TECHNOLOGY ELECTIVE CLASSES' EFFECTS ON MIDDLE SCHOOL STUDENTS' SELF-EFFICACY AND LEARNING ENGAGEMENT IN SCIENCE

by

Rebecca Farrell

Liberty University

A Dissertation Presented in Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy

Liberty University
2023

TECHNOLOGY ELECTIVE CLASSES’ EFFECTS ON MIDDLE SCHOOL STUDENTS’ SELF-EFFICACY AND LEARNING ENGAGEMENT IN SCIENCE

by Rebecca Farrell

A Dissertation Presented in Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy

Liberty University, Lynchburg, VA
2023

APPROVED BY:

Dr. Constance Pearson, Ed.D., Committee Chair

Hoiwah Benny Fong, Ed.D., Committee Member

ABSTRACT

The purpose of this quantitative, causal-comparative design was to examine the technology classes' effects on private middle school students' self-efficacy, self-regulation, task value, and learning goal orientation between students in technology electives and non-technology electives. The topic was introduced using historical, theoretical, and societal backgrounds. Further literature review led to a synthesis of the literature investigating technology classes, STEM education, self-efficacy, task value, learning goal orientation, and self-regulation. Further investigations found and synthesized literature that focused on middle school students and their connections to the above topics. The sample for the setting was drawn from 136 participants enrolled in three private schools in Florida. The SALES Questionnaire was utilized to collect data on self-efficacy, task value, learning goal orientation, and self-regulation. After the students completed the questionnaire, the researcher analyzed data using a MANOVA analysis to determine significant differences between the four dependent variables. Finally, a discussion of the results took place and implications, limitations, and future research were also discussed.

Keywords: STEM education, self-efficacy, task value, self-regulation, learning goal orientation, Problem-based learning, motivation

Table of Contents

List of Tables

List of Figures

List of Abbreviations

English Language Learners (ELLs)

Problem-Based Learning (PBL)

Science, Technology, Engineering, and Mathematics (STEM)

Florida Standardized Assessment (FSA)

Students’ Adaptive Learning Engagement in Science Questionnaire (SALES)

Motivated Strategies for Learning Questionnaire (MSLQ)

Statistical Package for the Social Sciences (SPSS)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quantitative, causal-comparative design was to examine the technology classes’ effects on private middle school students’ self-efficacy, self-regulation, task value, and goal orientation between students in technology electives and non-technology electives. Chapter One offers a background for topics of student self-efficacy, middle school students, and STEM education. Included in this background is the theoretical framework specifically linked to this study and students in science education. The problem statement provides the scope of the current literature on the subject. The research questions for this study were provided once a significance for this study and the purpose for this study were discussed in length.

Background

As technology has developed exponentially over the last two decades, education has also changed to account for that technology (Akcanca, 2020). Technology has allowed students to experience the world and to create materials in new and exciting ways (Akcaoglu et al., 2021; Boda & Brown, 2020). While technology integration has become a huge part of the school system today, a vast amount of research connects technology to education through STEM (Science, Technology, Engineering, and Mathematics) education (Akcanca, 2020; Casey et al., 2018). Likewise, as STEM education continues to be developed, teachers are urged regularly to utilize the different tenets of STEM education to reach more diverse student populations (Barak & Yehiav, 1994; Bippert & Harmon, 2017). Furthermore, STEM education has experienced a drastic shift in the last ten years as technology has become more readily available to every learner (Herro et al., 2018). As technology integration has become more of an integral part of

STEM education, much research has been conducted on the effects specific technology programs have on motivation, self-efficacy, and science achievement (Lie et al., 2019; Ryoo, 2015; Shu & Huang, 2021).

Technology has been utilized to impact many populations of students, especially as demographics within American schools have been drastically shifting to be more diverse (Curran & Kitchin, 2019). As the achievement gaps have been seen to also be shifting, the gaps within science are becoming more pronounced (Betancur et al., 2018; Curran & Kitchin, 2019). High-stakes testing within science and mathematics classes shows that achievement gaps exist amongst many different sets of students (LaForce et al., 2019) a problem that has exponentially grown due to current events. This indicates a need to focus research on the tenets of STEM to understand how technology is impacting students in multiple facets of their education (Betancur et al., 2018; LaForce et al., 2019). Additionally, it is understood that motivation and achievement are directly related to each other and student engagement in the classroom (Çoban & Kamis, 2019; Velayutham et al., 2011; Eccles & Wigfield, 2002).

While research targets motivation and engagement within diverse populations, research has shown that self-efficacy drops across different student populations as they move from elementary to middle school in the United States (Fahle et al., 2019). However, as STEM education permeates more school programs, career paths, and science classrooms, a necessity for STEM education’s effects on various components of education has been found and called for within research (Ugras, 2019). Moreover, as STEM education has been found to have impacts on engagement and motivation in students, connections between motivation and engagement have also been found through self-efficacy, self-regulation, task value, and learning goal orientation (Aldridge & Rowntree, 2021; Pintrich & De Groot, 1990; Velayutham et al., 2011).

Historical Overview

Since the early twenty-first century, STEM education has become at a forefront of all science education. However, STEM education started with the use of the four disciplines to ensure interest in career paths built in the four tenets of STEM education (Ramaley et al., 2005). As STEM education has developed, the definition of STEM itself has been difficult to pinpoint. Furthermore, there has been little evidence to suggest the interdisciplinary approach has any real significance related to science content knowledge (McComas & Burgin, 2020). At its inception into the American school system, STEM education was closely linked to problem-based learning and the idea that career motivation could be determined through access to more STEM-related activities (Çevik, 2018). However, as STEM began to gain acceptance in the educational system, science classes were no longer called science classes, but STEM classes and science fairs became known as STEM fairs. Tracks of classes were considered STEM tracks and entire schools were deemed "STEM magnet schools" (Judson, 2014).

Nonetheless, research within STEM education has shown a large focus on high school, college, and elementary students, as evident by instrumentations developed over the years to measure motivation and engagement in students (Soltani & Askarizadeh, 2021; Velayutham et al., 2011). Moreover, much research has shown that there are achievement gaps within science, especially among the more diverse populations within American schools (Romo et al., 2018). This achievement gap has become more pronounced as diversity has increased in public schools, leading to the need for more research to be devoted to the problem (Soland & Sandilos, 2021). Likewise, as research devotes much-needed effort to achievement gaps, gaps within learning predict that gaps within motivation and learning engagement exist as well (Eccles & Wigfield, 2002).

While research directly related to achievement is necessary within middle school education, the historical understanding that motivation and engagement are linked directly to achievement (Eccles & Wigfield, 2002) shows the need for research to be conducted related to motivation and engagement within science classes. While historically, motivational theory was based on needs and goals (Bandura, 1977, 1993; Maslow, 1943), a more modern version of motivation yields evidence of task value, goals, and beliefs to be a huge component of motivation within students (Eccles & Wigfield, 2002). Also, as research around motivation developed along with STEM education, it was evident that connections between the different components of motivation were necessary for different populations (Velayutham et al., 2011). With the diversity within the school system increasing, understanding how STEM education, and more precisely technology education, has had impacts in the past but also impacts current society, is vital for this study and future research in these areas of study (Schneiderwind & Johnson, 2020).

Finally, self-efficacy, achievement goal theory, expectancy-value theory, and self-regulated learning have all contributed to educators' current understanding of motivation within the classroom. Due to their connection with the idea that students who measure higher in self-efficacy, learning goal orientation, task value, and self-regulation often have higher motivation and achievement (Bandura, 1993; Midgley, 2002; Pintrich & De Groot, 1990; Schunk, 2020; Zimmerman, 2002, 2008), these adaptive motivation theories play an important role in understanding students' performance within schools and different content areas (Ayuso et al., 2021; Pintrich & De Groot, 1990; Velayutham et al., 2011; Zimmerman, 2002). Additionally, research has revealed that successful learning and engagement within classrooms are directly proportional to self-efficacy, task value, learning goal orientation, and self-regulation, all of which are indicators of motivation and engagement (Aldridge & Rowntree, 2021; Kaplan et al., 2009; Zimmerman, 2000, 2008).

Society-at-Large

As COVID-19 hit the educational system in early 2020, educational research has shifted its gaze upon technology and its impact on learning and motivation (Soland & Sandilos, 2021). This shift in learning has led to an increase in STEM education-related studies and the impact technology, and even COVID-19 have upon other disciplines (Haverback, 2020; Shu & Huang, 2021). Likewise, the requirement for STEM literacy and emphasis on STEM-related fields has grown exponentially since the pandemic’s onset (Braund, 2021). Therefore, it is crucial to look at how technology has impacted middle school students’ science learning engagement and motivation since the 2020 COVID-19 pandemic began. Finally, there needs to be more research on the challenges faced by teachers over the last two years related to STEM education and technology use regarding engagement and motivation within science classes.

Additionally, STEM education has become a household educational term as more students and parents are exposed to curriculum and programs that are geared towards producing more students who are interested in STEM fields (Akcanca, 2020). According to several educators, STEM education being a household term does not stop ambiguity when it comes to the overall definition of STEM education (MacDonald et al., 2020). Many educators offer different terminology and more recent studies have shown some trepidation that teachers have experienced when present with STEM education opportunities (MacDonald et al., 2020). While the ambiguity of STEM education on a foundational level still exists within schools, it is apparent that research conducted within STEM education and learning engagement needs to show more continuity to have a larger impact on education in general (Aldridge & Rowntree, 2021; Ayuso et al., 2021; Casey et al., 2018; Herro et al., 2018).

Theoretical Background

Motivation's link to self-efficacy is imperative because without students believing they can achieve a goal or they can accomplish a task, they will not be motivated to do so (Bandura, 1993). As students achieve in school, it has been found that their understanding of their work and their ability to complete that work are closely connected (Bandura, 1977; Eccles & Wigfield, 2002). Self-efficacy is also what affects other tenets of current motivation theory such as self-regulation, goal orientation, and task value (Eccles & Wigfield, 2002; Velayutham et al., 2011). If students have higher self-efficacy, those other areas typically are found to show higher values as well (Aldridge & Rowntree, 2021; Velayutham et al., 2011). Self-efficacy's broad focus allows researchers to use it to measure students' understanding of their motivation, work, and achievement in all arenas of education (Brown et al., 2016; Haverback, 2020). While research has been conducted in large quantities regarding self-efficacy, gaps within the research have been found to show that further research is needed regarding middle school students' self-efficacy within technology classes such as coding and digital literacy in general (Shu & Huang, 2021).

Problem Statement

As motivation, science achievement, and STEM education are further researched, a clear gap in the literature is found. One of the largest gaps in the literature is technology classes' role in the achievement and motivation of middle school student populations (Shu & Huang, 2021; Ugras, 2018). As the changing demographics within schools are becoming more apparent to educators and researchers (Romo et al., 2018), the impact STEM has on different populations is evident and it has become crucial to focus resources and research on STEM within the differing school populations and schools (Brown et al., 2016). Most focus within STEM currently is on perceptions and motivation, however as technology permeates more of education, research reveals more gaps in its actual and apparent influence on students in different subject areas related to STEM education.

According to McComas and Burgin (2020), one of the areas that necessitate further study in STEM education is the connection of the disciplines of STEM impacting not only achievement but learning engagement in the classroom. The researchers suggest further study on the impacts of the interdisciplinary approach to science and how it may or not truly impact content knowledge (McComas & Burgin, 2020). Moreover, much of the research suggests limited results related to self-efficacy, motivation, and achievement as they cannot gain a truly randomized sampling of students (Aldridge & Rowntree, 2021; Soltani & Askarizadeh, 2021). Many of the generalizations and impacts research has on student populations are only applicable to smaller sets and regions of students (Garza et al., 2019; Romo et al., 2018; Wang & Degol, 2017). The problem not addressed in the literature is whether technology elective classes have any impact on self-efficacy, learning goal orientation, self-regulation, and task value within middle school students' science learning engagement and motivation (Aldridge & Rowntree, 2021; Garza et al., 2019; Herro et al., 2018; Romo et al., 2018; Soltani & Askarizadeh, 2021; Ugras, 2019; Wang & Degol, 2017)

Purpose Statement

The purpose of this quantitative, causal-comparative design is to examine the technology classes' effects on private middle school students' self-efficacy, self-regulation, task value, and goal orientation between students in technology electives and non-technology electives. As studies in student technology education have been called for in previous research (Darling-Aduana & Heinrich, 2018; McComas & Burgin, 2020), this study seeks to utilize a motivation-based questionnaire to determine the impact that technology classes that focus on digital literacy and creations have upon middle school students. Many studies focus on the use of emergent technology programs to aid reading or vocabulary acquisition (Darling-Aduana & Heinrich, 2018); however, the purpose of this study is to discover if technology elective classes have an impact on motivation and learning engagement in science classes explicitly.

For this study, the dependent variables, or what will be measured by the SALES Questionnaire in this study, are self-efficacy, task value, learning goal orientation, and self-regulation (Velayutham et al., 2011). The independent variable, or what is being manipulated in this study (Warner, 2013), is whether students are placed in technology classes or not. Measuring motivation using the questionnaire will allow the study to show if technology classes have a significant impact on private middle school students in Florida (Aldridge & Rowntree, 2021; Donalson & Halsey, 2020; Soltani & Askarizadeh, 2021). All middle school students involved in the study are enrolled in private schools in Florida, although they vary in demographics, abilities, and technology background.

Significance of the Study

This study will add to the discipline of STEM education as well as motivational theory. As the focus of this study is on technology classes and science motivation, it ties closely with studies that infuse technology and science and their impact on motivation and learning content knowledge (Garza et al., 2019; Lie et al., 2019; Ugras, 2018). Furthermore, this study will hopefully add to the existing implications that technology can support and increase motivation in science and schools in general (Ugras, 2018). This study will further add to the discipline of STEM education by hopefully confirming that participation in technology classes can also increase self-efficacy, learning goal orientation, task value, and self-regulation (Aldridge & Rowntree, 2021; Casey et al., 2018; Çoban & Kamis, 2019; Shu & Huang, 2021).

Additionally, this study will hopefully help other schools and organizations make decisions regarding students' placement within elective classes and possible STEM-related tracks such as STEM electives (Çoban & Kamis, 2019; Donalson & Halsey, 2020; Romo et al., 2018). This study could have an impact on future research and even educational policy regarding the integration of technology electives. This study hopes to show that placement within technology classes could aid students in their science classes as well by showing a connection between technology and motivation and engagement. Finally, this study hopes to answer the research questions discovered by the gaps in the literature and determine if any significance can be found related to achievement, technology, science content, and motivation.

Research Question(s)

RQ1: Is there a difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire?

Definitions

1. *Adaptive Learning Engagement*—the characteristics that promote students' learning engagement and attainment of the personal achievement goals (Velayutham et al., 2011)

2. *Learning Goal Orientation*—Based on achievement goal theory, development of competence in learning, understanding, and mastering tasks and goals (Ames, 1992; Velayutham et al., 2011).
3. *Motivation* – The desire to complete tasks or accomplish goals (Maslow, 1943).
4. *Problem-Based Learning* – the method of learning through a problem and trial and error (Barrows & Tamblyn, 1980).
5. *Self-Efficacy* – The beliefs people have about their learning and their ability to achieve a particular outcome (Bandura, 1977).
6. *Self-Regulation*- how students meta-cognitively, motivationally, and behaviorally engage in learning (Velayutham et al., 2011; Zimmerman, 2008).
7. *STEM Education* – The traditional interdisciplinary, problem-based learning approach to incorporating the four tenets of its name to education and building interest in pursuing a career within one of the four fields: science, technology, engineering, or mathematics (McComas & Burgin, 2020).
8. *Task Value*- how students determine and place value and expectations on achievement-related choices and performance within the classroom (Eccles & Wigfield, 2002)

CHAPTER TWO: LITERATURE REVIEW

Overview

A systematic review of the literature was conducted to explore the current issue of motivation and achievement gaps in middle school students who are currently enrolled in remedial reading and mathematics classes. This chapter will present a review of the current literature related to self-efficacy, science and STEM involvement, and the effects technology has been found to have on middle school students. In the first section, the theories relevant to classroom engagement and motivation will be discussed, along with the concept of problem-based learning. These theories will be followed by a synthesis of recent literature regarding middle school students, current research related to students' motivation in science, and the role technology electives have on their school motivation and achievement scores. This synthesis also includes a review of current STEM education research and technology education research as it relates to different student populations and interests in STEM-related fields. Lastly, the literature surrounding the factors which lead to middle school students' success in science classes and schools, in general, will be reviewed. In the end, a gap in the literature will be identified, presenting a viable need for the current study.

Theoretical Framework

The review of the literature will examine how self-efficacy has been shown to affect different student populations and its history within education. As researchers look further into the impact technology has upon middle school students within STEM education, research can be found that shows the impacts self-efficacy already has had on STEM education and middle school students. While this study seeks to study motivation and engagement, it is understood that the underlying motivational theory of self-efficacy must be examined to better understand the other measures of the current study such as self-regulation, task value, and learning goal orientation.

