Struyf et al. (2019) conducted a study which identified the relationship between student and teacher as a significant factor in student engagement. Their study looked at STEM learning environments and the factors that influence student-centered engagement. The study that both the academic and emotional relationship between the student and the teacher impacted both the students’ attitude and academic success (Struyf et al., 2019). Additionally, a study by Xuan et al. (2019) indicated the student-teacher relationship is predictor of not only student academic success, but social-emotional wellness.

The current study evaluated student-teacher relationships and the impact on a student’s attitude towards learning Engineering content vocabulary. During this intervention students were often in conversation with the teacher about the content vocabulary. The teacher had already established a relationship with the students, some positive and some negative, as they had been in class together for six months prior to the implementation of the innovation. The teacher had worked to establish a relationship of mutual understand and respect, while upholding the expectations and rule of the classroom.

When asked about the importance of the teacher-student relationship in the focus group interviews, a common concept kept arising. The students felt a definite association
between their relationship with the teacher and their level of engagement. One student, Lou, commented, “If you like the class, you will remember it [the instructional material] more than for a class that is boring.” This statement was echoed by Billy with, “Easily, it [engagement], it just, for me just depends on, uh, whose class it is.” Both of these students directly correlated classroom engagement and effort with the relationship with the teacher.

A pattern was found when comparing the Attitudes Towards Learning Survey to the academic gains. For example, Bobby only showed an increase of 49 points on his content vocabulary score, and produced a loss of 6% on his survey. When asked about engagement, Bobby responded:

“Cause I want to go into like business or like I, like, I have a lawn business and like, it really like stresses me out that I'm at school wasting my time, stressing really hard classes when I could be making more than my teachers per hour mowing grass. So, kind of like it's like, it was just weird to think about how I'm at school for the purpose to make money and get a job in the future when I'm not able to do that because I'm at school at the moment.”

This statement reinforces his lack of belief in the importance of school and his lack of relationship and mutual respect for his teachers.

In this study, although technology was a positive influence on academic outcomes, relevance and relationships proved to be a greater impact on over all attitudes towards learning.
Implications

Instruction and instructional platforms continually change, offering new methods for conveying content to students. Technology has become a significant factor in structuring academic lessons, especially since the Covid-19 pandemic. For these reasons, this study has significant implications. The five categories of implications are: (1) implications for teachers, (2) implications for students, (3) personal implications, (4) implications for my classroom, and (5) implications for future research.

Implications for Teachers

Teachers have a tremendous influence over students. They are the classroom authority, content source, and, to most students, the person in control of the grade. Good instructors look for ways to properly use technology, engage students, and develop a relationship that will lead to academic success (Sethi & Scales, 2020). The study revealed that in order for teachers to successfully implement technology for academic vocabulary gains, two areas must be taken into consideration: (1) relevance of the assignment, and (2) relationship with the student.

Relevance of the Assignment

One way in which teachers can ensure student success is by providing a clear explanation of the relevance of the assignment. This study provided evidence of the importance of understanding the “why” for an assignment, as well as, understanding the material itself. A clear understanding of relevance is positively associated with student motivation (Belet, 2018). Our focus groups discussed assignments that provided clear relevance and those were ambiguous in purpose or appeared as busy work. I tried to be clear in my explanations of purpose and goal of any assignment, relevance to the
material, and examples of application in real life. Participants provided a great deal of feedback regarding the assignments I provided. I found that they appreciated more activities that allowed for interaction and provided an evident purpose. The focus groups also revealed a contradiction to general thinking about today’s teenagers; they prefer less technology and increased traditional activities. This is a factor of relevance. Students were adamant that a web quest brought automatic negative feelings as they are perceived as time fillers and worthless. Teachers must ensure that any use of a web quest is valuable, usable, and with clear learning intentions for the student. It is also important that the technology used has a purpose. The students commented on a need to have the technology make sense. This included utilizing real-world technology and not just educational technology. This may be in the form of career apps, devices, or scenarios.

**Relationship with the Student**

Pollock (2019) noted the substantial impact on student success resulting from a positive relationship with significant adult at school. Developing a relationship and allowing the student to feel like a stakeholder in their education was a key component of this researcher’s instructional style. I frequently stopped to talk to students about their day, showed interest in their activities, listened to their concerns, and rewarded them for positive behaviors. This was not something taught in my educational training program, but instilled in me by a mentor. When I began this study, I made clear to my students the purpose of the study and the need for absolute honesty. Some students questioned if I would want to know if they did not like something. Our open and honest discussion, based on the relationship we had already established, gave the students ownership in the class activities and in my research itself.
The relationship between a teacher and student was also found to have negative consequences. Teachers must be cautious of their reactions and interactions as these forms of feedback to students can cause disengagement. Students expressed less desire to do work for classes in which they felt the teacher did not like them, did not really teach, or did not seem to care. Regardless of the subject matter or the level of interest it elicits from the student, the relationship with the teacher will influence student success.

**Implications for Students**

The student in today’s classroom has the opportunity to experience learning in a wide variety of formats, on a wide variety of platforms, and with a wide variety of content basis. As a result of the current study, I would recommend students become their own advocate for learning. Students must empower themselves to do three things: (1) ask questions, (2) seek understanding, and (3) own their learning.

*Ask Questions*

Students often ask questions, but often do not know the appropriate way to ask or what to ask. It is critical for the student to ask questions and show interest and be an active participant in developing a relationship with the teacher and classmates. During the study I frequently talked to the students about what we were doing and how it impacted them. I found students enjoyed the class more when they asked questions and worked to be part of the conversation.

