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Making eLearning Engaging: The Effect of Technology Strategies on Student Engagement and Content Knowledge Development in a Secondary Mathematics Digital Classroom

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DEDICATION

This dissertation is dedicated to my parents, Cathleen and John Knapp, who have taught me the life skills and work ethic necessary to persevere through my education – from kindergarten to my Ed.D. Thank you for your continual support and for listening to my long and painful phone calls about my dissertation. This dissertation is also dedicated to Danielle, who has believed in me and inspired me to push past my limits. Thank you for loving me (and giving me space) throughout the endless hours of researching, writing, and revising. Thank you for also telling me to take a break when I have reached my limit. Your heart and strength amaze me.

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ABSTRACT

This action research study employed a mixed-methods design to examine the effect of technology strategies on secondary students' engagement and development of geometry content knowledge in an eLearning setting. Seeking to understand student preferences of the technology tools, this two-week study was conducted during a geometry unit on quadrilaterals and employed the following technology tools: student response systems (SRS), computer-assisted instruction (CAI), gamification, and teacher-made screencasts. Quantitative data was collected on student engagement, the usefulness of the technology, and student self-efficacy through a Likert-scale survey after each day of using technology. Qualitative data were collected through purposeful interviews with students on engagement, perceived usefulness of the technology, and ease of use. All data were collected electronically through Canvas, an online learning management system, and all interviews were conducted through WebEx, a video conferencing system. The data were blended in a triangulation design. The results showed that students were most engaged with Khan Academy and the math video game. Students preferred both of these tools, as well ask Kahoot, to the other technology tools, while the teacher-made screencasts paired with Kahoot and Khan Academy were the most beneficial to their content knowledge development. The results also showed that students found the teacher-made screencasts the most beneficial to their self-efficacy in geometry. These insights informed an action plan to share the results of this study with my school district and colleagues, as well as inform my future research plans.

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LIST OF ABBREVIATIONS

ADHD...Attention-Deficit Hyperactivity Disorder

CAI... Computer-Assisted Instruction

CP.. College Preparatory

SRS ....Student Response Systems

TAM3.. Technology Acceptance Model 3

UGT .... Uses and Gratifications Theory

CHAPTER 1

INTRODUCTION

Ms. Norbury begins each school year eager to meet the students with whom she will spend the next 90 school days. She spends hours planning lessons to prepare for the high school students who will enter her geometry classroom. As the first day of school arrives and she greets her students at the door, Ms. Norbury is immediately taken aback by Tim's statement, "math is boring," followed by his disengagement from her lesson plans. These plans frequently include direct instruction, group activities, and independent work, yet Tim is more focused on how many followers he has on his Instagram and is determined to download Fortnite onto his MacBook Air. Although he needs this class to graduate, Tim never engages with Ms. Norbury's class and finds himself so deep in a hole with makeup work that he is unable to make his way out. Eventually, due to frustration, Tim decides to drop out of high school.

STATEMENT OF PROBLEM

Unfortunately, this is a scenario I have witnessed first-hand in my classroom. A handful of students in my geometry core classes are more engaged with technology than the math skills they need to learn to graduate. In my high school setting, geometry core is typically comprised of students who are not planning to attend a four-year college or university and are likely to enter the workforce after graduation. Students enrolled in this course are in tenth through twelfth grade. These students are not satisfied with traditional mathematics learning strategies, including handwritten notes and independent practice problems. Even attempts at differentiated instructional methods are less engaging for students than in years past because of the ever-changing technological world they live in.

Increasingly, technology has become a distraction in my classroom that negatively impacts students’ learning. My current school setting has gone 1-to-1: the district provided each student with a MacBook Air to afford all students with technology in the classroom and to increase their college and career readiness skills before graduating high school. These efforts follow a pattern throughout the history of education: technology has often been viewed as a solution to schools’ problems (Pimm & Johnston-Wilder, 2005). However, though the intent of my current school district is positive, in my experience, students often use their school-issued devices in ways that conflict with this intent. Furthermore, many students have access to a Smartphone, which can also become a distraction during classroom instruction. Technology has become a distraction in my classroom when it is not used in a way that benefits students’ learning and engagement. This misuse of technology has made me apprehensive about implementing technology tools in my classroom.

Technology has also negatively impacted my students’ engagement because many of the students in my geometry core classes have attention-deficit hyperactivity disorder (ADHD). Students who have ADHD frequently struggle with engagement in mathematics (Mautone et al., 2005). In addition to students’ lack of focus, students who are truant or learn at a slower pace are having difficulty maintaining the pace of the other students in the classroom. This has led to an increasing number of low-achieving students in my core classes.

The lack of engagement and low achievement witnessed in my geometry core classes have motivated me to implement technology learning strategies to increase student engagement and support their understanding of geometry. It has become evident that many of my core students are unenthusiastic about direct instruction and independent practice and may value the use of technology to learn and master geometry. Furthermore, students in my core classes who have ADHD struggle with staying on task for long periods of time. When the COVID-19 pandemic forced all students in South Carolina into an eLearning setting, the use of technology to engage and support students' development of content knowledge became of utmost importance. Using technology tools to engage and maintain the attention of my geometry students in this setting was vital to their success with geometry.

Research has shown that male students typically prefer educational video games when compared to female students (Garneli et al., 2017). In this study, 70% of the participants are male. Because of their enthusiasm toward technology and video games, I resolved to adapt my teaching style to use their cell phones and MacBooks rather than resist them in this eLearning setting. When schools closed due to COVID-19, teachers had the option to develop paper and pencil work for students; however, I elected to implement technology strategies to increase student engagement and enthusiasm in a virtual setting, maintaining my commitment to this study.