Theory of Self-Efficacy

Self-efficacy is based on decades of research anchored on the impact student motivation and thinking have had on students’ learning (Bandura, 1977). Albert Bandura was an educational philosopher with beliefs deeply rooted in social cognitive theory (Schunk, 2020). This theory was developed on the premise that people learn from their interactions and settings and has led to a more modern understanding of learning theory (Brown et al., 2014; Schunk, 2020). Learning, according to Bandura (1977), occurs while learners interact with their surroundings and the people within their surroundings. This could include working with peers, seeing others model a task or instruction, or engaging with the content material to learn the content knowledge needed for a given subject.

However, the major tenet regarding motivation within the social cognitive theory is self-efficacy. Defined by Bandura (1977), self-efficacy is the beliefs people have about their learning and thinking (Bandura, 1977, 1993). Strictly focusing on students, self-efficacy is indicative of future performance, as students with higher self-efficacy in each area tend to outperform their counterparts with lower self-efficacy (Bandura, 1993). Self-efficacy is connected to the idea that students who have higher self-efficacy are more motivated, and this is directly related to their completion of projects and school assignments (Bandura, 1993).

The theory of self-efficacy plays a role in how teachers and educators approach students (Schunk, 2020). Understanding that self-efficacy affects students’ motivation (Bandura, 1993), teachers often help students to adjust their mindset to overcome obstacles instead of succumbing to them. Since self-efficacy has such strong ties to motivation and learning and has an impact on the motivation and behavior of students (Bandura, 1977), it is evident that research related to self-efficacy is found in most of the education fields of research and design methods. By examining the research related to self-efficacy within STEM education, trends can be found to recognize gaps within the literature. Self-efficacy is a powerful prediction of what choices students will make, the effort they give to tasks, and perseverance to complete assignments and achieve goals (Velayutham et al., 2011). Lastly, self-efficacy has become a large determinant of task-orientated goals, performances, and behaviors (Aldridge & Rowntree, 2021; Velayutham et al., 2011).

Since self-efficacy is tied to task-orientated goals, performances, and behaviors, it is clear that other theories can also connect to self-efficacy. Achievement goal theory has always been closely linked to self-efficacy and is one of the key factors within research on motivational theories (Midgley, 2002). As students set goals and achieve them, there has been seen to be a direct correlation between goal orientation and self-efficacy (Eccles & Wigfield, 2002). Moreover, expectancy-value theory discusses the value students place upon other tasks and their subsequent desire to complete those tasks (Eccles, 1983; Eccles & Wigfield, 2002). Based on Bandura's social cognitive theory (1977), expectancy-value theory connects heavily with self-efficacy as it is often a force students contemplate the value of any specific task. However, self-regulation is more heavily researched by students as it often encompasses goal orientation and task value, just as it is encompassed by the theory of self-efficacy.

Zimmerman (1989) described self-regulated students as being wholly active in their learning and goal-setting (Eccles & Wigfield, 2002). Furthermore, Zimmerman (2000) stated that self-regulated learners use self-regulated strategies necessary to complete tasks, have a high self-efficacy, and set several and varied goals for themselves (Pintrich, 2000). According to Eccles and Wigfield (2002), it becomes apparent how modern motivational theory connects self-efficacy, learning goal orientation, and task value to self-regulation as it is facilitated by self-regulation theories (Pintrich & De Groot, 1990). Many models of self-regulation have shown to focus more on goal orientation than task value (Eccles & Wigfield, 2002; Rheinberg et al., 2012), however, connections have still been made by researchers more recently related to self-efficacy and task value as well (Velayutham et al., 2011; Soltani & Askarizadeh, 2021).

Self-Efficacy and Motivation Theory

As motivation is a key component of students' self-efficacy, understanding motivational theory more closely is equally important. According to Maslow (1943), motivation is linked to levels, or within a hierarchy of needs. The hierarchy of needs spans from basic survival needs, or the prepotent of all needs (Maslow, 1943), to a need for self-actualization where behavior is fueled by the pursuit of personal growth (Schunk, 2020). The behaviors of people within the first four levels were based on a deprivation of whatever needs they are lacking (Maslow, 1943; Schunk, 2020). If individuals are deprived of anything they determine they need, Maslow (1943) suggests that they will then be motivated towards that deprivation before they are motivated to do something else.

Moreover, the lack of motivation that is often observed in students and individuals is connected to this theory (İlter, 2021; Schunk, 2020). This lack of motivation is found more in low-income populations and more diverse populations as the physiological and belonging needs of these students are in greater demand (Maslow, 1943). As Maslow (1943) states, the motivation of these students will be higher if their basic needs are met daily. Therefore, schools have resorted to providing free meals to students in low-income areas, which typically have a higher diversity of students. Coupling these programs with instructional methods and strategies that allow for all learners feel as though they belong inside the classroom, can lead to students feeling more motivated to learn and succeed in the classroom, and increase school-wide participation in general (Bandura, 1993; Maslow, 1943; & İlter, 2021).

Related Literature

The review of the literature reveals trends and provides a broader scope of the issues surrounding STEM education, self-efficacy, motivation, and adaptive learning engagement in science and the connections between them all. Current research found about science and technology classes is discussed in length and provides insight into the current body of knowledge related to STEM education. As self-efficacy and motivation literature is discussed about the theories of this study, gaps are revealed in the literature showing the need for the current study. Future studies and gaps and limitations of related studies to the current study provide insight into the relevance and validity of the current study.

Science Technology, Engineering, and Mathematics (STEM) Education

Science, technology, engineering, and mathematics education, or STEM education, is currently one of the leading movements within education today (Lie et al., 2019). STEM education was developed to interest students within STEM fields as well as develop a more positive attitude and mindset in STEM classes such as science and mathematics (Lie et al., 2019). Based on problem-based learning and a student-centered approach, STEM education has provided educators an insight into how to make learning more engaging for students (Aldridge & Rowntree, 2021). As STEM education has become an integral part of most programs across the country, a look at the research regarding technology, achievement scores, and motivation within STEM-related courses is vital to understanding its impact on different populations of students (Lie et al., 2019). STEM education is often viewed by educators and researchers to entice elementary and secondary students to pursue STEM careers, or to be a part of the STEM pipeline (van den Hurk et al., 2019).

The STEM Pipeline

STEM education has always been utilized in many ways and areas; however, one of the largest terms for STEM education is the STEM pipeline. The term itself comes from the need for more up-and-coming professionals to choose careers in STEM itself (Skrentny & Lewis, 2022). Skrentny and Lewis (2022) expanded upon the idea that the STEM pipeline is seen as a single track as students choose STEM courses in high school, move onto STEM majors in their post-secondary schools, and then into STEM careers. If someone at any point moves away from STEM-based careers, then the pipeline is determined to have "leaked" (van den Hurk et al., 2019). Therefore, as students move along the pipeline, the number of individuals within the STEM track of education dwindles until society is left with the individuals within the STEM workforce.

This leak in the STEM pipeline is where much of current STEM education research exists (Casto & Williams, 2020; van den Hurk et al., 2019). Casto and Williams (2020) examined the STEM pipeline in North Carolina for leaks within the pipeline and the lack of diversity within the pipeline. They found that the disproportionate demographics between male and female students were statistically significant as well as the diversity within the STEM pipeline in which they conducted their study (Casto & Williams, 2020). Much of this study as well as other studies focus on how to retain individuals, especially females and diverse populations within STEM (Casto & Williams, 2020; Skrentny & Lewis, 2022; van den Hurk et al., 2019). However, much research is conducted as well to ensure that students move from high school into STEM fields by cultivating their interests in STEM careers.

Futures in STEM Fields

Research supports the goal of creating students who are interested in pursuing STEM-related careers (Çevik, 2018; Wille et al., 2020; Young et al., 2017). As interests in STEM careers were analyzed, researchers found that there is not only an achievement gap between non-ELL students and ELL students but a demographic gap in STEM-related jobs (Çevik, 2018; Mau & Li, 2018). As the gap shifts with changing demographics, research has also shifted to focus more on ELL and Hispanic populations within schools (Fahle et al., 2019). Not only have demographics shifted within research, but research has shown that self-efficacy and futures in STEM fields are linked, showing that the higher a student's self-efficacy in high school, the higher the likelihood of them entering a STEM career will be (Çevik, 2018; Lent et al., 2018). Therefore, the literature also suggests that there is a large connection between motivation and engagement within STEM classes and later interest in STEM-related fields (Mau & Li, 2018; Patel et al., 2019).

Furthermore, futures in STEM careers are heavily focused on female populations, with a strong push amongst programs to equalize the number of female to male workers within the STEM fields (Wang & Degol, 2017). As gender gaps are realized and found within STEM fields, researchers seek to find the underlying causes of them. However, gender gaps are observed across the board, not just within Caucasian populations. Latino, African American, and ELL student populations have all been observed to have gender gaps within STEM education and STEM-related careers (Wang & Degol, 2017). Some research suggests that the gender gap exists based on interests, while others suggest it is related to test anxiety and perceptions early on within STEM education (Ayuso et al., 2021). However, there is one clarification made across the research, the gaps within STEM career interests warrant continual study as focus areas change towards more technology and medical-related fields within new and differing populations of students such as the ELL student populations and different gender populations (Ayuso et al., 2021; Wang & Degol, 2017).

STEM Education at Varying Levels

Since it has been determined that STEM education has impacted and changed education over the last two decades, a look at the impact it has had upon different parts of the STEM pipeline is vital to the understanding of its impact on different student populations. As students move up the STEM pipeline, students experience drastic shifts in expectations put on them by teachers and families (Mau & Li, 2018). Likewise, the leakage mentioned regarding the STEM pipeline tends to begin as students move into middle school and secondary schools, into post-secondary schools, and eventually onto careers (Casto & Williams, 2020). This “leak” is commonly attributed to student motivations being transferred to non-STEM areas by their self-interests, familial pressures, or shifts in interest levels. due to differing levels of success. Therefore, a discussion of how the STEM pipeline appears in recent literature allows for gaps within the literature to be found within the current population.

Post-Secondary and STEM Education. STEM education has an end goal of keeping individuals within STEM careers (Skrentny & Lewis, 2022). Therefore, an investigation into the literature on STEM education at post-secondary institutions allows for a broader understanding of STEM education and the STEM pipeline. Due to the ease of research, a vast majority of literature exists related to post-secondary STEM students and studies. The increased demand for students to choose STEM-focused careers and then enter the workforce in STEM careers has led to studies determining if students possess the skill necessary to be successful within their STEM careers (Carlisle & Weaver, 2018; Wu et al., 2018). Moreover, researchers are looking at what motivates students to choose STEM-related fields and majors as well as what makes them continue in the fields they chose when entering a post-secondary institution (Wu et al., 2018).

Not only is research focused on the motivations and choices of students in post-secondary institutions, but it is also focused heavily upon underrepresented groups such as females or minority populations. According to Xu et al. (2020), research has indicated that only a small portion of underrepresented populations proceed to participate in STEM-related workforces. Moreover, institutions are working diligently to broaden participation within female populations and minority groupings (Xu et al., 2020). Therefore, as STEM research continues, the need to bridge the gaps within education becomes more prevalent as post-secondary institutions address the leakages experienced within the STEM pipeline (Alvarado & Muniz, 2018). Casad et al. (2019), found that female students were more likely to be disengaged from their STEM majors if their self-esteem and self-efficacy were lower. Therefore Casad et al. (2019) called for more programs and research to be conducted to help female STEM students to remain engaged and motivated within STEM-related majors.

Secondary Schools and STEM Education. Not only are post-secondary students an important part of the STEM pipeline, but high school students' interests and engagement in STEM education must be retained for them to move into STEM majors in post-secondary institutions (Mau & Li, 2018). High school students often participate in more immersive STEM programs than in middle schools, such as medical tracks, technology tracks, or general STEM tracks found within the courses in many schools. Much of the research related to high school students and STEM education revolves around the impact STEM education, activities, and programs have had on high school students' motivations, achievement, and engagement in STEM education (Scott-Parker & Barone-Nugent, 2019). The literature reveals that students fully immersed in STEM education at the high school level are more likely to enter STEM-related fields at the post-secondary level and have a positive outlook on STEM education (Scott-Parker & Barone-Nugent, 2019).

In contrast to positive outcomes within studies towards STEM integration, there are components of STEM education that do not show significant data for students majoring in STEM fields. Cheng et al. (2021) conducted a study showing the use of 3D printers and their apparent use in furthering students' interest in STEM careers. Their research showed that 3D printer integration levels had no apparent impact on students' interests, but their data did show that there remains a gap between male and female student interests in STEM majors and careers (Cheng et al., 2021). Often, results of studies on STEM activities and programs show mixed levels of success on the impact of students in choosing a STEM career path (Vennix et al., 2018). As research focuses on student interests, it often must focus not only on secondary education but split high school from middle school as subcategories of secondary education.

Middle Schools and STEM Education. Students who have an interest in STEM when in middle school, often show that they have higher self-efficacy and interest in continuing in advanced science classes in high school (Baran et al., 2019). For middle schoolers, there are a plethora of programs related to STEM inside and outside of school (Baran et al., 2019). For some students these out-of-school experiences also allow parents and families to come together to support students, which has been seen to foster more interest in STEM further down the STEM pipeline (Cheng et al., 2021). Baran et al. (2019) conducted a study focused on the impact that after-school STEM programs would have on middle school students and attitudes and found that there was an increase from the start to the end of the program in their sample population. However, some studies suggested that there was no significant impact on attitudes towards

STEM in middle school science classrooms after a project-based learning unit or STEM program (Lin et al., 2019).

Since education's ultimate focus is on the academic achievement of students, STEM education's impact on middle school achievement is also vital to understanding why it is important to continue to research STEM education's overall impact on different student populations. STEM practices have been found to increase academic achievement in each of the areas of STEM education and have been found to positively impact the learning experience of middle school students (Baran et al., 2019; Kurt & Benzer, 2020). Sondergeld et al. (2020) found that students enrolled in STEM initiatives were better prepared for STEM-related courses later, had higher academic success, and had higher overall scores in interests, knowledge, and grades. This evidence along with other studies has shown how, if utilized and implemented well, STEM can positively impact many different populations of students within middle schools and support their interests as they move onto high school and beyond (Ballenger, 2019; Hughes-Roberts et al., 2019; Patel et al., 2019; Sondergeld et al., 2020).

Science and Technology in STEM Education

The first two tenets of STEM education are science and technology. As this study seeks to find possible connections between science and technology classes with typically low-motivated students, it is important to delve into the research surrounding these two areas (Casey et al., 2018). As science and technology are interwoven within the curriculum, there is evidence to suggest that technology not only impacts students and increases their knowledge of problem-solving, but also increases their motivation and attitudes toward science and technology as well (Casey et al., 2018; Mutegi et al., 2019). According to Saraç (2018), not enough studies were found to focus on academic performance, and it was suggested that more research be conducted related to the academic achievement of students specifically in STEM-related areas.

Science Education. Science education has always been an important part of STEM education. As researchers and educators seek to involve students in more science-related fields and opportunities, the focus of science education has shifted to include technologically literate students (Saraç, 2018). As this shift towards technology has occurred as technology has advanced, research has continued to see what effects motivation, technology, and other areas of education have had on academic achievement within the core subjects (İlter, 2021). Likewise, science education has shown connections to student learning engagement and motivation as more STEM-related subjects are incorporated (Soltani & Askarizadeh, 2021).

Science education has always been deemed a hands-on content area due to the laboratory investigations it is known for in education. However, as students from across cultures and demographics come together to understand science content that is disseminated through active, hands-on learning, these instructional tactics have been found to have the highest impacts on academic achievement and student motivation (Kanadli, 2019). As science education advances with the implementation of STEM practices and project-based learning tactics, a further look at how to improve academic achievement in future studies across all populations has been called for in multiple studies (Wang & Degol, 2017; Casey et al., 2018). Researchers have also found that science education should incorporate more design thinking, computational thinking, and creative problem-solving into the science curriculum (Galoyan et al., 2019, 2022; Heliawati et al., 2021; Kanadli, 2019; Weintrop et al., 2016).

Technology Education. Technology education is an enormous component of STEM education today, often overflowing and aiding the other three components of the STEM acronym. As education develops with the aid of computers and other related programs, the use of technology in education should be differentiated from the classes that focus solely on technology education such as coding and robotics (Saraç, 2018). Technology in the form of robotics and coding has allowed students to access a new industry of workers and has propelled a more diverse group of students to enter technology fields and degrees once they complete their secondary education (Saraç, 2018). Science and technology have been aided using STEM education as they promote and are promoted by a PBL approach (Casey et al., 2018; Demir et al., 2021; Saraç, 2018).