*Seek Understanding*

During the focus group interviews I heard comments like “And um, she just like bombards us with like, she’ll give us a test and it’s got like a hundred questions and it’s like a sense and you have to fill it in with the vocab word,” and, “It’s like they didn’t give
us direction on how to answer to those type of questions for the vocabulary.” Both of these statements express a lack of understanding by the students. It is critical that the student make the initiative to ask for clarification when the content is not clear. This questioning may be for application of a term, context of use, or any other area needing clarification.

**Own Their Learning**

Student buy-in, the amount of ownership and personal engagement in work, has found to be positively associated with student success (Shaw et al., 2019). Within the current study, student ownership of learning directly impacted their success as they were required to study outside of the classroom. I do not normally assign homework in my class, especially because the majority of the assignments are hands-on and require group interactions. When I discussed ownership of work with my students, I discovered a very obvious divide. Some students stressed over grades, stayed up late studying, and were very focused on academic success. On the opposite end of this spectrum were students who admitted, “I can’t remember the last time I actually studied a set of vocab cards.” Students must take the initiative to take ownership of their work and make it a part of their routine. The teacher can only provide the resources and information, it is the job of the student to process the information and put in the effort to achieve mastery.

**Personal Implications**

Throughout this study, I gained insight into my classroom and the students I teach. I learned a lot about my role in their educational journey and discovered ways to improve my instructional strategies. The study has shown me how important it is to know my students when making decisions about instruction. Two considerations emerged
as a result of this reflection: (1) changed perceptions about instruction and (2) changed perceptions about my students.

**Changed Perceptions about Instruction**

As an active participant in this study, I have had the opportunity to reflect on how I approach instruction and how my students respond to instruction. I have always been a supporter of multimedia strategies. I have taught numerous workshops on the topic. I have been instrumental in implementing these technologies in my school. When the Covid-19 pandemic hit, I felt confident in my ability to continue teaching my students with high-quality lessons utilizing various technology-based platforms. As time passed, and we returned to school, I was thrilled to continue to use these platforms because I, like so many others, thought that today’s student preferred to be on their devices. As this study progressed, and my participants began to use the components of the intervention, the desire to move away from a digital platform and into a traditional platform became apparent.

This study provided students with “on demand” tools for accessing and studying the vocabulary. The design of the instruction was to provide visually appealing activities, peer collaboration, peer communication, and equal opportunity for learning. I purposefully chose platforms that were familiar to the students and included visual and auditory content. Although the technology platforms provided the desired academic outcome, I have determined it may have greater success when combined with tactile activities. As a result, I have changed my instructional approach to academic vocabulary instruction to include a combination of technology and paper-and-pencil activities.
Changed Perceptions about My Students

My participation in this study, particularly with the focus groups, provided great insight into my students and their thinking. The first thing that stood out is their level of competitiveness. Throughout the various activities, whether Quizlet Live, Quizizz, or Word Cloud, the students wanted the highest score, best rank, or largest term in the cloud. This was evidenced by comments in our focus group. Students commented in the need to appear as smart.

The second perception change as a result of this study is in the influence of peers on their attitudes. High school students put great importance on how their peers see things (Bahar, 2016). When conducting the focus group interviews, I noticed a pattern of students changing their opinions and following the path of their classmates. For example, in one group the topic of a certain teacher and her aggressive teaching style was brought up by a student. There was an immediate shift from a positive conversation about teachers and instruction to a mass conversation about negative classroom experiences. This has made me more aware of the dynamics of my classroom and the power of subliminal influence by peers.

Implications for My Classroom

Throughout the study, I was able to see myself as a facilitator of the learning process. I wanted to provide creative ways to accelerate learning and provide a positive experience for my students. This study showed the importance of consideration of both of these factors within the design of instruction. As a result, the following two categories emerged: (1) changed perception about technology and (2) changed perception about student learning styles.


**Changed Perception About Technology**

As the study and my conversations with my focus groups concluded, I quickly began to realize the need to have purposeful and limited use of technology in activities. As a technology teacher and trainer, this was a tough concept to accept. My classroom is abounding with technology tools and my students spend a great deal of time working with these items. The change I referenced is with the technology I will use in my instruction.

When asked in the focus groups, there were students who did not see value in the technology being used. Carrie reinforced this when she said, “I feel like I also am a better test taker when it's paper it's I feel like it's less intimidating.” Another viewpoint that reduces the value of technology being used in school was presented by Sharon with the statement, “I think it would be good if we learned how to use the technology that is being used in the real world rather than just doing everything on our own.” Both of these statements have led me to reevaluate how I am presenting material and how the technology I am presenting relates to the real-world.

Technology has its place in education and in the professional world. Technology is a part of our lives and will continue to be as it progresses. The balance has to be in the use of technology and the use of traditional educational activities. As a result of this study, I plan to work harder to find a balance of traditional activities and digital activities. This growth and change in my strategy are part of my ongoing learning as an educator.

**Changed Perception About Student Learning Styles**

I, like many other teachers, assumed that my students were mainly visual learners. The high school student of today grew up with video games, handheld devices, and a
plethora of television programs. They have been bombarded with visual information. What I learned through this research is a desire from my students to return to tactile learning, to have more collaborative learning, and to have more direct instruction.

My students are high level students taking a course load with the intention of pursuing higher studies in engineering. They are adept in computer programs and often produce wonderful digital presentations. They are self-driven and motivated, but they are also still kids. As much as I push them to be think creatively and independently, they still want direction. When asked about working in groups on the vocabulary review, Roger said, “And it's also like the element of it I think is sort of big for that like collaboration aspect of it, where you're communicating with everybody.” This sentiment was echoed by Carrie when she compared student co-teaching to instruction by the teacher, “And definitely like when we, it like, um, people explain it in their own way, made it, made it make sense to me because it came from like a student's point of view where some things just don't make sense.”