However much technology research remains on the use of technology in content areas and its effects on learning in content areas (Önal & Demir, 2017). As researchers have found effects and impacts that assistive technology such as smart boards and online learning programs have had on students (Önal & Demir, 2017), other research focuses on a specific technology such as what virtual reality, robotics, and computer programs can add to different disciplines (Casey et al., 2018). Likewise, it has been suggested that more research should be conducted on the connection technology has to improve education to ensure that the use of different technologies within schools and educational programs is fully understood and able to be synthesized by policymakers (Casey et al., 2018).

Academic achievement within technology classes is often tied to students being able to use and manipulate computer-based programs or devices (Demir et al., 2021). However, academic achievement in reading, mathematics, and other content areas has been aided using assistive technology (Demir et al., 2021; İlter, 2021). As academic achievement remains a focus of policymakers within the American education system, researchers continue to call for more studies on academic achievement and how it relates to STEM education, technology use, education, and content area classes (İlter, 2021). According to literature, students who participate in programming courses, robotics, or classes that focus on other twenty-first century skills typically are more likely to be motivated, achieve higher academically, and build their critical thinking skills (Hughes-Roberts et al., 2019).

Moreover, the focus of the current study is highly supported by studies that show connections between technology education and academic achievement. According to Usengül and Bahçeci (2020), science academic achievement was linked to robotics education. Robotics, technology and language-infused strategies within science classes have all shown success in the academic growth of students (Casey et al., 2018; Garza et al., 2019). This link found in this study shows that technology education plays a larger role in content area education than originally thought or intended (Mutegi et al., 2019; Usengül & Bahçeci, 2020). As technology education is researched more in-depth, more research is called for about the connection between technology education and content area knowledge acquisition (Usengül & Bahçeci, 2020). Performance on tests is often an indicator of self-efficacy, task value, and self-regulation; however recent studies have shown that this is even true within computer programming and technology classes (Akcaoglu et al., 2021).

Instructional Practices in STEM Education

Instructional methods and new learning models are developed to engage and motivate all learners based on research conducted within different settings of education**.** While plenty of instructional practices have been utilized within education over the last century, as STEM education developed at the turn of the twenty-first century, the need for major shifts in instructional practices became apparent. This shift, although having already begun, was made more apparent over the last two decades as demographics have also shifted within American schools and the STEM pipeline. The shift in instructional methods showed that the need for teachers to have students utilize problem-solving, critical thinking, and logical reasoning skills was the most imperative within the STEM pipeline (Liao et al., 2021). Therefore, two of the most prevalent instructional practices in STEM education are student-centered learning and problem-based learning.

Student-Centered Learning. Student-centered learning is based on the premise that the teacher is guiding learning, but the students are the ones actively engaged in learning (Brown et al., 2014). Liao et al. (2021) studied the connection between student-centered learning and an artificial intelligence project conducted by students and found that achievements were greater in students who received student-centered instruction. This study, along with others, suggests that student-centered learning is one of the primary tenets of STEM education’s instructional methods (Hill et al., 2019; Liao et al., 2021). Likewise, as student-centered learning becomes the prevalent focus of instructional practices within STEM education, its effectiveness and success have also been focused upon in detail (Shekhar et al., 2020). While no component of education is perfect, student-centered learning is effective in producing student success and positively impacting student motivations (Hill et al., 2019; Liao et al., 2021; Shekhar et al., 2020).

Problem-Based Learning. Problem-based learning (PBL) was developed to help medical students, but it was quickly understood to be beneficial in many different educational settings (Barrows & Tamblyn, 1980). The idea of problem-based learning helped develop many STEM-based curricula as science education has long since been connected to the trial-and-error methodology and a more student-centered approach to learning (Liao et al., 2021). Moreover, this style of learning has been proven to create more meaningful learning, and therefore more retention of information (Brown et al., 2014). Problem-based learning (PBL) is closely tied to

STEM education as it allows students to approach learning through problem-solving instead of rote memorization. Created originally for medical students to learn hands-on approaches within the medical field, PBL was designed for a student-centered environment (Barrows & Tamblyn, 1980). PBL seeks to have students learn by being given a problem to solve. Since its development, PBL has been utilized in many areas of education and has been linked to higher student motivation in multiple studies (Akcanca, 2020; Ugras, 2018).

PBL is especially useful for STEM-related education as any advancement in STEM fields requires professionals and students to solve relevant and current problems faced by themselves, their communities, or the world at large. Problem-based learning has helped build the premise of many STEM curricula today and is one of the leading theories behind many STEM programs (Akcanca, 2020). As students begin to work through the branches of STEM education, they are quickly asked to apply content to problems, just as the theory of PBL suggests and this is how learning becomes more meaningful over time (Çevik, 2018; Ugras, 2018). There is evidence as well that PBL is positively linked to STEM education and achievement (Çevik, 2018). Therefore, understanding how PBL ties into different areas of education is a pivotal part of understanding its usefulness in curriculum development across STEM fields and in the classroom.

Criticisms of STEM Education

Defining STEM. Much of STEM education has merit within research-based education; however, some criticisms are offered by some critics. One of the largest critiques of STEM education is the lack of a definitive definition (McComas & Burgin, 2020). Without a definitive definition nationwide, districts, schools, and teachers are left to determine their unique take on STEM education, leading to varying degrees of success (McComas & Burgin, 2020). This is because it allows for too wide a range of instructional implementations within the same arena of education. Furthermore, the lack of continuity in STEM education could potentially lead to the loss of students in the STEM pipeline (Lykkegaard & Ulriksen, 2019; McComas & Burgin, 2020). Finally, many critics agree that a better definition and consequently more uniform curricular changes would help with the ambiguity of what STEM means within education (McComas & Burgin, 2020).

STEM Pipeline Leakage. Yet another criticism of STEM education is focused on the success or lack thereof in keeping students interested in STEM careers. A lot of this is focused on the gender and racial gaps that already have been found to exist within STEM education (Bippert & Harmon, 2017; Casey et al., 2018; Fahle et al., 2019; Patel et al., 2019). Much research has been focused on what leads students to choose STEM-related fields, classes, and majors and how gender, race, and ethnicity have been and continue to be the predominant issue with pipeline leakage (Lent et al., 2018). Mau and Li (2018) examined factors that influenced high school students' career aspirations and found that familial career influences played an imperative role in what students choose. Therefore, it is suggested within research that as part of the STEM leakage problem to incorporate families more in students' STEM education (Mau & Li, 2018).

Teacher Training. Finally, another area of criticism comes in that of teacher training for STEM education. There is a base of research surrounding teachers' self-efficacy, perceptions, and actual competence in teaching from the STEM construct (Kanadli, 2019). Likewise, according to Kanadli (2019), it was found that many teachers reported a lack of training in STEM and would like to see more seminars, conferences, professional development, and resources before implementing STEM education practices and programs in their classroom (Cheng et al., 2021). Teachers often complain about the lack of support regarding new technology in classrooms and struggle to maintain curriculum while also contending with core curriculum demands. Moreover, the larger class sizes typically limit the applicability of STEM programs in the classroom as management of resources and behaviors becomes an issue (Kanadli, 2019; Leonard et al., 2018; Liu et al., 2021). Therefore, criticisms that lie specifically on teacher preparation and training are well founded but also are being addressed at a high rate as new teachers enter the field (Cheng et al., 2021).

Motivation

Motivation is a multifaceted and convoluted theory to grasp within education as it is comprised of a multitude of components, especially within education. According to Schunk (2020), motivation is linked to learning and is the process of beginning and sustaining goal-directed behavior. Furthermore, motivation is related to the needs of students (Maslow, 1943), leading to the motivations being different for each student. Students who are not being fed or are homeless will be less motivated to worry or even try to achieve in science or technology classes (Donalson & Halsey, 2020; Maslow, 1943). Although students are individually unique, their basic needs and the expectations to which they are held remain the same, causing anxiety and pressure amongst the lower achieving students within schools (Çoban & Kamis, 2019).

It has long since been accepted by educators that STEM-related instruction practices have a positive impact on student motivation (Baran et al., 2019). However, further investigations into current motivation within STEM fields are vital to the understanding of STEM education's impact on science and technology education and interest in each field (Julià & Antolí, 2019). Amotivation, or a lack of motivation, has been studied as well as educators have noticed an upward trend in lack of motivation with the impacts of COVID-19 on schools still largely unknown to any real extent (İlter, 2020). According to İlter (2021), higher academic amotivation is linked to much lower academic achievement. As motivation and learning engagement in STEM is focused upon more through different courses and all the tenets of STEM, researchers are focusing more on the underlying causes of motivation across content areas (Soltani & Askarizadeh, 2021).

As technology education becomes more integrated into schools, especially secondary and post-secondary schools, a further review of the literature related to technology classes, education, and motivation is necessary (Demir et al., 2021; İlter, 2021). According to Göloğlu and Nezih (2021), not only is assistive technology useful for aiding academic achievement but it has been seen to help teachers with PBL as well as show an increase in motivation and attitudes towards technology and learning content (Akcanca, 2020; İlter, 2021). Many researchers and curriculum developers look to increase motivation within education by incorporating games and robotics, and these methods have been found to show positive trends in motivation as well as learning in general (Johnson, 2019; Soltani & Askarizadeh, 2021). Along with robotics and computer games, augmented reality has been utilized to degrees of success, while also showing that they increase engagement in learning and motivate students to explore new arenas (Boda & Brown, 2020; Liu et al., 2021; Shu & Huang, 2021).

Furthermore, as research focuses mostly on motivation, reviewing literature related to technology’s impact on motivation is needed. However, as assistive technology is not the only type used within schools, a focus should also be on technology education’s effect on motivation (Uca Özturk et al., 2021). Much of the existing body of knowledge related to technology and motivation revolves around the use of technology within content classes (Darling-Aduana & Heinrich, 2018; Herro et al., 2018), but gaps have been found in studies related to the motivation of technology effect on motivation within some populations of students and areas of technology education (Casey et al., 2018; Lie et al., 2019; & Mutegi et al., 2019).

The connection between science and technology is seen even more within the modern motivational theory (Aldridge & Rowntree, 2021). Although much research has shown that there are indisputable connections between technology and science, not much research shows what long-term work within technology or computer classes has on science motivation (Akcaoglu et al., 2021; Aldridge & Rowntree, 2021; Julià & Antolí, 2019). Multiple studies show that science learning is directly related to motivation (Aldridge & Rowntree, 2021; Soltani & Askarizadeh, 2021), still, the literature does not connect separate technology settings to science motivation. The literature indicates that technology does affect science learning and motivation (Casey et al., 2018; Lie et al., 2019; Liu et al., 2021; & Mutegi et al., 2019; Namli & Aybek, 2022). Nonetheless, there is little research that offers the two STEM tenets as separate entities as suggested within the current study.

Self-Efficacy

Self-efficacy as an overall concept has been researched in multiple areas of education and behavioral sciences. Since it is a far-reaching concept within education, many researchers devote time and effort to understanding exactly how it impacts and is impacted by different programs, activities, and areas of education (Brown et al., 2016; Fahle et al., 2019; Haverback, 2020; Miles & Naumann, 2021; Namli & Aybek, 2022; Prewett & Whitney, 2021; Soland & Sandilos, 2021; Tomás et al., 2020; Tsai et al., 2019; Webb-Williams, 2018). Self-efficacy is known to impact not only academic achievement but participation within classes as well (Tomás et al., 2020). Likewise, impacts on self-efficacy by different programs, activities, and instructional methods have shown that student-centered learning has had the highest impact regardless of educational level or demographic (Güdel et al., 2019).

One of the leading areas of self-efficacy research within education is related to teachers' self-efficacy within multiple areas of education (Boulden et al., 2021). Since no parental consent is necessary, teacher and college student populations are easier to sample from and they are an obvious choice in understanding how their self-efficacy can impact others (Boulden et al., 2021). Research has indicated that teacher self-efficacy is often wide-ranging and differs between pre-service and experienced teachers as well (Bippert & Harmon, 2017; Prewett & Whitney, 2021). However, the current study seeks to determine if self-efficacy impacts students, therefore a closer look at the literature regarding middle school students, academic achievement, and STEM education is necessary to understand the gaps within the literature.

Self-Efficacy and Academic Achievement

Academic achievement is an area that is constantly under review as educators and policymakers seek to improve this area consistently and constantly year to year. Literature suggests that not only is there a direct link between student self-efficacy and achievement, but teachers' self-efficacy and negative effects can also impact student achievement (Prewett & Whitney, 2021). Since self-efficacy is based on the concept of students' perceptions of abilities and engagement, research has shown how it can have a significant impact on students' academic achievement (Chipangura & Aldridge, 2017; Donalson & Halsey, 2020). Mantooth et al. (2021) examined undergraduate students' self-efficacy and their performance within an undergraduate statistics class and found that their results supported the large body of research that suggests the more confident students are in their achievement the better they tend to perform. Additionally, self-efficacy and achievement are tied regardless of student demographics, although drops in self-efficacy are reported as students move higher up in their education. Consequently, this connection between self-efficacy and achievement is true for students regardless of their level of education but can be impacted by other environmental factors outside of the controlled classroom (Mantooth et al., 2021).

Self-Efficacy and Middle School Students

Literature related to middle school students shows that there is a sharp decline in self-efficacy between elementary and middle school students across demographics (Fahle et al., 2019). However, as middle schoolers are immersed in different programs and curriculum, it is evident that the expectations put upon them shift dramatically between elementary and middle school (Prewett & Whitney, 2021). Tomás et al. (2020) examined the relationship between academic self-efficacy, achievement, and hope among middle school students in the Dominican Republic. It was found that the higher self-efficacy middle schoolers had, the higher engagement they had, and subsequently higher academic achievement (Tomás et al., 2020). This research combined with the vast amount of literature suggests that large amounts of research should continue to focus heavily on self-efficacy and student engagement in the classrooms.

Middle school students have been found to thrive from hands-on experiences, much like elementary school students (Lie et al., 2019). Since research-based educational practices and curriculum is in building student engagement, the instructional practices and focus of many modern educational programs and activities naturally fit middle schooler preferences (Collie et al., 2019). Collie et al. (2019) examined the connection between student motivations, engagement, and self-efficacy throughout middle and high school and found that higher self-efficacy was associated with lower disengagement and task value over time. Finally, much of the research related to middle schoolers’ self-efficacy and achievement is now related to STEM education. Therefore, a closer look at the impact self-efficacy has on STEM education within the literature will provide further insight not only into STEM education but self-efficacy as well.

Self-Efficacy and STEM Education

Within STEM education, self-efficacy is often measured by students' perceptions and interests within STEM classes (Brown et al., 2016). Self-efficacy is often related in part to the confidence students have within themselves and is increased the more they seek to improve within STEM classes as well (Micari & Pazos, 2021). However, STEM education often leads to students increasing their self-efficacy due to their increased confidence in not only their content area knowledge but their use of technology problem-solving skills (Çevik, 2018). Additionally, self-efficacy within STEM education has led to research being connected heavily to their science learning concepts and self-regulation strategies (Webb-Williams, 2018).

Research on self-efficacy has led to educators creating new programs within STEM education to further propel and promote interests and achievement within STEM (Galoyan et al., 2019). These programs are often based on the research-based concept that student-centered learning and hands-on experiences often create a higher level of self-efficacy, interest, and motivation in students to complete tasks (Galoyan et al., 2019; Hughes-Roberts et al., 2019). The understanding that student-centered learning allows for higher self-efficacy has been the leading component of STEM programs for students at all educational levels (Liu et al., 2021; MacDonald et al., 2020; Namli & Aybek, 2022; Patel et al., 2019; Ugras, 2018). Consequently, researchers have looked for ways to implement STEM activities to engage students and build their self-efficacy within each of the individual tenets of STEM as well (Liu et al., 2021; Namli & Aybek, 2022; Ugras, 2018).

Self-Efficacy in Science Education. As one of the components of STEM education, science education is a large focus within the STEM paradigm. Furthermore, self-efficacy's impact on science education and consequently the reverse is a large part of the current related literature (Heliawati et al., 2021; Herro et al., 2018; Lie et al., 2019; Miles & Naumann, 2021; Webb-Williams, 2018). As researchers investigate self-efficacy, the idea of science self-efficacy has emerged as students determine their abilities to conduct scientific research (Miles & Naumann, 2021). Since the idea of STEM education is built upon students applying content knowledge, it is imperative to understand how science self-efficacy impacts students' aspirations and beliefs (Miles & Naumann, 2021; Webb-Williams, 2018). Likewise, research has shown the right instructional methods within science education and proper use of resources can have a large effect on students' self-efficacy (Heliawati et al., 2021; Herro et al., 2018; Lie et al., 2019).

Self-Efficacy in Technology Education. Focusing specifically on self-efficacy within technology, more evidence is provided on the impacts that technology education and programs can have on self-efficacy (Akcanca, 2020; Akcaoglu et al., 2021; Boda & Brown, 2020). Technology's explosion into education over the last decade alone has led to significant shifts in focus in the recent literature (Cheng et al., 2021). Studies have shown that technology has a particular impact on STEM education; however, it is dependent upon the proper implementation of that technology for the most significant results (Cheng et al., 2021; Huang, 2022; Hughes-Roberts et al., 2019; Liao et al., 2021). Huang (2022) studied the impact that virtual reality headsets could have on student self-efficacy. A newer technology in school Huang (2022) argued that there needs to be more research related to emerging technologies in the classroom and self-efficacy. The study resulted in no significant difference between the virtual reality headsets and self-efficacy (Huang, 2022). Consequently, the literature indicates the need for further research to be conducted related to science, technology, and self-efficacy (Akcaoglu et al., 2021; Boda & Brown, 2020; Casey et al., 2018; Huang, 2022).

Self-Efficacy and Adaptive Learning Engagement

This study seeks to find the connection between self-efficacy in science class and technology classes' role in that motivation. To obtain a measurable score and data for the study, the SALES questionnaire will be utilized, which measures self-efficacy, learning goal orientation, self-regulation, and task value (Aldridge & Rowntree, 2021; Velayutham et al., 2011). Researchers often utilize these four subcategories to determine the motivation, self-efficacy, and adaptive learning engagement of students in many areas of education (Aldridge & Rowntree, 2021). Adaptive learning engagement is connected to modern motivational theory and self-efficacy is often used to measure adaptive learning engagement (Aldridge & Rowntree, 2021).

Task Value. Research has led to the understanding that expectancies and task values tend to be mediators between environmental factors and achievement, as proposed by current motivational models (Schunk, 2020). However, expectancy theory, or task value, allows students to determine the importance they put on tasks and achievement in the classroom, linking it closely to self-efficacy as well (Aldridge & Rowntree, 2021; Eccles & Wigfield, 2002). As students place various levels on tasks within different disciplines starting in late elementary schools, it is evident that research is necessary to understand how it relates to disciplines in higher levels of education as well (Güdel et al., 2019). Therefore, STEM education is often focused upon a student-centered approach to learning lending students to focus heavily on completing STEM tasks above others (Güdel et al., 2019).

Task value within science is especially important to the motivation of students (Vinni-Laakso et al., 2019). Task value, or expectancy value, within science education, often comes down to students' self-efficacy beliefs and goal orientation within the science classroom (Soltani & Askarizadeh, 2021). Furthermore, as students put a value on their learning and understanding of science, a higher expectancy value has shown that they have an increased interest in STEM-related careers (Wille et al., 2020). Moreover, self-efficacy and task value have been found to increase when technology, such as robotics, is incorporated into learning (Leonard et al., 2018). Hill et al. (2019) found that teachers and professors often have the largest impact on student task value within STEM careers and one way to help students have a higher task value on assignments is to make assignments more relatable to the students' environments.

Beier et al. (2019) examined the effects of project-based learning with undergraduate STEM classes on self-efficacy and task value. The researchers discovered that higher self-efficacy within the STEM classes led to higher levels of task value and students completed more tasks within the project-based learning unit than without it (Beier et al., 2019). The overwhelming majority of literature calls for more research to be conducted related to different demographics of students and their willingness to be engaged, complete tasks, and continue to aspire to STEM careers (Beier et al., 2019). Finally, researchers continue to call for and focus on the impacts different STEM programs and instructional methods have upon not only the completion of tasks but goals individuals aspire to in STEM careers.

Goal Orientation. As students set goals and begin to work towards those goals, they develop reasoning and purposes to focus on learning and mastery (Eccles & Wigfield, 2002; Midgley, 2002; Schunk, 2020). An emphasis on learning goals within the classroom has shown positive influences on students' learning goal orientation as well as self-efficacy in general

(Midgley, 2002) According to Schunk (2020), goals are influenced by student perceptions of tasks and demands, and if the difficulty is deemed too high, students often have a lower learning goal orientation (Ames, 1992; Midgley, 2002). Since the goal of STEM education is often to lead more individuals into STEM careers, STEM education often supports achievement goal theory as well as its connection to self-efficacy (Schunk, 2020). Practically, however, learning goal theory often is seen in the literature as goal orientation.

Goal orientation often plays a significant role within STEM education as students remain engaged through their current and future goals related to STEM education, STEM majors, and potential STEM careers. Closely linked to expectancy value, goal orientation leads students to determine if their goals are attainable in their own eyes (Collie et al., 2019). Additionally, as students' futures in STEM fields are the goal of STEM educators and STEM industries, the research focus on student's beliefs and perceptions in persisting in STEM continues to be a component of self-efficacy research (Collie et al., 2019). Sasson (2019) speculated that internship programs within science research could help foster self-efficacy, goal orientation, and persistence in STEM fields. As goal orientation has a large impact on persistence within STEM fields, research has also revealed that even legislators continue to find ways to help students, especially minority demographics, to pursue STEM careers. However, goal orientation is not only tied to research regarding self-efficacy, but that to self-regulation as students need to have high levels of self-regulation to persist in STEM fields in post-secondary schools and careers.

Self-Regulation. Self-regulation within STEM education is an important component of understanding STEM education's impact on motivation and learning. Additionally, self-efficacy and self-regulation both play a pivotal part in technology education. As a major component of STEM education, engineering dominates much of the STEM education research conducted in recent years as it often integrates technology as well (Zheng et al., 2020). According to Zheng et al. (2020), self-regulation plays an important role in not only learning but engagement as well. Furthermore, self-regulation is a key factor in students learning computer software and problem-solving when creating content on computers across STEM areas (Tsai et al., 2019; Zheng et al., 2020).

According to Tsai et al. (2019), self-regulation may be the most important component of learning computer programs and working with STEM content areas. Moreover, self-regulation's connection to goal orientation allows for most learners to set goals while working as well (Tsai et al., 2019). Computational thinking's connection to STEM education, especially within technology education, has been found to connect technology to self-efficacy and self-regulation (Galoyan et al., 2022; Lockwood & Mooney, 2017). Within computational activities and technology education such as programming activities, students have stated that they would most likely apply their computational thinking skills specifically to mathematics and science classes (Leonard et al., 2018; Lockwood & Mooney, 2017; Namli & Aybek, 2022). Finally, as self-regulation remains a component of research within self-efficacy the existing literature gaps show the need for more research to be conducted within all levels of STEM education, including middle school populations.

Summary

The ideology behind STEM education is not only based on motivational theory but has a strong part in understanding how it affects academic achievement (Schunk, 2020; Stewart et al., 2020). Self-efficacy and motivation, as closely linked together as they are, can be seen to be affected by multiple components within schools, education, and students' lives (Patel et al., 2019; Schunk, 2020). The information synthesized from the research shows the vast amount of knowledge amassed regarding STEM education as well as how technology education has expanded in the last few years (Güdel et al., 2019; Namli & Aybek, 2022; Shu & Huang, 2021; Ugras, 2018, 2019). Additionally, research has shown a gap in how students' science self-efficacy and engagement could be affected by placement in technology classes (Huang, 2022; Hughes-Roberts et al., 2019; Lin et al., 2019; Namli & Aybek, 2022). Since the goal of STEM education is to engage students in futures within STEM fields (Baran et al., 2019), literature has shown the copious amount of research conducted on factors that contribute to achievement and self-efficacy, and motivation within multiple student populations (Alvarado & Muniz, 2018; Baran et al., 2019; Beier et al., 2019; Carlisle & Weaver, 2018; Casad et al., 2019; LaForce et al., 2019; Sasson, 2019; van den Hurk et al., 2019; Vennix et al., 2018).

It is commonly accepted within the American education system, that any educational program or curricula utilized within schools must show evidence of academic success with students and must be research-based to show that decisions were not made on a whim. Although STEM education seeks to increase interest in STEM-related fields across student demographics, the implementation of STEM education strategies and lessons, including PBL strategies, shows academic results as well (Çevik, 2018; Shu & Huang, 2021). Over the last twenty years, surmounting evidence has shown the wide range of STEM programs and the varying degrees of success these programs have experienced. According to Çevik (2018), STEM education increases scores among high school students and the PBL approach utilized within STEM education supports those learning goals. The ability of students to make learning meaningful and create things also helps to build their knowledge and skills, thus increasing their test scores (Brown et al., 2014; Shu & Huang, 2021). Lastly, the PBL model of STEM education allows for more collaboration between students, and this has been shown to have a positive impact on self-regulation and learning among students (Micari & Pazos, 2021).

As the related literature was synthesized along with the theoretical framework, a trend was revealed to support the problem and purpose of the current study. As recent studies show different limitations and gaps, there have been gaps in the literature regarding middle school students’ motivation and engagement in science classes related to their placement in technology classes or not (Soltani & Askarizadeh, 2021). In multiple studies, limitations and future studies are suggested with different areas or populations such as moving a study from elementary to middle school-aged students (Fahle et al., 2019; Kurt & Benzer, 2020; Lie et al., 2019). The further connection to science from technology class placement still needs a variety of studies to add to the current knowledge base (Güdel et al., 2019; Namli & Aybek, 2022; Shu & Huang, 2021; Ugras, 2018, 2019). Therefore the purpose of this study is to examine the technology classes’ effects on private middle school students’ self-efficacy, self-regulation, task value, and goal orientation between students in technology electives and non-technology electives.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative, causal-comparative design is to examine the technology classes' effects on private middle school students' self-efficacy, self-regulation, task value, and goal orientation between students in technology electives and non-technology electives. This chapter begins by introducing the causal-comparative design, including all variables. The research questions and null hypothesis follow. The participants, setting, instrumentation, procedures, and data analysis plans are present.

Design

For this study, a causal-comparative design was used. This design fits the current study because of the nature of the data being collected as well as the groups being compared. As subjects are placed into one of the two groupings by the schools, it is important that no further manipulations take place to see the true impacts that technology elective classes have upon self-efficacy, task value, self-regulation, and learning goal orientation (Gall et al., 2007). A causal-comparative design is used when researchers seek to observe and investigate naturally occurring groups and the effects those groups may have on one or more variables (Gall et al., 2007; Creswell & Guetterman, 2019; Mertens & McLaughlin, 2004). However, several threats to internal validity exist for a design that measures at the beginning and end of the study (Creswell & Guetterman, 2019). Further potential threats to internal validity exist for participants; however, proper sampling methods can help with the potential threats regarding the participants (Creswell & Guetterman, 2019; Gall et al., 2007).

The causal-comparative design compares outcomes from two or more groups. According to Gall et al. (2007), the critical feature of a causal-comparative study is that the independent variable is measured in forms of categories, either ordinal scales or nominal scales. Grouping individuals for this design are typically a control and a comparison group, or the independent variable. Additionally, the formation of comparison groups is the pivotal factor in determining if a causal-comparative study should be used (Gall et al., 2007). As grouping is decided, different grouping techniques could be used, such as naturally occurring groups, extreme grouping techniques (taken from the two extremes of the same groups), or matching (Gall et al., 2007).

For the current study, the causal-comparative static-group design is the most appropriate choice because the purpose of the study is to examine technology classes' effects on private middle school students' self-efficacy, self-regulation, task value, and goal orientation between students in technology electives and non-technology electives. As the grouping for this study is decided outside the study and needs no further manipulation, it is apparent that a causal-comparative design is what fits best for the design model. Studies have shown where and when causal-comparative studies are useful to investigate STEM and self-efficacy and are often used to do both (Patel et al., 2019). Additionally, the use of causal-comparative research in studies within STEM education show how this design could be suitable for the current study's focus.

According to Gall et al. (2007), the variables are still clearly defined but relate to the cause and effect investigation that is indicative of the causal-comparative study. A causal-comparative design is a non-experimental design that has a presumed cause (the independent variable) and a presumed variable (dependent variable), although there can be more than one of either the independent or dependent variable or both depending upon the design of the study and the analysis procedures. Nonetheless, the researcher has less control over the independent variable and cannot use random sampling (Joyner et al., 2018). Thus, the independent variable for the current study, or the presumed cause (Gall et al., 2007), is whether the middle school students are scheduled into technology classes or scheduled into some other elective. The dependent variables for this study are the students' scores on self-efficacy, task value, self-regulation, and learning goal orientation using the Students' Adaptive Learning Engagement in Science (SALES) Questionnaire.

Research Question(s)

RQ1: Is there a difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire?

Hypothesis(es)

The null hypothesis for this study is:

$H_0$1: There is no difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire.

Participants and Setting

The current study seeks to investigate how technology elective classes affect the self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores within science classes. This section will highlight the participants of the study and their demographics. A convenience sampling method was used for this study due to the use of naturally occurring groupings. Sampling size is discussed related to suggestions from research design texts regarding a MANOVA statistical analysis (Gall et al., 2007; Creswell & Guetterman, 2019). The setting for this study takes place in private school technology and science classes in Florida.

Population

The participants for this study were drawn from a `convenience sample of middle school students located in southeastern Florida during the fall semester of the 2022-2023 school year. The schools used in the current study were several private schools within the same area of Florida. A choice was made to exclude sixth-grade students from this study because some private schools classify them as elementary school and some classify them as middle school. Since this could affect the internal validity and reliability of the study, the researcher decided it was best to exclude sixth-grade students from the study.

Participants

For this study, the number of participants sampled was 136 participants which corresponded with the required minimum when assuming a medium effect size. A one-way MANOVA testing with 2 groups requires a minimum of 126 students (42-54 in each group) when assuming a medium effect size using partial η^2 with a statistical power of .8 at the .05 alpha level would be 45 to 55 per group (Warner, 2013). The sample came from a convenience sampling of three private middle schools within the same area in Florida.

Within each school, students have a choice to take different electives, some of which are technology classes; however, all students were sampled from private school science classes. The comparison groups were determined based on the electives of students within middle school science classes and whether they had a technology elective or not. The first comparison group were those students who were in technology classes throughout their day and the other group was those who had a different elective other than technology classes. 49 participants took technology classes that introduced coding, robotics, animation, video creation, digital art or any combination of it, and 87 participants who were not in technology classes beyond typing and Microsoft Office. Demographic information was collected from the students in 3 private schools who were involved in the study. Table 1 shows the demographic information collected from the students.

Table 1

Participants' Demographics

Demographic Characteristics	Number in Technology Electives	Number in Non-Technology Electives
Grade		
7th Grade	9	32
8th Grade	40	55
Ethnicity		
Caucasian	32	43
Hispanic	4	11
African American	4	8
Asian	4	7
Multi-Racial	2	9
Pacific Islander	0	1
Other	1	0
Choose Not to Reply	2	8
Gender		
Female	21	49
Male	28	38

Setting

The setting for this study will be the three private schools in Florida. Since all participants in the study are within the same science classes with the same science teachers, likely, there is no disparity between scores within and between groups. Students within the technology class group also experience key critical thinking, problem-solving, and project-based learning. All students coded as a part of technology classes were exposed to robotics, coding, editing photos, and videos to enhance or create something new, creating animations, creating video games, or any combination of them. Technology students all work with the same technology programs to design and learn how to use computers to solve problems or to create. These students also are in their technology electives and other electives throughout the week.

Instrumentation

The instrument used for this study was the Students' Adaptive Learning Engagement in Science (SALES) Questionnaire to test students' self-efficacy, task value, self-regulation, and learning goal orientation within science class (See Appendix for permission to use the instrument.) The SALES Questionnaire was developed by Velayutham et al. (2011) to allow researchers to utilize a motivation questionnaire more suited for lower secondary students. The developers found that the Motivated Strategies for Learning Questionnaire (MSLQ) was designed to be utilized with research on post-secondary students, not middle school or high school students (Pintrich et al., 1991; Velayutham et al., 2011). Velayutham et al. (2011) determined that not only was the wording of several questions difficult to comprehend for students, but the conceptualization and measurements of the constructs were thought to be ambiguous and more theoretical than they should be for middle school and high school students. Also, they felt as though 44 questions may be too many for lower secondary students and therefore sought to lessen the number of questions. Therefore, the SALES Questionnaire was developed to overcome the issues the developers had with the MSLQ (Velayutham et al., 2011).

The developers used Trochim and Donnelly's (2006) framework for construct validity (Velayutham et al., 2011) to show that the construct fulfilled both translation and criterion-related validity. The constructs of the questionnaire are self-efficacy, learning goal orientation, task value, and self-regulation. The construct validity for each of the four constructs the authors claim is shown through item values and percent variance for each construct. The researchers conducted a Principal component analysis of each of the 32 items split between the four constructs. This led to the eigenvalue (or item value) for each factor as greater than 1, and the cumulative variance for all four constructs was higher than 0.5 on their respective construct, indicating that all items could be retained (Velayutham et al., 2011). According to Velayutham et al. (2011), the item values (eigenvalues) for each construct were as follows: self-efficacy=15.01, self-regulation=1.71, task value = 2.08, and learning goal orientation= 1.44. The percent variance for each construct was also reported (self-efficacy= 46.90%, task value = 6.49%, self-regulation = 5.35%, and learning goal orientation = 4.51%).