The students have directed me to adjust vocabulary instruction to implement more collaborative activities and tactile instruction. This allows me to provide the baseline terminology in a manner to meet the learning styles of my students and allow them to focus on the value of the material instead of the method of presentation.

**Implications for Future Research**

The findings for this study suggest several implications for future research. Implications to consider are: (1) impact of Covid-19 pandemic on student attitudes towards learning, (2) evaluation of technology-based instruction on academic gains, and (3) evaluation of student learning styles on technology-based instruction.
**Impact of Covid-19 Pandemic on Student Attitudes Towards Learning**

Prior research on student attitudes towards learning was completed prior to the change in educational platforms due to the Covid-19 shutdown. The students in this study were participating post the Covid-19 pandemic and after spending a great deal of time in distance learning. These students were transformed from classroom instruction to digital, independent instruction. Future research could be implemented to study the impact of this change in instructional design. Additionally, future studies could compare student test scores prior to and post pandemic.

**Evaluation of Technology-Based Instruction on Academic Gains**

This study worked to understand the impact of a technology-based module on vocabulary scores. Students completed a pretest and posttest and participated in multiple technology-based activities. For future studies, looking at the academic impact on various subjects may be of value. This could help with curriculum design and planning. It may also provide insight into areas that are best served by technology and those best served by traditional methods of instruction.

**Evaluation of Student Learning Styles on Technology-Based Instruction**

This study was conducted post Covid-19 in a high school classroom. The participants had been through two years of partial or fully virtual education. The participants had been in Google Meet settings for many, and often all, of their classes. As a result, many students expressed a desire to move to tactile and group instruction and away from individual and technology-based instruction. For future studies, it would be beneficial to ascertain if the result of the same study would be the same after a few years.
of traditional school. This could help with curriculum design as it would provide educators with greater information about the current learning styles of students.

**Limitations**

In this study, there were a few limitations that should be noted. The limitations are discussed in the following sections: (1) methodological limitations and (2) limitations associated with findings.

**Methodological Limitations**

The results of the current study were specific to the participants, setting, and context in which it was conducted. That makes these results unable to be generalized to the larger population (Mertler, 2019). It would be unfair to generalize the results to a larger population as my sample was a small group of students in a suburban high school during the first-year post Covid-19 shutdown. The participants were a purposive sample due to the fact that I used my own students (Mehring, 2014; Mertler, 2019). Another limitation of the study was in the length as it only lasted 5 weeks and was in the second semester of the course. Spending a longer period of time and implementing the study in the first semester may have allowed for more data and a less biased opinion of both the students and the teacher (Morse, 2015). This additional data and change of implementation time would have added validity to the results.

**Limitations Associated with Findings**

Regarding the findings of the study, there were a few limitations in the findings that should be reported. The first was that the assessment was created by the researcher, which causes difficulty in comparing it to other studies, as well as being content specific and limiting the ability to compare the results to other courses (Prefume, 2015). Also, the
survey did not fully explore the students’ attitudes towards classroom relationships, a known factors in motivation (Sethi & Scales, 2020), or the impact of Covid-19 on their attitudes towards learning and increased stress levels (Williams et al., 2021). The researcher felt the validity and reliability of the study and the conclusions of the study were incomplete as a result of this missing data.

The majority of the students in the study were part of the magnet program, which requires an 80 in the course in order to receive credit. This demand for program mastery may have influenced their motivation to score well and, therefore, may have increased academic gains and survey results.

**Concluding Thoughts**

The research in this study leads the researcher to believe that as powerful of a tool as technology can be, it is only as effective as the classroom relationship and supplementary instruction provided by the teacher. Although this study saw success in the academic gains, focus group discussions made it clear that there was a desire to move away from strictly technology-based instruction. The students desired to have clear communication and reasoning for the activities. They wanted to see relevance in the work, otherwise they viewed it as busy work. Participants were eager to share their thoughts, to encourage each other, and to be part of the classroom dynamic. Overall, I plan to continue to use the various technology platforms but in the context of supplementary exercises to the collaborative activities and classroom discussions.

Dr. Brad Johnson has a quote that seems very apropos for the results of the study, “Relationships before rigor, grace before grades, patience before programs, love before lessons” (Powell-Smith, 2022).
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### APPENDIX A

#### ENGINEERING VOCABULARY QUIZLET

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction Line</strong></td>
<td>Lightly drawn lines used to layout a drawing and guide drawing of other lines such as object lines.</td>
</tr>
<tr>
<td><strong>Dimension</strong></td>
<td>A measurable extent, such as the three principal dimensions of an object: width, height, and depth.</td>
</tr>
<tr>
<td><strong>Dimension Line</strong></td>
<td>A line which represents distance.</td>
</tr>
<tr>
<td><strong>Edge</strong></td>
<td>The line along which two surfaces of a solid meet.</td>
</tr>
<tr>
<td><strong>Ellipse</strong></td>
<td>An oval shape generated by a point moving in a plane so that the sum of its distances from two other points (the foci) is constant and equal to the major axis.</td>
</tr>
</tbody>
</table>

*IED Unit 2 Vocabulary*
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension Line</td>
<td>Line which represents where a dimension starts and stops. Perpendicular to the dimension line.</td>
</tr>
<tr>
<td>Hidden Line</td>
<td>A dashed line type that shows interior detail not visible from the outside of the part.</td>
</tr>
<tr>
<td>Isometric Sketch</td>
<td>A form of pictorial sketch in which all three drawing axes form equal angles of 120 degrees with the plane of projection.</td>
</tr>
<tr>
<td>Loader Line</td>
<td>Line which indicates dimensions of arcs, circles and detail.</td>
</tr>
</tbody>
</table>