In terms of validity and reliability, the SALES Questionnaire was analyzed to determine whether it met all assumptions and validity tests. Bartlett's test of sphericity showed that $\chi^2 = 29234.753$ and this value was statistically significant ($p < 0.001$). The Kaiser-Maiyer-Olkin measure of adequacy was high (0.973), allowing for further analysis (Velayutham et al., 2011). The Cronbach's alpha coefficient was calculated for each set and was found to be above 0.90, showing the reliability of the constructs: self-efficacy (α=0.92), learning goal orientation (α=0.91), task value (α=0.92), and self-regulation (α=0.91) (Velayutham et al., 2011). An ANOVA was used to establish concurrent validity and show that all eta-squared values are significant ($p<0.001$) for each scale [Learning goal orientation (0.22), task value (0.17), self-efficacy (0.18), self-regulation (0.17)], suggesting that each scale in the questionnaire differentiated significantly and this supports internal validity (Velayutham et al., 2011). Pearson's correlation (one-tailed) was used to assess predictive validity and all scales were found to have significant correlation with students' science achievement ($p<0.001$), supporting the predictive validity (Velayutham et al., 2011).

The SALES Questionnaire consists of 32 questions, 8 questions for each subcategory of self-efficacy, task value, self-regulation, and learning goal orientation. According to Velayutham et al. (2011), learning goal orientation (students' development of competence in learning and mastering of skills), self-efficacy (students' understanding of their abilities and intelligence), task value (students' expectations of success, choices, and performance), and self-regulation (the degree to which students participate in the learning process) are each of the subscales. This instrument has been utilized in other studies related to STEM education and motivation. Aldridge and Rowntree (2021) used the SALES Questionnaire to determine self-efficacy and self-regulation in female science students. Chipangura and Aldridge (2017) employed the instrument to test multimedia's impacts on students' perceptions, like what the current study is looking to investigate. Finally, Soltani and Askarizadeh (2021) used the questionnaire to investigate the connections between learning engagement and motivation with science learning tasks and concepts, such as test-taking and memorization.

Students will answer the 32 items (8 for each subscale) by answering each statement on a 5-point Likert Scale as follows: (1) strongly disagree, (2) disagree, (3) are not sure, (4) agree, or (5) strongly agree. Each scale, self-efficacy, task value, learning goal orientation, and self-regulation, can have a score as low as 8 and a score as high as 40 with 8 showing a low score and

40 being the highest. Furthermore, a score of 32 would indicate a low adaptive learning engagement in science, and a score of 160 would be the highest total adaptive learning engagement in science. Since there are no reverse items, no reverse or negative scoring is needed for any items. The instrument should be administered to each group within a 30–40-minute time frame, shorter, depending on the student population. The instrument will be administered by the teachers or researchers, and they will be instructed to have students go to the website where the instrument will be administered to ensure the anonymity of the participants. No training on administration or rating is necessary, as the instrument is designed to be administered and scored through online administration.

Procedures

Securing IRB approval was necessary from the university and the schools in question before the research can begin (See appendix for IRB approval). Once the proposal was approved by the university IRB, it was submitted to the private school boards for approval. Once any corrections were made from the suggestions of either IRB committee, participants were elicited from middle school science classes within the schools and were given the chance for a week to have a parent-opt out form signed (See appendix for parent opt-out form). Parents were made aware through their students' science teachers and were given all information about the study a week before the survey was administered. Teachers were given a brief overview of how to administer the SALES questionnaire and were given a choice to complete it in a given timeframe (a day of their choosing to administer on their own) or establish a day for the researcher to come to their site to help them administer the survey. To provide an incentive for students and teachers to take and administer the questionnaire, teachers were given gift cards, and students were offered food of their choice (from a list of candy and snacks). If a student has opted out of the survey, they were given a logic puzzle to complete to earn their incentive.

The researcher administered the survey any time after the first quarter of the school year to ensure that they have had adequate time to engage in technology classes or not, and their required science courses. The researcher administered the SALES questionnaire by asking the science teachers to give the students time to complete the questionnaire. The first part of the questionnaire asked students to provide grade level, gender, ethnicity, elective class(es), and technology exposure. Students were asked to keep their names off the surveys to ensure anonymity and the teacher checked each paper before returning them to the researcher. Once the researcher receives the scores from the questionnaire, data were checked for any errors or problems and organized by participant (named by a number, 1-number of participants in the study), and their scores in each subscale and their overall score, and their placement in technology elective classes or not. Data was recorded through Microsoft Excel spreadsheets.

Once all data was received from participants and organized, it was analyzed to see if any statistical differences or significance exists. At all stages of data collection, all information that could identify the participants was protected. Data were stored securely and only the researcher had access to records. Any computerized data were stored on a password-protected computer using encrypted files. The data will be retained for five years after the completion of this research study.

Data Analysis

The statistical analysis used for the current study was one-way MANOVA using the Statistical Package for the Social Sciences (SPSS). One-way MANOVA is used in research to determine whether groups differ on more than one dependent variable with only one independent variable (Warner, 2013). Since this study had four dependent variables measured by the SALES questionnaire, a one-way MANOVA was a suitable choice to analyze the independent variable's effect on each of the dependent variables. Since the current study sought to determine the effect technology classes have on self-efficacy, self-regulation, goal orientation, and task value, a one-way MANOVA was the most fitting analysis to use. MANOVA determines whether the population averages on a set of dependent variables vary across levels of a factor or factors (Green & Salkind, 2017, p. 161).

First, to conduct descriptive statistics, the standard deviations and means for each group and the dependent variables were determined. For each statistical analysis conducted during the current study, the data screen included visual screening for missing and inaccurate entries. To test for the various assumptions, several assumption tests were performed. A box and whisker plot was used to screen data for extreme outliers, extreme outliers are measured as above 3 IQRs from the mean in each pair of variables. To test the assumption of normality, the Kolmogorov-Smirnov test was used from SPSS, any *p*-value less than 0.05 are not normally distributed, and greater than 0.05 are normally distributed. To test for multivariate outliers, Mahalanobis' distance was used, and any entry above 18.47 was determined to be an extreme outlier (Warner, 2013).

To look for a linear relationship between each pair of dependent variables, an Assumption of Multivariate Normal Distribution was conducted by looking for a linear relationship between each pair of dependent variables. If the variables are not linearly related, the power of the test is reduced. The assumption was tested by plotting a scatterplot matrix for each group of the independent variable, looking for the classic "cigar shape" between each of the six pairs of dependent variables. To test for the Assumption of Homogeneity of Variance matrices, SPSS would use Box's M test of equality of covariance and if the data fails the assumption, Levene's test of homogeneity of variance would be used to determine where the problem may lie. Finally, an absence of multicollinearity should be utilized and any correlation over .80 presents a concern for this. This will be done by generating a correlation matrix between each of the four dependent variables and ensuring that the *r* value is not above 0.80 for any pairs of the variables.

Once assumptions for the MANOVA were met, the statistical analysis was conducted on the data. Testing for the groups differing on the dependent variables using a general linear model was conducted. The *p*-value for Wilk's Lambda or Pillai's should be less than .05 for any effects chosen to reject the null hypothesis that there is no difference among middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores. If any violations exist to the assumption of homogeneity of variance, then Pillai's Trace will be used, but if there are no concerns for these violations then Wilk's Lambda will be utilized (Warner, 2013). For a medium effect size with an alpha (α) of .05 and desired statistical power of .80, each group of the independent variable must have a minimum of 45 participants (Warner, 2013). The statistic that was used to determine the effect size was the partial eta squared (η^2). If the MANOVA produces significant differences between groups for any of the dependent variables, other statistical analyses will be conducted to determine if statistical differences are found between variables. Multiple one-way ANOVAs will be conducted, one for each dependent variable using Bonferroni correction (Warner, 2013). It is not necessary to conduct Tukey Honesty Significant Difference Post Hoc tests due to only having two distinct groups (Warner, 2013).

CHAPTER FOUR: FINDINGS

Overview

The purpose of this quantitative, causal-comparative study was to determine if there was a difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire. The researcher looked at the SALES Questionnaire scores amongst 7th and 8th-grade students within 3 separate private schools. Students were grouped based on their placement within technology classes or not. To establish whether there was a significant difference between the subcategory scores on the SALES Questionnaire, the multivariate analysis of variance (MANOVA) was run on the data.

Research Question

RQ1: Is there a difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire?

Null Hypothesis

$H_0$1: There is no difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire.

Descriptive Statistics

Participant Demographics

This study consisted of 149 private middle school students spread between three private middle schools in Southwestern Florida during the 2022-2023 school year. Of the 149 participants, 13 of the questionnaires were deemed unusable for the study as participants did not complete one side of the questionnaire. The remaining 136 participants reported demographic information regarding gender, ethnicity, and grade level were recorded in Table 1. Participants were given the opportunity to opt out of the study: however, no participant opted out.

Dependent Variables

The dependent variables of learning goal orientation, task value, self-efficacy, and self-regulation were measured from responses on the SALES Questionnaire using exploratory data analysis to determine the mean and standard deviation for each. The SALES Questionnaire consisted of 32 questions that utilized a 5-point Likert scale that measured students’ adaptive learning engagement in science classrooms. The scale ranged from strongly disagree to strongly agree. Responses were as follows: Strongly Disagree = 1, Disagree = 2, Not Sure = 3, Agree = 4, and Strongly Agree = 5. The total adaptive learning engagement in science scores on the SALES Questionnaire ranged from 32 to 160. A score of 32 was interpreted as the lowest level of adaptive learning engagement, whereas a score of 160 was interpreted as the highest level of total adaptive learning engagement. Subscale scores ranged from 8 to 40, where 8 would be interpreted the lowest score for that factor, and 40 would be interpreted as the highest score. Each of the subscale scores were the dependent variables for the current study. Scores for the subscales were found with the following responses: Learning Goal Orientation items (Statements 1,2,3,4,5,6,7, and 8), Task Value items (Statements 9, 10, 11, 12, 13, 14, 15, and 16), Self-

Efficacy items (Statements 17, 18, 19, 20, 21, 22, 23, and 24), and Self-Regulation items (Statements 25, 26, 27, 28, 29, 30, 31, and 32). The SALES Questionnaire was scored by the researcher finding the mean, sum, and standard deviation of the Likert Scale responses. The scores are reported in Table 2.

Table 2

Descriptive Statistics: SALES Scores

Elective		*N*	Minimum	Maximum	*M*	*SD*
Technology Electives	Learning Goal Orientation	49	20	40	33.51	5.61
	Task Value	49	12	39	29.29	6.05
	Self-Efficacy	49	11	40	30.78	7.73
	Self-Regulation	49	9	40	30.71	7.02
	Valid N (listwise)	49				
Non-Technology Electives	Learning Goal Orientation	87	11	40	32.77	5.26
	Task Value	87	8	40	28.63	6.47
	Self-Efficacy	87	17	40	31.55	5.38
	Self-Regulation	87	13	40	29.86	6.18
	Valid N (listwise)	87				

Results

Hypothesis

The null hypothesis for this study was that there would be no difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire. Data analysis was conducted to answer the research question and to address this hypothesis.

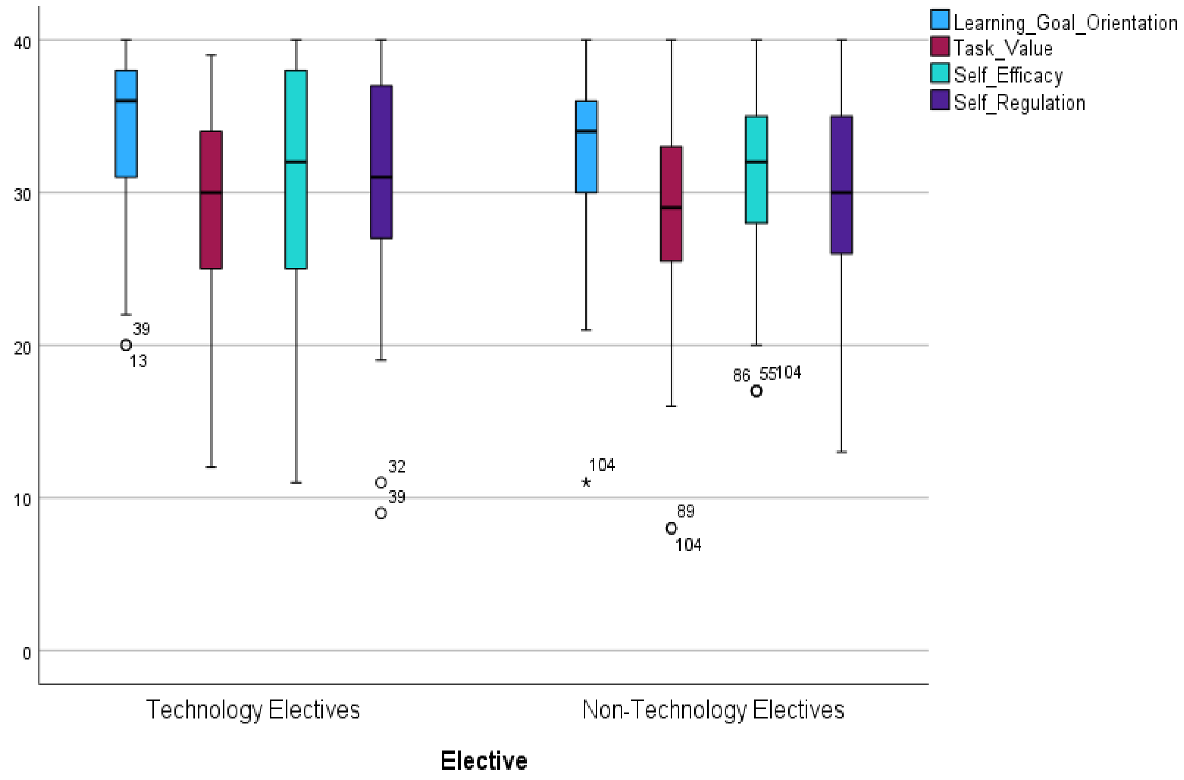
Assumption Tests

Inspection of Outliers

To ensure that the one-way MANOVA was the appropriate statistical analysis for the data collection in this study, several assumption tests were conducted. Data screening was conducted by first doing a visual scan of the data and then through an inspection of outliers for any possible incorrect entries. The analysis started by the data being analyzed for any extreme outliers among the data using boxplots. The boxplots revealed that there was one extreme outlier for learning goal orientation. This participant answered the questionnaire honestly and there were no mistakes found in data entry. Other outliers were identified as seen in Figure 1.

Figure 1

Boxplot for Inspection of Outliers



Note. Boxplots were used to identify outliers within technology and non-technology electives for each of the dependent variables. Upon examination of the boxplots, outliers were discovered. Data were checked to ensure correct coding, entry, and information, which were all found to be correct for each outlier. There were no measurement errors detected; therefore, all outliers, including the extreme outlier (#104) for learning goal orientation, were determined to be considered genuinely unusual data points. Since the results of the study were determined to be the same with or without the outliers being removed, along with MANOVA remaining robust to violations of assumptions, the researcher decided to include all outliers in the data set, to remain consistent and transparent in reporting results (Gall et al., 2007; Warner, 2013). In order to test for the assumption of multivariate outliers, Mahalanobis' distance was used as this was recommended for assumptions when conducting a one-way MANOVA (Warner, 2013). With having four independent variables the cut-off value was 18.47 (Warner, 2013). One outlier was found having MAH = 23.64. Since the data was reviewed as being accurate, it was determined this was a genuinely unique data point. This data point was included to maintain transparency of results in reporting and analyses for readers.

Test of Normality

A one-way MANOVA requires data to have multivariate normality, which was determined using the Kolmogorov-Smirnov test. As seen in Table 3, using the Kolmogorov-Smirnov test, normality was violated for both elective groups, technology electives and non-technology electives, for learning goal orientation ($p < .001$, and $p = .003$, respectively). Normality was also violated for non-technology electives in task value ($p = .027$). No other values violated the assumption of normality as $p > .05$ for the rest of the values for the groups and variables. Gall et al. (2007) and Warner (2013) both stated that MANOVA is robust to violations of normality, therefore the researcher continued with the data analysis. Results from the tests of normality are found in Table 3.