*IED Unit 2 Vocabulary*
<table>
<thead>
<tr>
<th><strong>Line Conventions</strong></th>
<th>Standardization of lines used on technical drawings by line weight and style.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long-Break Line</strong></td>
<td>A line which indicates that a very long objects with uniform detail is drawn foreshortened.</td>
</tr>
<tr>
<td><strong>Multi-View Drawing</strong></td>
<td>A drawing which contains views of an object projected onto two or more orthographic planes.</td>
</tr>
<tr>
<td><strong>Object Line</strong></td>
<td>A heavy solid line used on a drawing to represent the outline of an object.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Oblique Sketch</td>
<td>A form of pictorial in which an object is represented as true width and height, but the depth can be any size and drawn at any angle.</td>
</tr>
<tr>
<td>Orthographic Projection</td>
<td>A method of representing three-dimensional objects on a plane having only length and width.</td>
</tr>
<tr>
<td>Perspective Sketch</td>
<td>A form of pictorial sketch in which vanishing points are used to provide the depth and distortion that is seen with the human eye.</td>
</tr>
<tr>
<td>Pictorial Sketch</td>
<td>A sketch that shows an object’s height, width, and depth in a single view.</td>
</tr>
</tbody>
</table>

**IED Unit 2 Vocabulary**
<table>
<thead>
<tr>
<th>Plane</th>
<th>A flat surface on which a straight line joining any two points would wholly lie.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile</td>
<td>An outline of an object when viewed from one side.</td>
</tr>
<tr>
<td>Projection Line</td>
<td>An imaginary line that is used to locate or project the corners, edges, and features of a three-dimensional object onto an imaginary two-dimensional surface.</td>
</tr>
<tr>
<td>Projection Plane</td>
<td>An imaginary surface between the object and the observer on which the view of the object is projected and drawn.</td>
</tr>
<tr>
<td><strong>Proportion</strong></td>
<td>1. The relationship of one thing to another in size, amount, etc. 2. Size or weight relationships among structures or among elements in a single structure</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Scale</strong></td>
<td>1. A proportion between two sets of dimensions used to develop accurate, larger or smaller prototypes, or models. 2. A straight-edged strip of rigid material marked at regular intervals that is used to measure distances. Also referred to as a ruler.</td>
</tr>
<tr>
<td><strong>Section Lines</strong></td>
<td>A series of thin lines used in a section view to indicate where the cutting plane line has cut through material. Similar to hatching in art.</td>
</tr>
</tbody>
</table>

**IED Unit 2 Vocabulary**
<table>
<thead>
<tr>
<th><strong>Short-Break Line</strong></th>
<th>A line which shows where part is broken to reveal detail behind the part or to shorten a long continuous part.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sketch</strong></td>
<td>A rough representation of the main features of an object or scene and often made as a preliminary study.</td>
</tr>
<tr>
<td><strong>Solid</strong></td>
<td>A three-dimensional body or geometric figure.</td>
</tr>
<tr>
<td><strong>Technical Working Drawing</strong></td>
<td>A drawing that is used to show the material, size, and shape of a product for manufacturing purposes.</td>
</tr>
<tr>
<td><strong>Three-Dimensional</strong></td>
<td>Having the dimensions of height, width, and depth.</td>
</tr>
</tbody>
</table>

**IED Unit 2 Vocabulary**
<table>
<thead>
<tr>
<th><strong>Two-Dimensional</strong></th>
<th>Having the dimensions of height and width, height and depth, or width and depth only.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vanishing Point</strong></td>
<td>A point in space, usually located on the horizon, where parallel edges of an object appear to converge.</td>
</tr>
</tbody>
</table>
APPENDIX B

ENGINEERING VOCABULARY ASSESSMENT

Unit 2 Vocabulary

CCSS.ELA-LITERACY.CRA.L.6
Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

1. An imaginary surface between the object and the observer on which the view of the object is projected and drawn.

Mark only one oval.

- Construction Line
- Projection Plane
- Projection Line
- Section Lines

2. The line along which two surfaces of a solid meet.

Mark only one oval.

- Profile
- Plane
- Edge
- Solid
3. A line which represents distance.

   Mark only one oval.
   - Two-Dimensional
   - Extension Line
   - Dimension Line
   - Long Break Line

4. Oblique pictorial where height, width, and depth are represented at full scale.

   Mark only one oval.
   - Cabinet Oblique
   - Cavalier Oblique
   - Long-Break Line
   - Center Line

5. Line which shows where part is broken to reveal detail behind the part or to shorten a long continuous part.

   Mark only one oval.
   - Extension Line
   - Short-Break Line
   - Long-Break Line
   - Center Line
6. Having the dimensions of height and width, height and depth, or width and depth only.

*Mark only one oval.*

- Two-Dimensional
- Long Break Line
- Dimension
- Dimension Line

7. A measurable extent, such as the three principal dimensions of an object: width, height, and depth.

*Mark only one oval.*

- Dimension
- Two-Dimensional
- Hidden Line
- Extension Line

8. A rough representation of the main features of an object or scene and often made as a preliminary study.

*Mark only one oval.*

- Sketch
- Plane
- Oblique Sketch
- Dimension
9. A form of pictorial sketch in which all three drawing axes form equal angles of 120 degrees with the plane of projection.

Mark only one oval.

- Pictorial Sketch
- Oblique Sketch
- Isometric Sketch
- Perspective Sketch

10. An imaginary line that is used to locate or project the corners, edges, and features of a three-dimensional object onto an imaginary two-dimensional surface.

Mark only one oval.

- Section Lines
- Projection Line
- Perspective Sketch
- Projection Plane

11. A drawing which contains views of an object projected onto two or more orthographic planes.

Mark only one oval.