Table 3

Tests of Normality

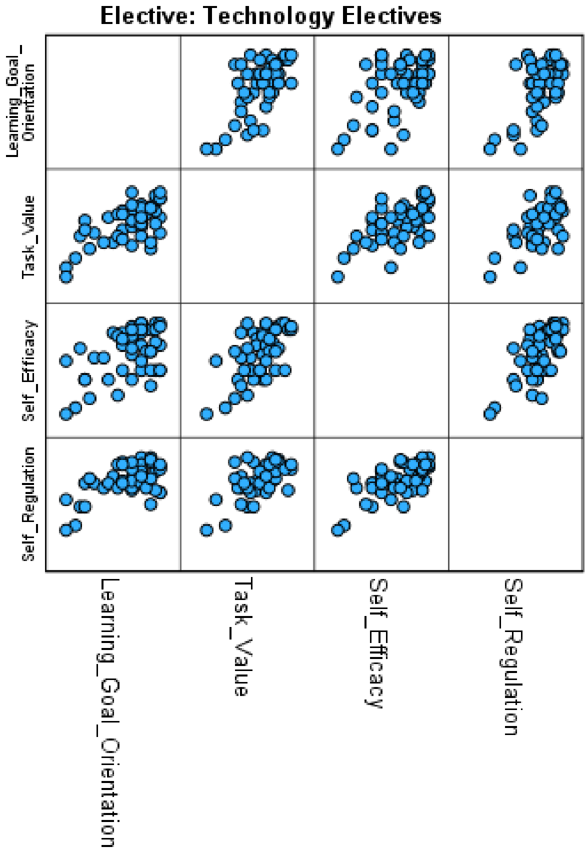
		Kolmogorov-Smirnov[a]		
	Elective	Statistic	*df*	Sig.
Learning Goal Orientation	Technology Electives	.188	49	<.001
	Non-Technology Electives	.121	87	.003
Task Value	Technology Electives	.118	49	.083
	Non-Technology Electives	.102	87	.027
Self-Efficacy	Technology Electives	.118	49	.087
	Non-Technology Electives	.084	87	.185
Self-Regulation	Technology Electives	.118	49	.086
	Non-Technology Electives	.073	87	.200*

Assumption of Linearity

The next assumption tests for MANOVA required data to be screened for linear relationships between the dependent variables for each group of independent variables. To ensure this scatter plot matrices were created for each elective type, non-technology electives and technology electives, and then examined to determine whether a linear relationship existed. Figures 2 and 3 show that there was a linear relationship between the 4 dependent variables.

Figure 2

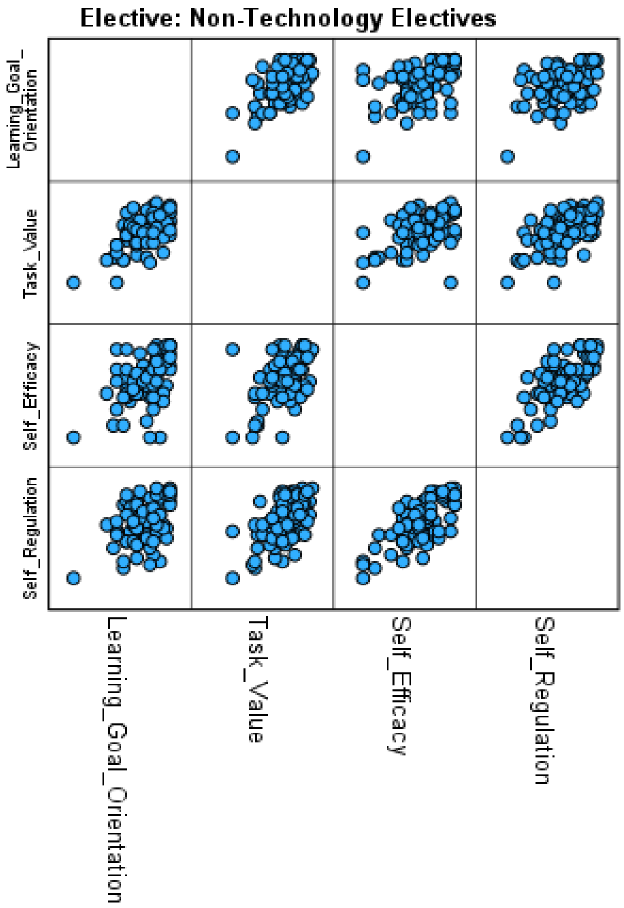
Scatterplot Matrix for Technology Electives



Note. Scatterplot matrix was used to examine the linear relationship between learning goal orientation, task value, self-efficacy, and self-regulation amongst students in technology electives.

Figure 3

Scatterplot Matrix for Non-Technology Electives



Note. Scatterplot matrix was used to examine the linear relationship between learning goal orientation, task value, self-efficacy, and self-regulation amongst students in non-technology electives.

Assumption of Multicollinearity

Once the data were tested for linear relationships, multicollinearity was tested with the Pearson correlation coefficient to determine the correlation strength between each of the 4 dependent variables. A correlation matrix between each of the four dependent variables was generated to ensure that Pearson's r was not above 0.8 for any pairs of variables. The correlation between learning goal orientation and task value was $r(136) = .629$, $p < 0.001$. The correlation between learning goal orientation and self-efficacy was $r(136) = .479$, $p < .001$. The correlation between learning goal orientation and self-regulation was $r(136) = .517$, $p < .001$. The correlation between task value and self-efficacy was $r(136) = .536$, $p < 0.001$. The correlation between task value and self-regulation was $r(136) = .583$, $p < .001$. The correlation between self-efficacy and self-regulation was $r(136) = .689$, $p < .001$. These correlations indicate a moderate positive correlation among the dependent variables where $r < 0.8$. Table 4 shows that this assumption of the absence of strong multicollinearity was met.

Table 4

Correlation Matrix

		Learning Goal Orientation	Task Value	Self-Efficacy	Self-Regulation
Learning Goal Orientation	Pearson Correlation	--			
	N	136			
Task Value	Pearson Correlation	.629**	--		
	Sig. (2-tailed)	<.001			
	N	136	136		
Self-Efficacy	Pearson Correlation	.472**	.536**	--	
	Sig. (2-tailed)	<.001	<.001		
	N	136	136	136	
Self-Regulation	Pearson Correlation	.517**	.583**	.689**	--
	Sig. (2-tailed)	<.001	<.001	<.001	
	N	136	136	136	136

**. Correlation is significant at the 0.01 level (2-tailed).

Note. Correlation matrix used to assess multicollinearity between learning goal orientation, task value, self-efficacy, and self-regulation.

Assumption of Homogeneity of Variance

To test for the assumption of homogeneity of variance, the researcher used Box's M test of equality of covariance. When using this test, the researcher looked for a *p*-greater than .001, which was found at $p = .102$. This indicated that the homogeneity of covariances had not been violated. Table 5 shows the results of Box's M test.

Table 5

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

Box's *M*	16.501
F	1.591
df1	10
df2	46737.398
Sig.	.102

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Elective

One-Way MANOVA Results

A one-way MANOVA was conducted to answer the research question. The results of the MANOVA are shown in Table 6, using Wilk's Lambda to report any statistical significance from between the groups if $p < .05$. There was no statistical difference between elective types and the dependent variables where F (4,131) = .983, $p < .419$; partial $\eta^2 = .029$. This indicated that there were no statistical differences found between electives. Results from the multivariate test are shown in Table 6.

Table 6

Wilks' Lambda Multivariate Test

Effect		Value	*F*	Hypothesis *df*	Error *df*	Sig.	Partial Eta Squared
Elective	Wilks' Lambda	.971	.983[b]	4.000	131.000	.419	.029

Since there was no statistical evidence between the groups, there was no need for post hoc testing, such as running multiple ANOVAs using Bonferroni's correction. The result of the multivariate test led the researcher to fail to reject the null hypothesis. Therefore, there was no statistical difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire.

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter presents the results of the data collected comparing technology students and non-technology students to determine if their scores in learning goal orientation, task value, self-efficacy, and self-regulation showed a difference between the two groups of students. A discussion will provide an overview of how the results of this study aligned with the theoretical framework and the literature. This discussion will lead to conclusions being made about the implications of the results of the current study and how it could impact educational stakeholders. Limitations are also discussed and their impacts on the results of the collected data. Finally, possible future research and studies are discussed in light of the results and the impact it could have on the fields of STEM education, self-efficacy, and middle school students.

Discussion

This quantitative, causal-comparative design aimed to examine the technology classes' effects on private middle school students' self-efficacy, self-regulation, task value, and goal orientation between students in technology electives and non-technology electives.

Research Question

RQ: Is there a difference between middle school technology elective students' and middle school non-technology elective students' self-efficacy scores, task-value scores, self-regulation scores, and learning goal orientation scores as measured by the Students' Adaptive Learning Engagement in Science Questionnaire?

The findings of this study addressed the research question by determining there was no statistical difference between students in technology electives and students in non-technology electives by comparing their scores on learning goal orientation, task value, self-efficacy, and self-regulation. There was no significance found where $p > 0.05$, and the null hypothesis was not rejected; therefore, the lack of statistical significance reported through a one-way MANOVA (see Table 6) revealed that there were no significant differences found between students in each elective in their learning engagement in science class. This could be due to the similar school, socioeconomic, and familial settings of the students involved in the current study and support other studies finding that many factors affect motivation and learning goal orientation (Aldridge & Rowntree, 2021; Zheng et al., 2020). Moreover, when comparing the independent variables of technology electives and non-technology electives similarities between groups of students were recorded with small variations between groups. Students from both groups had an average mean of 33.14 for learning goal orientation, 28.96 for task value, 31.165 for self-efficacy, and 30.285 for self-regulation 30.285. These data demonstrate that on average, students in all schools had a higher adaptive learning engagement and were above the median score of 20 in each of the categories. While many studies report statistical differences when related to technology implementation (Akcanca, 2020; Akcaoglu et al., 2021; Boda & Brown, 2020; & Galoyan et al., 2019), there are some that report no statistical significance between similar components related to the current study (Huang, 2022).

Additionally, analyses (See Table 4) revealed that a positive moderate correlation existed between dependent variables, the strongest being between self-efficacy and self-regulation. This suggests that students score closest between these variables and these variables have an impact on their learning engagement in science classrooms. Even positive moderate correlations between students' learning goal orientation, task, value, self-efficacy, and self-regulation create an understanding that they are each linked components between the independent variable and adaptive learning engagement (Velayutham et al., 2011; Webb-Williams, 2018). Webb-Williams

(2018) suggested that self-efficacy and self-regulation in particular have become more connected over the last two decades due to a shift in science to be more peer-led than ever before. Similarly, Soltani and Askarizadeh (2021) have suggested that the highest correlations between factors are between learning goal orientation and task value, with self-efficacy and self-regulation also having a strong correlation. This was similar to the current study as correlations were highest between the same two pairs of factors, but the current study had the highest connections between self-efficacy and self-regulation ($r(136) = .689$, $p < .001$). This was only slightly higher than task value and learning goal orientation ($r(136) = .629$, $p < 0.001$).

The beliefs students have about their own ability to learn in a school setting also impact their behaviors, or their ability to accomplish tasks successfully (Bandura, 1993; Eccles & Wigfield, 2002). Thus, by better understanding students' learning goal orientation, task value, self-efficacy, and self-regulation scores, educators can be better prepared to anticipate student behaviors that may impact their learning engagement in the science classroom. Although the null hypothesis failed to be rejected, the results of the current study suggest that the students in the current study believe they can set goals, giving tasks appropriate priority, think highly of their abilities and success, and can accomplish tasks with relative internal motivation (self-regulation). This was evidenced by above-average scores on each of the SALES Questionnaire subscales as seen by their means on each category (See Table 2).

Past studies in self-efficacy theory have shown that many variables affect students' self-efficacy and that as they age, their self-efficacy scores follow certain trends (Aldridge & Rowntree, 2021; Fahle et al., 2019). Moreover, studies on self-efficacy reveal that many more studies are required to fully understand it in the twenty-first century (McComas & Burgin, 2020). As reported in many studies, these data suggested that generalizations and impacts to practice were limited or not possible because of the inability to gain a randomized population (Soltani & Askarizadeh, 2021). The results of the current study corroborate others' findings that although self-efficacy, self-regulation, task value, and learning goal orientation are often related to and predictors of each other, there were no statistical differences found (Aldridge & Rowntree, 2021). This may suggest that a wider, more diverse sample population could show a statistical difference between the two elective groups in self-efficacy, learning goal orientation, task value, and self-regulation due to the extra-curricular factors that are too similar between private school students. Since all students were in private schools, the scores can be linked to the similarities that private schools have such as familial involvement, socioeconomic status, and often smaller school environments. These similarities amongst private school students can also lead to fewer issues in engagement and failing grades among students, leading to higher engagement scores amongst the current study's population.

While STEM education programs and technology integration have been shown in the literature to positively impact each of the dependent variables (Folberg & Kaboli, 2020; Leonard et al., 2018; Tsai et al., 2019; & Zheng et al., 2020), there have been STEM programs that have shown little impact on self-efficacy and learning engagement as well (Huang, 2022). Similarly, the results of this study, which failed to reject the null hypothesis, support other studies which also find there are no statistical differences between their groups in areas such as technology and science (Huang, 2022). Therefore, while no generalizations can be made due to the lack of statistical significance of the results, this study can still add to the literature, and provide implications, limitations, and suggestions for future research regarding self-efficacy, learning engagement, and the connections between science and technology education.

Implications

This study contributed to the body of research related to STEM education, self-efficacy, learning goal orientation, task value, and self-regulation. As the study sought to understand the impact technology classes could have upon learning goal orientation, task value, self-efficacy, and self-regulation, the lack of statistically different results between the two groups implied that there is more to these categorical scores than just elective placement as the two groups while exposed to different levels of technology, were still too similar in other variables such as family settings. Likewise, researchers have critiqued STEM education especially in reference to the differing levels of implementation within schools and the lack of a clear definition (Lesseig et al., 2019; Lykkegaard & Ulriksen, 2019; & McComas & Burgin, 2020). As teachers continue to implement new STEM curricula and technology initiatives, and as parents decide on which educational route to send their students, the current study can add to their understanding of technology's role in students' learning (Huang, 2022).

Many studies have also shown that self-efficacy is and has been impacted by familial, age, gender, and socioeconomic factors (Brown et al., 2016; Fahle et al., 2019; Haverback, 2020; Miles & Naumann, 2021; Namli & Aybek, 2022; Prewett & Whitney, 2021; Soland & Sandilos, 2021; Tomás et al., 2020; Tsai et al., 2019; & Webb-Williams, 2018), that are often not diverse enough among private school students. The similarities in the present study may be able to lead the researcher, and other educational stakeholders to understand that there is much more research necessary to determine if technology electives truly impact self-efficacy in any statistically different way. Impacts on self-efficacy as reported by the literature showed that the current study could only provide a snapshot of learning goal orientation, task value, self-efficacy, and self-regulation within these students since there were too many variables that could have affected this with such a similar population of students (Aldridge & Rowntree, 2021; Webb-Williams, 2018; Zheng et al., 2020)As students age, the literature indicates that their self-efficacy will change (Fahle et al., 2019), signifying that single results from one study are not enough to provide the generalizations and overarching information desired, but suggest a need for more studies in the areas of technology electives involving more coding, robotics, and creating items using technology (Huang, 2022).

Limitations

The differing levels of implementation of STEM programs and components in schools is one of the largest threats to the validity of any study related to STEM education (Mau & Li, 2018), or any combination of the four tenets. For this current study, the disparity in technology access between the three schools was one of the largest limitations and threats to internal validity. While not only comparing students' placement in technology classes, the researcher noticed that some students had access to robotics at one school, while some students reported not even having been taught typing skills at another school. Moreover, this study was conducted within a small sample of students within private schools in the area, in a small area of Florida, which could have a direct impact on generalizations made by the results of this study. This could have had significant impacts on the statistical power of the study and could have been the leading cause as to why the study yielded no statistical differences between types of elective classes. Larger, and more diverse, sample sizes should be utilized in future research to account for the limitations the data presented after analysis.

The statistical analysis revealed a limitation in that learning goal orientation violated the assumption of normality in both groups of students and for task value in non-technology elective students. Moreover, learning goal orientation data had an extreme outlier in the non-technology elective which was kept for transparency of results. Also, the scatterplot matrices revealed that there was a slightly less linear relationship between learning goal orientation and self-efficacy in students within technology electives. While the MANOVA is robust to violations of assumptions (Warner, 2013), it should be noted that these all limit the analysis that can be conducted with this data and the generalizations that could be made due to the reduced power of the results.

Recommendations for Future Research

Since the current study found that there was no significance between technology classes and non-technology classes, it was determined that there should be more research conducted related to the implementation of technology and its effects on science engagement, learning, and other content areas as well. The following are recommendations for future research:

1. A similar study should be conducted with a larger population within different private schools in the area to address any disparities within private school education and organization.
2. A similar study should be conducted comparing private, charter, and public schools to address disparities between the different entities and course offerings on learning engagement in science classrooms using a very similar methodology.
3. A quasi-experimental study should be conducted to compare the effects technology electives have on learning engagement in science classrooms at the beginning, middle, and end of the same school year.
4. A case study could be conducted to compare different schools’ implementations of technology electives and its effects on learning engagement in science classrooms between the two schools.