- Projection Plane
- Two-Dimensional
- Multi-View Drawing
- Technical Working Drawing
12. A series of thin lines used in a section view to indicate where the cutting plane line has cut through material. Similar to hatching in art.

*Mark only one oval.*

- Section Lines
- Extension Line
- Projection Plane
- Perspective Sketch

13. Standardization of lines used on technical drawings by line weight and style.

*Mark only one oval.*

- Long Break Line
- Three-Dimensional
- Line Conventions
- Two-Dimensional

14. Line which indicates dimensions of arcs, circles and detail.

*Mark only one oval.*

- Long Break Line
- Extension Line
- Leader Line
- Center Line
15. A flat surface on which a straight line joining any two points would wholly lie. 1 point

Mark only one oval.

- Plane
- Ellipse
- Object Line
- Hidden Line

16. A drawing that is used to show the material, size, and shape of a product for manufacturing purposes. 1 point

Mark only one oval.

- Perspective Sketch
- Technical Working Drawing
- Pictorial Sketch
- Multi-View Drawing

17. A sketch that shows an object's height, width, and depth in a single view. 1 point

Mark only one oval.

- Isometric Sketch
- Pictorial Sketch
- Long-Break Line
- Center Line
18. A line which indicates that a very long object with uniform detail is drawn foreshortened.

Mark only one oval.

- Extension Line
- Center Line
- Long Break Line
- Short Break Line

19. A heavy solid line used on a drawing to represent the outline of an object.

Mark only one oval.

- Hidden Line
- Center Line
- Object Line
- Long Break Line

20. A dashed line type that shows interior detail not visible from the outside of the part.

Mark only one oval.

- Long Break Line
- Section Lines
- Hidden Line
- Center Line
21. Oblique pictorial where depth is represented as half scale compared to the height and width scale. 1 point

Mark only one oval.

☐ Cabinet Oblique
☐ Center Line
☐ Cavalier Oblique
☐ Long Break Line

22. A form of pictorial in which an object is represented as true width and height, but the depth can be any size and drawn at any angle. 1 point

Mark only one oval.

☐ Section Lines
☐ Oblique Sketch
☐ Perspective Sketch
☐ Isometric Sketch

23. A form of pictorial sketch in which vanishing points are used to provide the depth and distortion that is seen with the human eye. 1 point

Mark only one oval.

☐ Isometric Sketch
☐ Oblique Sketch
☐ Section Lines
☐ Perspective Sketch
24. Having the dimensions of height, width, and depth.  
   Mark only one oval.
   - Three-Dimensional
   - Two-Dimensional
   - Multi-View Drawing
   - Line Conventions

25. A three-dimensional body or geometric figure.  
   Mark only one oval.
   - Sketch
   - Edge
   - Solid
   - Profile

26. An outline of an object when viewed from one side.  
   Mark only one oval.
   - Ellipse
   - Solid
   - Profile
   - Center Line
27. A proportion between two sets of dimensions used to develop accurate larger or smaller prototypes, or models. 2. A straight-edged strip of rigid material marked at regular intervals that is used to measure distances. Also referred to as a ruler.

Mark only one oval.

- Solid
- Plane
- Proportion
- Scale

28. A method of representing three-dimensional objects on a plane having only length and width.

Mark only one oval.

- Extension Line
- Orthographic Projection
- Technical Working Drawing
- Pictorial Sketch

29. Line which represents where a dimension starts and stops. Perpendicular to the dimension line.

Mark only one oval.

- Dimension Line
- Extension Line
- Center Line
- Long Break Line
30. A point in space, usually located on the horizon, where parallel edges of an object appear to converge.

*Mark only one oval.*

- Extension Line
- Vanishing Point
- Long Break Line
- Projection Plane

31. 1. The relationship of one thing to another in size, amount, etc. 2. Size or weight relationships among structures or among elements in a single structure.

*Mark only one oval.*

- Projection Plane
- Proportion
- Dimension
- Projection Line

32. Lightly drawn lines used to layout a drawing and guide drawing of other lines such as object lines.

*Mark only one oval.*

- Extension Line
- Short-Break Line
- Projection Plane
- Construction Line
33. A line which defines the center of arcs, circles, or symmetrical parts.  

   Mark only one oval.

   ○ Center Line
   ○ Dimension Line
   ○ Long Break Line
   ○ Hidden Line

34. An oval shape generated by a point moving in a plane so that the sum of its distances from two other points (the foci) is constant and equal to the major axis.

   Mark only one oval.

   ○ Ellipse
   ○ Projection Line
   ○ Plane
   ○ Profile

Technical Application

CCSS.ELA-LITERACY.RST.9-10.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
For the image below, identify each type of line.

35. 1.1

Mark only one oval.

- Dimension Line
- Leader Line
- Extension Line
- Object Line
- Construction Line
- Center Mark
- Section Line
- Hidden Line
36. 1.2

Mark only one oval.

- Dimension Line
- Leader Line
- Extension Line
- Object Line
- Construction Line
- Center Mark
- Section Line
- Hidden Line

37. 1.3

Mark only one oval.