5. A similar instrument could be developed to compare learning engagement in other content areas and then run a similar study based on each of the content areas and compare the results between each content area and technology electives' effect on their learning engagement.
6. Another instrument should be made to be able to determine students' learning engagement in technology classes as well.

REFERENCES

Akcanca, N. (2020). 21st-century skills: The predictive role of attitudes regarding STEM education and problem-based learning. *International Journal of Progressive Education, 16*(5), 443-458. http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2F21st-century-skills-predictive-role-attitudes%2Fdocview%2F2488223492%2Fse-2%3Faccountid%3D12085

Akcaoglu, M., Rosenberg, J. M., Hodges, C. B., & Hilpert, J. C. (2021). An exploration of factors impacting middle school students' attitudes toward computer programming. *Computers in the Schools*, *38*(1), 19–35. https://doi.org/10.1080/07380569.2021.1882209

Aldridge, J. M., Rowntree, K. (2021). Investigating relationships between learning environment perceptions, motivation and self-regulation for female science students in Abu Dhabi, United Arab Emirates. *Research in Science Education*. https://doi-org.ezproxy.liberty.edu/10.1007/s11165-021-09998-2

Alvarado, S. E., & Muniz, P. (2018). Racial and ethnic heterogeneity in the effect of MESA on AP STEM coursework and college STEM major aspirations. *Research in Higher Education*, *59*(7), 933-957. https://doi.org/10.1007/s11162-018-9493-3

Ames, C. A. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psycho*logy, *84*, 261–271. https://doi.org/10.1037/0022- 0663.84.3.261.

Ayuso, N., Fillola, E., Masia, B., Murillo, A. C., Trillo-Lado, R., Baldassarri, S., Cerezo, E., Ruberte, L., Mariscal, M. D., & Villarroya-Gaudo, M. (2021). Gender gap in STEM: A cross-sectional study of primary school students' self-perception and test anxiety in mathematics. *IEEE Transactions on Education*, *64*(1), 40–49. https://doi.org/10.1109/TE.2020.3004075

Ballenger, C. (2019). Reframing the achievement gap: Lessons from puzzling students. *Reading Teacher*, *73*(2), 141–147. https://doi.org/10.1002/trtr.1810

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117–148. doi:10.1207/s15326985ep2802_3

Barak, M., & Yehiav, R. (1994). Advancement of low achievers within technology studies at high school. *Research in Science & Technological Education*, *12*(2), 175. https://doi.org/10.1080/0263514940120206

Baran, E., Canbazoglu Bilici, S., Mesutoglu, C., & Ocak, C. (2019). The impact of an out-of-school STEM education program on students' attitudes toward STEM and STEM careers. *School Science & Mathematics*, *119*(4), 223–235. https://doi.org/10.1111/ssm.12330

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education*. ProQuest Ebook Central https://ebookcentral-proquest-com.ezproxy.liberty.edu

Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2019). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching*, *56*(1), 3–23. https://doi.org/10.1002/tea.21465

Betancur, L., Votruba-Drzal, E., & Schunn, C. (2018). Socioeconomic gaps in science achievement. *International Journal of STEM Education*, *5*.

Bippert, K., & Harmon, J. (2017). Middle School Teachers' Perceptions of Computer-Assisted Reading Intervention Programs. *Reading Psychology*, *38*(2), 203–230. https://doi.org/10.1080/02702711.2016.1245691

Boda, P. A., & Brown, B. (2020). Designing for Relationality in Virtual Reality: Context-Specific Learning as a Primer for Content Relevancy. *Journal of Science Education & Technology*, *29*(5), 691–702. https://doi.org/10.1007/s10956-020-09849-1

Boulden, D. C., Rachmatullah, A., Oliver, K. M., & Wiebe, E. (2021). Measuring in-service teacher self-efficacy for teaching computational thinking: development and validation of the T-STEM CT. *Education & Information Technologies*, *26*(4), 4663–4689. https://doi.org/10.1007/s10639-021-10487-2

Braund, M. (2021). Critical STEM literacy and the COVID-19 pandemic. *Canadian Journal of Science, Mathematics & Technology Education, 21*(2), 339–356. https://doi.org/10.1007/s42330-021-00150-w

Brown, P. C., Roediger, H. L., III, & McDaniel, M. A. (2014). Make it stick: The science of successful learning. The Belknap Press of Harvard University Press.

Brown, P. L., Concannon, J. P., Marx, D., Donaldson, C. W., & Black, A. (2016). An examination of middle school students' stem self-efficacy with relation to interest and perceptions of STEM. *Journal of STEM Education: Innovations & Research*, *17*(3), 27–38

Carlisle, D. L., & Weaver, G.C. (2018). STEM education centers: Catalyzing the improvement of undergraduate STEM education. *International Journal of STEM Education*, *5*(1), 1-21. https://doi.org/10.1186/s40594-018-0143-2

Casad, B. J., Petzel, Z. W., & Ingalls, E. A. (2019). A model of threatening academic environments predicts women STEM majors' self-esteem and engagement in STEM. *Sex Roles, 80*(7-8), 469-488. https://doi-org.ezproxy.liberty.edu/10.1007/s11199-018-0942-4

Casey, J., Gill, P., Pennington, L., & Mireles, S. V. (2018). Lines, roamers, and squares: Oh my! using floor robots to enhance Hispanic students' understanding of programming. *Education & Information Technologies*, *23*(4), 1531–1546. https://doi-org.ezproxy.liberty.edu/10.1007/s10639-017-9677-z

Casto, A. R., & Williams, J. A. (2020). Seeking proportionality in the North Carolina STEM pipeline. *High School Journal*, *103*(2), 77–98. https://doi.org/10.1353/hsj.2020.0004

Çevik, M. (2018). Impacts of the project based (PBL) science, technology, engineering and mathematics (STEM) education on academic achievement and career interests of vocational high school students. *Pegem Egitim Ve Ogretim Dergisi = Pegem Journal of Education and Instruction, 8*(2), 281-306.

Cheng, L., Antonenko, P., Ritzhaupt, A. D., & MacFadden, B. (2021). Exploring the role of 3D printing and STEM integration levels in students' STEM career interest. *British Journal of Educational Technology*, *52*(3), 1262–1278. https://doi.org/10.1111/bjet.13077

Chipangura, A., & Aldridge, J. (2017). Impact of multimedia on students' perceptions of the learning environment in mathematics classrooms. *Learning Environments Research, 20*(1), 121-138. http://dx.doi.org/10.1007/s10984-016-9224-7

Çoban, E., & Kamis, Ö. (2019). Investigation of affective and socioeconomic variables predicting the achievement level of low- and high-achieving students. *Journal of Educational Issues*, *5*(1), 209–225.

Collie, R. J., Martin, A. J., Bobis, J., Way, J., & Anderson, J. (2019). How students switch on and switch off in mathematics: exploring patterns and predictors of (dis)engagement across middle school and high school. *Educational Psychology*, *39*(4), 489–509. https://doi.org/10.1080/01443410.2018.1537480

Creswell, J.W. & Guetterman, T.C. (2019). *Educational research: Planning, conducting, and evaluating quantitative and qualitative Research (6th ed.)*. Pearson.

Curran, F. C., & Kitchin, J. (2019). Why are the early elementary race/ethnicity test score gaps in science larger than those in reading or mathematics? National evidence on the importance of language and immigration context in explaining the gap-in-gaps. *Science Education*, *103*(3), 477–502. https://doi-org.ezproxy.liberty.edu/10.1002/sce.21491

Darling-Aduana, J., & Heinrich, C. J. (2018). The role of teacher capacity and instructional practice in the integration of educational technology for emergent bilingual students. *Computers & Education*, (*126*)417–432. https://doi.org/10.1016/j.compedu.2018.08.002

Demir, C. G., Önal, N. T., & Önal, N. (2021). Investigation of middle school students' attitudes towards science, technology, engineering and mathematics (STEM) education and determination of the predictors. *Journal of Science Learning*, *4*(2), 101-112. https://go.openathens.net/redirector/liberty.edu?url=https://www.proquest.com/scholarly-journals/investigation-middle-school-students-attitudes/docview/2540404990/se-2

Donalson, K., & Halsey, P. (2020). Adolescent readers’ perceptions of remedial reading classes: A case study. *Reading Improvement*, *57*(4), 187–196.

Eccles, J. (1983). “Expectancies, values, and academic behaviors”. In *Achievement and achievement motives*, Edited by: Spence, J. T. 75–146. San Francisco: Freeman.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109–132. https://doi.org/10.1146/annurev. psych.53.100901.135153

Fahle, E. M., Lee, M. G., Loeb, S., & Stanford University, P. A. for C. E. (PACE). (2019). A middle school drop: consistent gender differences in students’ self-efficacy. Working Paper. *In Policy Analysis for California Education, PACE*. Policy Analysis for California Education, PACE.

Folberg, A. M., & Kaboli, N. S. (2020). A mixed method examination of gender differences in perceptions of STEM among Iranian Americans. *Journal of Social Issues*, *76*(3), 543–576. https://doi.org/10.1111/josi.12393

Gall, M. D., Gall, J., & Borg, W. (2007). *Educational research: An introduction (8th ed.).* Pearson.

Galoyan, T., Barany, A., Donaldson, J. P., Ward, N., & Hammrich, P. (2022). Connecting science, design thinking, and computational thinking through sports. *International Journal of Instruction*, *15*(1), 601–618. https://doi.org/10.29333/iji.2022.15134a

Galoyan, T., Talafian, H., Hammrich, P., & Lamberson, L. (2019). Designing experiential learning environments in STEM. *Progress in Education*, 59. Nova Science Publishers.

Garza, T., Huerta, M., Tong, F., Lara-Alecio, R., & Irby, B. J. (2019). A survival analysis of a language-infused science inquiry intervention for English learners. *Journal of Educational Research*, *112*(3), 377–384. https://doi.org/10.1080/00220671.2018.1536965

Green, S. B., & Salkind, N.J. (2017). *Using SPSS for Windows and Macintosh: Analyzing and understanding the data* (8th ed.). New York, NY: Pearson Education, Inc.

Güdel, K., Heitzmann, A., & Müller, A. (2019). Self-efficacy and (vocational) interest in technology and design: An empirical study in seventh and eighth-grade classrooms. *International Journal of Technology & Design Education*, *29*(5), 1053–1081. https://doi.org/10.1007/s10798-018-9475-y

Haverback, H. R. (2020). Middle level teachers quarantine, teach, and increase self-efficacy beliefs: Using theory to build practice during COVID-19. *Middle Grades Review*, *6*(2).

Heliawati, L., Afakillah, I. I., & Pursitasari, I. D. (2021). Creative problem-solving learning through open-ended experiment for students' understanding and scientific work using online learning. *International Journal of Instruction, 14*(4).

Herro, D., Quigley, C., & Jacques, L. A. (2018). Examining technology integration in middle school STEAM units. *Technology, Pedagogy & Education*, *27*(4), 485–498. https://doi.org/10.1080/1475939X.2018.1514322

Hill, E. M., Anderson, L., Finley, B., Hillyard, C., & Kochanski, M. (2019). A Student-Centered Approach to Identifying Strategies and Obstacles to Learning for Undergraduate STEM Courses. *Journal of STEM Education: Innovations & Research*, *20*(1), 25–36.

Huang, W. (2022). Examining the impact of head-mounted display virtual reality on the science self-efficacy of high schoolers. *Interactive Learning Environments*, *30*(1), 100–112. https://doi.org/10.1080/10494820.2019.1641525

Hughes-Roberts, T., Brown, D., Standen, P., Desideri, L., Negrini, M., Rouame, A., Malavasi, M., Wager, G., & Hasson, C. (2019). Examining engagement and achievement in learners with individual needs through robotic-based teaching sessions. *British Journal of Educational Technology, 50*(5), 2736-2750. https://doi.org/10.1111/bjet.12722

İlter, İ. (2021). The relationship between academic amotivation and academic achievement: A Study on middle school students. *Journal of Theoretical Educational Science / Kuramsal Eğitimbilim Dergisi*, *14*(3), 389–410. https://doi.org/10.30831/akukeg.847145

Johnson, E. K. (2019). Waves: Scaffolding self-regulated learning to teach science in a whole-body educational game. *Journal of Science Education & Technology*, *28*(2), 133–151. https://doi.org/10.1007/s10956-018-9753-1

Joyner, R. L., Rouse, W. A., & Glatthorn. A. A. (2018). *Writing the winning thesis or dissertation (4th ed.).* Corwin: A SAGE Publishing Company.

Judson, E. (2014). Effects of transferring to stem-focused charter and magnet schools on student achievement. *Journal of Educational Research*, *107*(4), 255–266.

Julià, C., & Antolí, J. Ò. (2019). Impact of implementing a long-term STEM-based active learning course on students' motivation. *International Journal of Technology & Design Education*, *29*(2), 303–327. https://doi.org/10.1007/s10798-018-9441-8

Kanadli, S. (2019). A meta-summary of qualitative findings about STEM education. International Journal of Instruction, 12(1), 959-976.

Kaplan, A., Lichtinger, E. and Gorodetsky, M. (2009). Achievement goal orientations and self-regulation in writing: An integrative perspective. *Journal of Educational Psychology,* 101: 51–69.

Kurt, M., & Benzer, S. (2020). An investigation on the effect of STEM practices on sixth grade students' academic achievement, problem solving skills, and attitude towards STEM. *Journal of Science Learning, 3*(2), 79-88. https://doi.org/10.17509/jsl.v3i2.21419

LaForce, M., Zuo, H., Ferris, K., & Noble, E. (2019). Revisiting race and gender differences in STEM: Can inclusive STEM high schools reduce gaps? *European Journal of STEM Education*, *4*(1). https://files.eric.ed.gov/fulltext/EJ1222747.pdf

Lent, R. W., Sheu, H. B., Miller, M. J., Cusick, M. E., Penn, L. T., & Truong, N. N. (2018). Predictors of science, technology, engineering, and mathematics choice options: A meta-analytic path analysis of the social-cognitive choice model by gender and race/ethnicity. *Journal of Counseling Psychology*, *65*(1), 17–35. https://doi-org.ezproxy.liberty.edu/10.1037/cou0000243

Leonard, J., Mitchell, M., Barnes-Johnson, J., Unertl, A., Outka-Hill, J., Robinson, R., & Hester-Croff, C. (2018). Preparing teachers to engage rural students in computational thinking through robotics, game design, and culturally responsive teaching. *Journal of Teacher Education*, *66*(4), 386–407. https://doi.org/10.1177/0022487117732317

Lesseig, K., Firestone, J., Morrison, J., Slavit, D., & Holmlund, T. (2019). An analysis of cultural influences on STEM schools: Similarities and differences across K-12 contexts. International Journal of Science and Mathematics Education, 17(3), 449-466. https://doi.org/10.1007/s10763-017-9875-6

Liao, J., Yang, J., & Zhang, W. (2021). The student-centered STEM learning model based on artificial intelligence project: A case study on intelligent car. *International Journal of Emerging Technologies in Learning*, *16*(21), 100–120. https://doi.org/10.3991/ijet.v16i21.25001

Lie, R., Selcen Guzey, S., & Moore, T. J. (2019). Implementing engineering in diverse upper elementary and middle school science classrooms: Student learning and attitudes. *Journal* *of Science Education & Technology*, *28*(2), 104–117. https://doi.org/10.1007/s10956-018-9751-3

Lin, K., Hsiao, H., Williams, J., & Chen, Y. (2019). Effects of 6E-oriented STEM practical activities in cultivating middle school students' attitudes toward technology and technological inquiry ability. *Research in Science and Technological Education, 38(*1), 1-18. https://doi-org.ezproxy.liberty.edu/10.1080/02635143.2018.1561432

Liu, M., Shi, Y., Pan, Z., Li, C., Pan, X., & Lopez, F. (2021). Examining middle school teachers' implementation of a technology-enriched problem-based learning program: Motivational factors, challenges, and strategies. *Journal of Research on Technology in Education*, *53*(3), 279–295. https://doi.org/10.1080/15391523.2020.1768183

Lockwood, J., & Mooney, A. (2017). Computational thinking in education: Where does it fit? A systematic literary review. https://arxiv.org/abs/1703.07659

Lykkegaard, E., & Ulriksen, L. (2019). In and out of the STEM pipeline – a longitudinal study of a misleading metaphor. *International Journal of Science Education*, *41*(12), 1600–1625. https://doi.org/10.1080/09500693.2019.1622054

MacDonald, A., Huser, C., Shukla, S., & Lena, D. (2020). Effective Early Childhood STEM Education: Findings from little scientists' evaluation. *Early Childhood Education Journal*, *48*(3), 353-363. http://dx.doi.org/10.1007/s10643-019-01004-9

Mantooth, R., Usher, E. L., & Love, A. M. A. (2021). Changing classrooms bring new questions: environmental influences, self-efficacy, and academic achievement. *Learning Environments Research*, *24*(3), 519–535. https://doi.org/10.1007/s10984-020-09341-y

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*(4), 370–396. https://doi.org/10.1037/h0054346

Mau, W. J., & Li, J. (2018). factors influencing STEM career aspirations of underrepresented high school students. *Career Development Quarterly*, *66*(3), 246–258. https://doi.org/10.1002/cdq.12146

McComas, W. F., & Burgin, S. R. (2020). A critique of "STEM" education: Revolution-in-the-making, passing fad, or instructional imperative? *Science & Education*, *29*(4), 805–829. https://doi.org/10.1007/s11191-020-00138-2

Mertens, D. M., & McLaughlin, J. A. (2004). Other quantitative approaches: causal comparative, correlational, single-case, and survey research. In *Research and evaluation methods in special education* (pp. 69-93). SAGE Publications, Inc., https://dx.doi.org/10.4135/9781412985666

Micari, M., & Pazos, P. (2021). Beyond grades: improving college students' social-cognitive outcomes in STEM through a collaborative learning environment. *Learning Environments Research*, *24*(1), 123–136. https://doi.org/10.1007/s10984-020-09325-y

Midgley., C. (2002). *Goals, goal structures, and patterns of adaptive learning*. Routledge.