- Dimension Line
- Leader Line
- Extension Line
- Object Line
- Construction Line
- Center Mark
- Section Line
- Hidden Line
38. 1.4

*Mark only one oval.*

- [ ] Dimension Line
- [ ] Leader Line
- [ ] Extension Line
- [ ] Object Line
- [ ] Construction Line
- [ ] Center Mark
- [ ] Section Line
- [ ] Hidden Line

1 point

39. 1.5

*Mark only one oval.*

- [ ] Dimension Line
- [ ] Leader Line
- [ ] Extension Line
- [ ] Object Line
- [ ] Construction Line
- [ ] Center Mark
- [ ] Section Line
- [ ] Hidden Line

1 point
APPENDIX C
STUDENT ATTITUDES TOWARDS LEARNING ENGINEERING
VOCABULARY SURVEY

Research Survey - Attitudes Towards Learning Vocabulary
Please rate each statement.
1 = Strongly Disagree
2 = Disagree
3 = Neither Agree or Disagree
4 = Agree
5 = Strongly Agree

1. I think learning Engineering vocabulary is very useful to me.
   Mark only one oval.
   
   1  2  3  4  5
   Strongly Disagree  ☐  ☐  ☐  ☐  ☐  Strongly Agree

2. I paid full attention to the Engineering vocabulary learning activity in this course.
   Mark only one oval.
   
   1  2  3  4  5
   Strongly Disagree  ☐  ☐  ☐  ☐  ☐  Strongly Agree

3. I am interested in learning Engineering vocabulary.
   Mark only one oval.
   
   1  2  3  4  5
   Strongly Disagree  ☐  ☐  ☐  ☐  ☐  Strongly Agree
4. I feel that learning Engineering vocabulary is boring.

Mark only one oval.

1  2  3  4  5

Strongly Disagree  ○  ○  ○  ○  ○  Strongly Agree

5. I think the difficulty of the Engineering vocabulary meets my knowledge level.

Mark only one oval.

1  2  3  4  5

Strongly Disagree  ○  ○  ○  ○  ○  Strongly Agree

6. I think I have learned a lot of Engineering vocabulary in this course.

Mark only one oval.

1  2  3  4  5

Strongly Disagree  ○  ○  ○  ○  ○  Strongly Agree

7. I don't like learning Engineering vocabulary.

Mark only one oval.

1  2  3  4  5

Strongly Disagree  ○  ○  ○  ○  ○  Strongly Agree
8. The learning of Engineering vocabulary is irrelevant to my future life.

Mark only one eval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

9. I always actively complete the Engineering vocabulary assignments of this course without being reminded.

Mark only one eval.

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<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

10. I try to apply the vocabulary learned in this course to my other courses.

Mark only one eval.

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<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

11. I don’t like to think and infer when doing the vocabulary assignments for this course.

Mark only one eval.

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<tr>
<th></th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
12. I actively ask the teacher about the Engineering content vocabulary that interests me in the course.

   Mark only one oval.

   1  2  3  4  5

   Strongly Disagree    □  □  □  □  □  Strongly Agree

13. I prepare for vocabulary lessons before the class and review what I have learned after the class.

   Mark only one oval.

   1  2  3  4  5

   Strongly Disagree    □  □  □  □  □  Strongly Agree

14. Now I pay more attention to vocabulary in my other classes after taking the course.

   Mark only one oval.

   1  2  3  4  5

   Strongly Disagree    □  □  □  □  □  Strongly Agree

15. When the teacher is going to start a new unit in this course, I would read the unit content vocabulary first.

   Mark only one oval.

   1  2  3  4  5

   Strongly Disagree    □  □  □  □  □  Strongly Agree
16. I usually do assignments or prepare for a vocabulary test for this course when the deadline is approaching.

Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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</tbody>
</table>

Strongly Disagree   |   |   |   |   |   | Strongly Agree

17. If I do not understand the Engineering vocabulary of this course, I would ask the teacher or discuss it with my peers.

Mark only one oval.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
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<th>4</th>
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</tbody>
</table>

Strongly Disagree   |   |   |   |   |   | Strongly Agree

18. I try to use the vocabulary strategies I have learned in this course in my other courses.

Mark only one oval.

<table>
<thead>
<tr>
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</tbody>
</table>

Strongly Disagree   |   |   |   |   |   | Strongly Agree
**APPENDIX D**

**SURVEY MODIFICATIONS**

<table>
<thead>
<tr>
<th>Original Question</th>
<th>Modified Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel that the course content is rich.</td>
<td>Deleted</td>
</tr>
<tr>
<td>I think the learning content is very useful to me.</td>
<td>I think learning vocabulary is very useful to me.</td>
</tr>
<tr>
<td>I paid full attention to the learning activity in this course.</td>
<td>I pay full attention to vocabulary learning activities.</td>
</tr>
<tr>
<td>I often do my own thing in class.</td>
<td>Deleted</td>
</tr>
<tr>
<td>I am interested in this course.</td>
<td>I am interested in learning Engineering vocabulary.</td>
</tr>
<tr>
<td>I feel that the course is boring.</td>
<td>I feel that learning Engineering vocabulary is boring.</td>
</tr>
<tr>
<td>I think the difficulty of the learning content meets my knowledge level.</td>
<td>I think the difficulty of the Engineering vocabulary meets my knowledge level.</td>
</tr>
<tr>
<td>I think I have learned a lot in this course.</td>
<td>I think I have learned a lot of Engineering vocabulary in this course.</td>
</tr>
<tr>
<td>I don’t like this course.</td>
<td>I don’t like learning vocabulary.</td>
</tr>
<tr>
<td>The learning content of this course is irrelevant to my future life.</td>
<td>The learning of Engineering vocabulary is irrelevant to my future life.</td>
</tr>
<tr>
<td>I always actively complete the homework of this course without being reminded.</td>
<td>I always actively complete the vocabulary assignments of this course without being reminded.</td>
</tr>
<tr>
<td>I try to overcome the learning problems encountered in this course.</td>
<td>Deleted</td>
</tr>
</tbody>
</table>
I hope that I can get a good grade on this course.