Miles, J. A., & Naumann, S. E. (2021). Science self-efficacy in the relationship between gender & science identity. *International Journal of Science Education*, *43*(17), 2769–2790. https://doi.org/10.1080/09500693.2021.1986647

Mutegi, J. W., Sorge, B., Fore, G. A., & Gibau, G. S. (2019). A tale of two camps: A mixed methods investigation into racially disparate outcomes in a nanotechnology research experience. *Science Education, 103*(6), 1456–1477. https://doi-org.ezproxy.liberty.edu/10.1002/sce.21548

Namli, N. A., & Aybek, B. (2022). An investigation of the effect of block-based programming and unplugged coding activities on fifth graders' computational thinking skills, self-efficacy and academic performance. *Contemporary Educational Technology*, *14*(1), 1–16. https://doi.org/10.30935/cedtech/11477

Önal, N., & Demir, C. G. (2017). The use of the interactive whiteboard in mathematics and mathematics lessons from the perspective of turkish middle school students. *International Journal of Higher Education*, *6*(3), 195-208. https://go.openathens.net/redirector/liberty.edu?url=https://www.proquest.com/scholarly-journals/use-interactive-whiteboard-mathematics-lessons/docview/1969017600/se-2

Patel, N. H., Franco, M. S., & Daniel, L. G. (2019). Student engagement and achievement: A comparison of STEM schools, STEM programs, and non-STEM settings. *Research in the Schools*, *26*(1), 1-11. http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fstudent-engagement-achievement-comparison-stem%2Fdocview%2F2352139640%2Fse-2%3Faccountid%3D12085

Pintrich, P. R. (2000). “The role of goal orientation in self-regulated learning”. In *Handbook of self-regulation*, Edited by: Boekaerts, M., Pintrich, P. R. and Zeidner, M. 451–502. San Diego, CA: Academic Press.

Pintrich, P.R., & De Groot, E.V. (1990). Motivational and self-regulated learning components of learning and teaching contexts. *Journal of Educational Psychology*, 92, 33-40.

Pintrich, P. R., Smith, D. A., Garcia, T., & McKeachie, W. J. (1991). A manual for the use of the motivated strategies for learning questionnaire (MSLQ) (Technical Report No. 91- B-0004). Ann Arbor, MI: National Center for Research to Improve Postsecondary Teaching and Learning.

Prewett, S. L., & Whitney, S. D. (2021). The relationship between teachers' teaching self-efficacy and negative affect on eighth grade U.S. students' reading and math achievement. *Teacher Development*, *25*(1), 1–17. https://doi.org/10.1080/13664530.2020.1850514

Ramaley, J. A., Olds, B. M., & Earle, J. (2005). Becoming a learning organization: New directions in science education research at the national science foundation. *Journal of Science Education & Technology*, *14*(2), 173–189. https://doi-org.ezproxy.liberty.edu/10.1007/s10956-005-4420-8

Rheinberg, F., Vollmeyer, R., & Rollett, W. (2012). Motivation and action in self-regulated learning. *Handbook of Self-regulation*. 10.1016/B978-012109890-2/50044-5

Romo, H. D., Thomas, K. J. A., & García, E. E. (2018). Changing demographics of dual language learners and English learners: Implications for school success. *Social Policy Report*, 31(2), 1–35. https://doi-org.ezproxy.liberty.edu/10.1002/j.2379-3988.2018.tb00028.x

Ryoo, K. (2015). Teaching science through the language of students in technology-enhanced instruction. *Journal of Science Education & Technology*, *24*(1), 29–42. https://doi.org/10.1007/s10956-014-9518-4

Saraç, H. (2018). The effect of science, technology, engineering and mathematics-STEM educational practices on students' learning outcomes: A meta-analysis study. *Turkish Online Journal of Educational Technology - TOJET*, *17*(2), 125-142. https://go.openathens.net/redirector/liberty.edu?url=https://www.proquest.com/scholarly-journals/effect-science-technology-engineering-mathematics/docview/2101589656/se-2

Sasson, I. (2019). Participation in research apprenticeship program: Issues related to career choice in STEM. *International Journal of Science & Mathematics Education*, *17*(3), 467–482. https://doi.org/10.1007/s10763-017-9873-8

Schneiderwind, J., & Johnson, J. M. (2020). Disability and invisibility in STEM education. *Journal of Higher Education Theory and Practice, 20*(14), 101-104. http://ezproxy.liberty.edu/login?qurl=https%3A%2F%2Fwww.proquest.com%2Fscholarly-journals%2Fdisability-invisibility-stem-education%2Fdocview%2F2492329189%2Fse-2%3Faccountid%3D12085

Schunk, D. (2020). *Learning Theories: An educational perspective* (8th ed.). Pearson.

Scott-Parker, B., & Barone-Nugent, E. (2019). Enlightening STEM engagement during high school - make it real banana peel. *Journal of STEM Education: Innovations & Research*, *20*(1), 5–10. https://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=139832861&site=ehost-live&scope=site

Shekhar, P., Borrego, M., DeMonbrun, M., Finelli, C., Crockett, C., & Nguyen, K. (2020). Negative student response to active learning in STEM classrooms: A systematic review of underlying reasons. *Journal of College Science Teaching*, *49*(6), 45–54.

Shu, Y., & Huang, T.-C. (2021). Identifying the potential roles of virtual reality and STEM in Maker education. *Journal of Educational Research*, *114*(2), 108–118. https://doi.org/10.1080/00220671.2021.1887067

Skrentny, J. D., & Lewis, K. (2022). Beyond the “STEM pipeline”: Expertise, careers, and lifelong learning. *Minerva: A Review of Science, Learning & Policy*, *60*(1), 1–28. https://doi.org/10.1007/s11024-021-09445-6

Soland, J., & Sandilos, L. E. (2021). English language learners, self-efficacy, and the achievement gap: Understanding the relationship between academic and social-emotional growth. *Journal of Education for Students Placed at Risk, 26*(1), 20-44. http://dx.doi.org.ezproxy.liberty.edu/10.1080/10824669.2020.1787171

Soltani, A., & Askarizadeh, G. (2021). How students' conceptions of learning science are related to their motivational beliefs and self-regulation. *Learning & Motivation*, *73*, N.PAG. https://doi.org/10.1016/j.lmot.2021.101707

Sondergeld, T. A., Provinzano, K., & Johnson, C. C. (2020). Investigating the impact of an urban community school effort on middle school STEM-related student outcomes over time through propensity score matched methods. *School Science and Mathematics*, *120*(2), 90–103.

Stewart, J., Henderson, R., Michaluk, L., Deshler, J., Fuller, E., & Rambo-Hernandez, K. (2020). Using the social cognitive theory framework to chart gender differences in the developmental trajectory of STEM self-efficacy in science and engineering students. *Journal of Science Education & Technology*, *29*(6), 758–773. https://doi.org/10.1007/s10956-020-09853-5

Tomás, J. M., Gutiérrez, M., Georgieva, S., & Hernández, M. (2020). The effects of self-efficacy, hope, and engagement on the academic achievement of secondary education in the Dominican Republic. *Psychology in the Schools*, *57*(2), 191–203. https://doi.org/10.1002/pits.22321

Trochim, W. M., & Donnelly, J. P. (2006). The research methods knowledge base (3rd ed.). Cincinnati, OH: Atomic Dog.

Tsai, M.-J., Wang, C.-Y., & Hsu, P.-F. (2019). developing the computer programming self-efficacy scale for computer literacy education. *Journal of Educational Computing Research*, *56*(8), 1345–1360. https://doi.org/10.1177/0735633117746747

Ugras, M. (2018). The effects of STEM activities on stem attitudes, scientific creativity and motivation beliefs of the students and their views on STEM education. *International Online Journal of Educational Sciences*, *10*(5), 165–182. https://doi.org/10.15345/iojes.2018.05.012

Ugras, M. (2019). Determination of the effects of problem-based STEM activities on certain variables and the views of the students. *International Online Journal of Educational Sciences, 11*(1), 1–22. https://doi.org/10.15345/iojes.2019.01.001

Usengül, L., & Bahçeci, F. (2020). The effect of LEGO WeDo 2.0 education on academic achievement and attitudes and computational thinking skills of learners toward science. *World Journal of Education, 10*(4), 83-93. https://go.openathens.net/redirector/liberty.edu?url=https://www.proquest.com/scholarly-journals/effect-lego-wedo-2-0-education-on-academic/docview/2458999620/se-2

van den Hurk, A., Meelissen, M., & van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education*, *41*(2), 150–164. https://doi.org/10.1080/09500693.2018.1540897

Velayutham, S., Aldridge, J., & Fraser, B. (2011). Development and validation of an instrument to measure students' motivation and self-regulation in science learning. *International Journal of Science Education, 33*(15), 2159-2179. doi: 10.1080/09500693.2010.541529

Vennix, J., den Brok, P., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? International

Journal of Science Education, 40(11), 1263-1283. https://doiorg.ezproxy.liberty.edu/10.1080/09500693.2018.1473659

Vinni-Laakso, J., Guo, J., Juuti, K., Loukomies, A., Lavonen, J., & Salmela-Aro, K. (2019). The relations of science task values, self-concept of ability, and STEM aspirations among Finnish students from first to second grade. *Frontiers in Psychology*, *10*, 1449. https://doi-org.ezproxy.liberty.edu/10.3389/fpsyg.2019.01449

Wang, M.-T., & Degol, J. (2017). Gender Gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29*(1), 119–140. https://doi.org/10.1007/s10648-015-9355-x

Warner, R. (2013). *Applied statistics: From bivariate through multivariate techniques (2nd ed.).* Sage Publications.

Webb-Williams, J. (2018). Science self-efficacy in the primary classroom: using mixed methods to investigate sources of self-efficacy. *Research in Science Education*, *48*(5), 939–961. https://doi.org/10.1007/s11165-016-9592-0

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology*, *25*(1), 127-147.

Wille, E., Stoll, G., Gfrörer, T., Cambria, J., Nagengast, B., & Trautwein, U. (2020). It takes two: expectancy-value constructs and vocational interests jointly predict STEM major choices. *Contemporary Educational Psychology*, *61*(April), 101857–101858. https://doi-org.ezproxy.liberty.edu/10.1016/j.cedpsych.2020.101858.

Wu, X., Deshler, J., & Fuller, E. (2018). The effects of different versions of a gateway STEM course on student attitudes and beliefs. International Journal of STEM Education, 5(1), 1-12. http://dx.doi.org.ezproxy.liberty.edu/10.1186/s40594-018-0141-4

Xu, C., Smerdon, J. E., DeFries, R., & Unwin-Kuruneri, N. (2020). Sustainability education as a pathway to minority participation in STEM. New Directions for Teaching and Learning, *2020*(161), 139-154. https://doi-org.ezproxy.liberty.edu/10.1002/tl.20378

Young, J., Ortiz, N., & Young, J. (2017). STEMulating interest: A meta-analysis of the effects of out-of-school time on student STEM interest. *International Journal of Education in Mathematics, Science and Technology*, *5*(1), 62–74. https://doi-org.ezproxy.liberty.edu/10.18404/ijemst.61149

Zheng, J., Xing, W., Zhu, G., Chen, G., Zhao, H., & Xie, C. (2020). Profiling self-regulation behaviors in STEM learning of engineering design. *Computers & Education*, *143,* N.PAG. https://doi.org/10.1016/j.compedu.2019.103669

Zimmerman, B. J. (1989). A social cognitive view of self-regulated learning. *Journal of Educational Psychology*, *81*, 329-339.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, 25: 82–91.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*, 64–70. https://doi.org/10.1207/s15430421tip4102_2.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45,* 166–183. https://doi.org/10.3102/0002831207312909.

APPENDIX

SALES Questionnaire removed to comply with copyright.

Velayutham, S., Aldridge, J., & Fraser, B. (2011). Development and validation of an instrument to measure students' motivation and self-regulation in science learning. *International Journal of Science Education, 33*(15), 2159-2179. doi: 10.1080/09500693.2010.541529

Parental Opt-Out

Title of the Project: Technology Elective Classes' Effects on Middle School Students' Self-Efficacy and Learning Engagement in Science
Principal Investigator: Rebecca Farrell, Ph.D. Candidate, Liberty University

Invitation to be Part of a Research Study

Your child is invited to participate in a research study. Participants must be enrolled full-time in the 7th or 8th grades in their private middle school and must have been enrolled since the start of the school year. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to allow your child to take part in this research project.

What is the study about and why are we doing it?

The purpose of the study is to see if technology classes influence middle school private students' motivation and engagement in science classes. These classes include anything where students are asked to use technology to create something or use technology to solve problems.

What will participants be asked to do in this study?

If you agree to allow your child to be in this study, I will ask him or her to complete a questionnaire in science class. This should take approximately 20-30 minutes.

How could participants or others benefit from this study?

Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include being able to add to what educators already know about science and technology education, and students' motivation. Also, this study could lead to further research related to the overall effects technology electives have in science classes and provide educators with research-based data to make decisions about science and technology education.

What risks might participants experience from being in this study?

The risks involved in this study are minimal, which means they are equal to the risks your child would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses to the paper questionnaire will be kept anonymous and all data will be kept secure.
- Data will be stored on a password-locked computer. Hard copies of data will be stored in a locked filing cabinet located in a locked closet. After three years, all electronic records will be deleted, and paper documents will be shredded.

How will participants be compensated for being part of the study?

Participants will be compensated for participating in this study. Your child will be offered a school-approved snack (chips, candy, chocolate) once they are done with the questionnaire.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether to allow your child to participate will not affect your or his or her current or future relations with Liberty University. If you decide to allow your child to participate, he or she is free to not answer any question or withdraw at any time prior to submitting the questionnaire without affecting those relationships.

What should be done if a participant wishes to withdraw from the study?

If you choose to withdraw your child from the study or your child chooses to withdraw, please inform the researcher that you wish to discontinue his or her participation, and your child should not submit the study materials. Your child's responses will not be recorded or included in the study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Rebecca Farrell. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her. You may also contact the researcher's faculty sponsor, Dr. Constance Pearson.

Whom do you contact if you have questions about rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515, or email at irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University

Your Opt-Out

If you would prefer that your child **NOT PARTICIPATE** in this study, please sign this document, and return it to your child's science teacher one day before the date of the questionnaire.

____
Printed Child's/Student's Name

____
Parent/Guardian's Signature   Date

The following is the parent introductory letter sent home with the parent opt out forms.

Dear Parents,

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree in curriculum and instruction. I also hold a Bachelor of Science in Pre-medicine and a master's degree in middle-level science education. I am a Pennsylvania and Florida certified middle school science teacher and I wish to focus most of my future research on Science and Technology Education. I grew up in a private school and am still very active in my local church. My passion for ensuring Christian education is still a viable option for families, and the improvement of science and technology education led me to this current study's focus.

The purpose of my research is to see if technology classes influence middle school students' motivation and engagement in science classes, and I am writing to invite eligible participants to join my study.

Participants must be enrolled at school full-time in their private middle school in 7th or 8th grade and must have been enrolled since the start of the school year. Participants, if willing, will be asked to answer a questionnaire related to their learning engagement and motivation in science class. It should take approximately 20 to 30 minutes to complete the questionnaire. Participation will be completely anonymous, and no personal, identifying information will be collected.

To participate, please first review the parental opt-out form for your child. If you choose not to have your child participate, please sign the form and submit it to their science teacher. Students will be taking the questionnaire in science class. Please feel free to contact me or your child's teacher with any questions or concerns.

A consent form is attached. The consent document contains additional information about my research. If you choose not to have your child participate, please sign the form and return it to your child's science teacher one day before your teacher administers the questionnaire. All students who participate in the study will be given their choice of a school-approved snack.

Sincerely,

Rebecca Farrell