| I try to apply what I have learned in this course to my daily life. | I try to use the vocabulary I have learned in this course in my other courses. |
| I hate to think and infer when doing the homework for this course. | I don’t like to think and infer when doing the vocabulary assignments for this course. |
| I actively ask the teacher about the learning content that interests me in the course. | I actively ask the teacher about the vocabulary content that interests me in the course. |
| The course helps me learn to deal with problems in my own way. | Deleted |
| I prepare for lessons before the class and review what I have learned after the class. | I prepare for vocabulary lessons before the class and review what I have learned after the class. |
| Now I pay more attention to observing what happens in my daily life after taking the course. | Now I pay more attention to vocabulary in my other classes after taking the course. |
| When the teacher is going to start a new unit in this course, I would read the unit content first. | When the teacher is going to start a new unit in this course, I would read the unit content vocabulary first. |
| I usually do homework or prepare for the test for this course when the deadline is approaching. | I usually do assignments or prepare for a vocabulary test for this course when the deadline is approaching. |
| If I do not understand the learning content of this course, I would ask the teacher or discuss it with my peers. | If I do not understand the Engineering vocabulary of this course, I would ask the teacher or discuss it with my peers. |
| I am able to memorize several important terms to remind me of the key points in individual course units. | I am able to memorize important Engineering vocabulary to remind me of the key points in individual course units. |
| Even if the learning content is difficult to comprehend, I would like to remember it. | Even if the content vocabulary is difficult to comprehend, I would like to remember it. |
Sometimes I try to raise and answer questions to evaluate if I fully understand the learning content of this course.

Sometimes I try to raise and answer questions to evaluate if I fully understand the Engineering vocabulary of this course.

I try to use the vocabulary strategies I have learned in this course in my other courses.
APPENDIX E

INTERVIEW PROTOCOL

Thank you for helping me by participating in this discussion. It is important that you understand the basis of this research before we start. The purpose of this interview is to describe the impact of adding technology-based instruction on your vocabulary test scores and your attitudes towards learning vocabulary.

Throughout the last five weeks we have used a variety of technology-based learning apps to include Quizlet, Quizizz, and Google Slides, just to name a few. These applications were designed to both aid in my delivery of the material and your display of content mastery.

For this interview, I will be taking notes based on your responses as well as recording this interview. This is to ensure that the data that is being recorded is accurate. This interview is designed to be roughly thirty minutes in length; however, it could be longer or shorter based on the flow of the interview. Names will not be used in order to allow for anonymity and a full transcript will be available for your viewing shortly after the interview is complete.

Do you have any questions before we start? (Time left for clarification questions). OK! Let’s begin!
<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Interview Questions</th>
</tr>
</thead>
</table>
| **RQ1:** What is the effect of implementing a technology-based instructional module on content vocabulary test scores for students taking the Introduction to Engineering course? | **Focus Group of Students**  
1. What are your normal procedures to learn new vocabulary?  
   a. Tell me ways you study new vocabulary.  
   b. Tell me some of the ways teachers present vocabulary to you.  
   c. How do you react to learning new vocabulary?  
2. Have you utilized any technology-based strategies for learning vocabulary?  
   a. Tell me about any ways you utilize technology to learn content vocabulary.  
   b. Do your teachers give you a choice in how to learn the new vocabulary? If so, what do you normally choose?  
   c. Do you see a difference in your grade with these choices? Please explain.  
3. What are your average grades on vocabulary assessments?  
   a. Do you find a difference in grades for different classes?  
   b. With our addition of technology, did you see a difference in your expected grade and understanding of the content vocabulary? Please explain. |
| **RQ2:** What is the effect of implementing a technology-based instructional module on attitudes towards learning vocabulary for students taking the Introduction to Engineering course? | **Focus Group of Students**  
1. Is learning vocabulary important to you?  
   a. What makes learning vocabulary important?  
   b. Tell me about your reaction to getting new vocabulary.  
   c. Will you go to school beyond high school? |
2. Tell me about your study habits for learning new vocabulary.
   a. What tools do you use to learn new vocabulary?
   b. Do you prefer digital or paper for study? Why?
   c. How much time do you spend studying new vocabulary?
   d. Do you study a little at a time, or try to learn it all the day before the test?

3. Do you think you are a good student?
   a. Do you think you do well in class?
   b. Is it important for others to see you as a good student?
   c. Tell me about how your parents react to grades.

4. What grades do you normally receive on vocabulary tests?
   a. Are grades important?
   b. Are vocabulary words an important part of learning content?

5. As a result of this course of study, do you think you would change how you study new vocabulary? Please explain.

6. What processes did we use that you may apply to other classes?

7. Talk to me about how you felt when we began each type of technology. (Quizlet, Quizlet Live, Web Quest, Word Cloud)
APPENDIX F

CONSENT/ASSENT FORM

UNIVERSITY OF SOUTH CAROLINA
CONSENT TO BE A RESEARCH SUBJECT

The Effect of Implementing a Technology-Based Instructional Module on Vocabulary Scores for Introduction to Engineering Students

KEY INFORMATION ABOUT THIS RESEARCH STUDY:
You are invited for your child to volunteer for a research study conducted by Robin Amick a Curriculum and Instruction doctoral student with a concentration in Educational Technology at the University of South Carolina under the direction of Dr. Ismahan Arslan-Ari (arslanai@mailbox.sc.edu; 803-777-0538) in the department of Learning Design and Technologies. I am completing this study as part of my doctoral requirements at the University of South Carolina. The purpose of this study is to evaluate the academic impact of a technology-based instructional module for content vocabulary instruction in the Introduction to Engineering course. You are being asked to consent for your child to participate in this study because your child is enrolled in the course for the 2021-2022 school year. This study is being done at South Carolina midlands high school and will involve approximately 27 students. School and individual identities will remain strictly anonymous and confidential.
The following is a short summary of this study to help you decide whether to be a part of this study. More detailed information is listed later in this form.
Introduction to Engineering is the foundational course for the Engineering pathway. The vocabulary utilized in this course is fundamental for understanding the material as the student works through the Engineering courses. This study will be conducted over the course of five weeks during the regularly scheduled class periods. The procedures will include a pre-test and post-test on Engineering vocabulary, a survey of Attitudes Towards Learning Vocabulary, and an optional interview opportunity for students in one of two focus groups.
The vocabulary being taught within the studied is already a component of the course curriculum, but by participating in the study, data can be gathered and analyzed to understand the impact of this technology-based method of instruction on academic gains and student attitudes towards learning.
This form explains what your student will be asked to do, if you decide to allow participation. Please read it carefully and feel free to ask questions before you make a decision about participating.

PROCEDURES:
If you agree to participate in this study, you will do the following:
1. Complete a pre-test and post-test on content vocabulary.
2. Complete a survey both before and after the study about attitudes towards learning vocabulary.
3. Participate in focus group discussions about the experience and the activities. This interview will be voice recorded in order to ensure the details that you provide are accurately captured.
4. Complete a unit of Engineering content vocabulary.

DURATION:
Participation in the study involves thirteen class periods over a period of five weeks/months. Each period will last about 90 minutes.

RISKS/DISCOMFORTS:
Focus Groups:
Others within your focus group will hear what you say, and it is possible that they could tell someone. The researchers cannot guarantee what you say will remain completely private, but the researchers will ask that you, and all other group members, respect the privacy of everyone in the group.

Loss of Confidentiality:
There is the risk of a breach of confidentiality, despite the steps that will be taken to protect your identity. Specific safeguards to protect confidentiality include a student numeric identifier instead of names and password protected documentation.

BENEFITS:
You may benefit from participating in this study by an increase in academic gains, a stronger understanding of the Engineering content vocabulary, and exposure to alternative methods to learn, practice, and discern new vocabulary in other content areas.

COSTS:
There will be no costs to you for participating in this study and there is no extra credit offered because this is a naturally occurring component of the Engineering curriculum.

CONFIDENTIALITY OF RECORDS:
Information obtained about you during this research may be published, but you will not be identified. Information that is obtained concerning this research that can be identified with you will remain confidential and be destroyed within one year of completion of the study. This includes all data, recordings, and any other documents with personally identifiable information.

VOLUNTARY PARTICIPATION:
Participation in this research study is voluntary. Your student is free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the principal investigator listed on this form.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, or a study related injury, I am to contact Mrs. Robin Amick at 803-476-3442 or email ramick@lexrich5.org.
Concerns about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email: LisaJ@mailbox.sc.edu.

I agree to allow my student to participate in this study. I have been given a copy of this form for my own records.

____ I do not wish for my child to participate.

____ I agree for my child to participate in this study. I have been given a copy of this form for my own records.

________________________________________  ______________________________
Signature of Parent/Guardian                  Date

________________________________________  ______________________________
Researcher’s Signature                        Date

My participation has been explained to me, and all of my questions have been answered. I am willing to participate.

________________________________________  ______________________________
Print Name of Minor                            Date

________________________________________  ______________________________
Signature of Minor                            Date
APPENDIX G

UNIVERSITY IRB APPROVAL

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
DECLARATION OF NOT RESEARCH

Robin Amick
140 Smallwood Dr
Chapin, SC 29036-7304
Re: Pro00116066

Dear Mrs. Robin Amick:

This is to certify that research study entitled The Effect of Implementing a Technology-Based Instructional Module on the Engineering Content Vocabulary Academic Gains of Introduction to Engineering Students was reviewed on 10/22/2021 by the Office of Research Compliance, which is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). The Office of Research Compliance, on behalf of the Institutional Review Board, has determined that the referenced research study is not subject to the Protection of Human Subject Regulations in accordance with the Code of Federal Regulations 45 CFR 46 et. seq.

No further oversight by the USC IRB is required. However, the investigator should inform the Office of Research Compliance prior to making any substantive changes in the research methods, as this may alter the status of the project and require another review.

If you have questions, contact Lisa M. Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager
APPENDIX H

DISTRICT IRB APPROVAL

February 2, 2022

Robin Amick

[Name redacted]

The School District has approved your research request titled: "The Effect of Implementing a Technology-Based Instructional Module on the Engineering Concept Vocabulary Academic Gains of Introduction to Engineering Students". The research request has been approved as stated on your proposal to be conducted during the 2021-2022 school year. Please adhere to the following guidelines:

- Student social security numbers should never be used.
- Data directly identifying a person, such as name, address, telephone number, etc., may not be distributed in any form to outside persons or agencies. All such requests are to be forwarded to the Office of Community Services.
- At no time may student information, including that identified as 'Directory Information', be released to any outside entity for commercial, marketing, solicitation or other purposes.
- Faculty, students and staff doing research and seeking to survey students must suppress personally identifiable data and information to include: name, social security number, student ID number, address, telephone number, email address and no data may be used for commercial, for-profit, or marketing purposes.
- Institutional research, analysis and reporting functions and external surveys including departmental, college-based and university, should always suppress personally identifiable data as indicated above and identification of the district, schools, and staff members.
- Any further analysis and use of the collected data beyond the scope of the approved purpose must be requested through the Department of Accountability.

School District [Name redacted] wishes you good luck with the study. If you have any questions or need further assistance, please contact me at [Name redacted]

Sincerely,

[Signature]

Research Review Committee Chair
Office of Accountability

cc: [Name redacted], Principal, Dutch Fork High School
Mr. Joseph Dobler, Assistant Principal for Instruction, Dutch Fork High School

[Name redacted]