Research has shown a positive correlation between technology learning strategies and engagement, especially when technology is designed to support student learning (Chao et al., 2016; Duebel, 2018; Simelane-Mnisi & Mji, 2017; Smith, 2017). This is likely attributed to the prevalence of technology within youth culture (Emdin, 2016;

Smith, 2017). Teenagers are often interested in social media, online gaming, and researching topics of interest, as well as other uses of technology in their everyday lives. Because of this, the technology tools teachers implement must be relevant to students. While many researchers and teachers believe students will be engaged simply with the presence of technology, this is not always true, and the technology implemented must be of interest to students (Chao et al., 2016).

Duebel (2018) discusses how the implementation of technology as an everyday instructional tool has positive results on students' engagement. Likewise, Simelane-Mnisi and Mji (2017) found college students were engaged when student response systems (SRS) were employed in daily classroom instruction. Similarly, research has shown the importance of technology's alignment with students' cultural exchange, the mutual sharing of background information in a respectful manner (Emdin, 2016). Based on this research, lessons that are planned in alignment with students' technological culture may positively increase student engagement and achievement.

Technology in the classroom is not only meant to engage students but also to support students' understanding of content. Boaler (2016) discusses how many math apps and games are unhelpful because they encourage drill and rote memorization. Instead, technology in the mathematics classroom should enhance and further students' learning by supporting students' higher-order thinking skills in mathematics (Boaler, 2016; Duebel, 2018; Simelane-Mnisi & Mji, 2017; Smith, 2017). Therefore, my study not only focused on student engagement but also sought to implement technology that students find beneficial toward their development of new content knowledge.

Technology's effects on student engagement and learning have been researched internationally, yielding positive results (Chao et al., 2016; Duebel, 2018; Simelane-Mnisi & Mji, 2017; Smith, 2017). Furthermore, technology strategies' positive effect on students who have ADHD has also been widely researched (Mautone et al., 2005; Ota & DuPaul, 2002). More information on the effects of technology on student engagement and learning will be provided in Chapter 2.

Although research on technology's impact on student engagement has provided positive results, most research has focused on elementary and college students, whereas this action research study centers on students in tenth through twelfth grade. This study also differs from previous studies because I not only discovered what technology tools affected student comprehension and engagement; but, I also uncovered why through student data.

This study is unique from most research conducted on technology's impact on student engagement and comprehension because of the action research design. This methodology allowed me to modify and adjust my study to align with student data throughout the two-week study. Furthermore, as both the practitioner and researcher, I elicited opinions from my students that were valuable to the instructional decisions I made in a virtual classroom. Very little research has been conducted in a virtual secondary mathematics classroom. Likewise, existing research has not gathered feedback from students to influence decisions to implement technology in an eLearning setting. Technology can increase engagement when it is easy to use, supports the users' gratifications, and increases their self-efficacy. The following section will discuss how these facets serve as the theoretical framework in this study.

THEORETICAL FRAMEWORK

A lack of student engagement and several low-achieving students in my geometry core class encouraged me to conduct this study. Research has shown that engagement in mathematics decreases for most students between the ages of 11 and 15 (Chao et al., 2016). At this age, low engagement can negatively impact students' performance, because they are less focused on the content as it becomes more complex. In other words, engagement and achievement are closely related.

Students are often engaged with technology when it is designed to sustain their attention (Hawkins et al., 2017). Technology that has a novelty effect or does not have engaging features for students may not improve their overall engagement with mathematics, whereas game-like and goal-oriented technology that provides immediate feedback often engages students (Hawkins et al., 2017). Therefore, this action research study employed technology tools that encompass these attributes, guided by three theoretical concepts: student self-efficacy, Uses and Gratifications Theory (UGT), and the Technology Acceptance Model 3 (TAM3).

Self-efficacy is the belief one can succeed (Chao et al., 2016). Students with higher levels of self-efficacy in math are more likely to persevere through problems (Liu et al., 2018). Also, high self-efficacy is conducive for students to develop learning strategies to increase engagement (Liu et al., 2018). Hence, self-efficacy in mathematics serves as a framework within this study.

Increased student engagement may also occur when technology is implemented that students find enjoyable or gratifying (Chao et al., 2016; Emdin, 2016). UGT, "a framework for explaining user motives for a particular media" (Gallego et al., 2016, p.

83), accepts that technology use is intentional, and users seek to use technology to meet their individual needs. These educational needs include searching for information, usefulness, and convenience of technology (Pribeanu & Balog, 2017). In this study, all of the daily technology strategies were provided in individual modules. Some of these resources were optional, including teacher-made screencasts and supplemental computer-assisted instruction (CAI), and students could choose whether they wanted to engage with these tools based on their individual needs.

Students may feel that technology effectively supports their learning when it is user-friendly and useful. These themes are present in the Technology Acceptance Model (TAM), which was first developed by Davis (1989) and later revised and broadened to TAM3 (Onal, 2017). The variables of TAM3 include "perceived ease of use, perceived usefulness, behavioral intent, and usage behavior" (Onal, 2017, p. 69). TAM3 acknowledges that when users believe technology is easy to use and useful toward their intent, they are more likely to use the technology regularly (Onal, 2017).

Self-efficacy in mathematics, UGT, and TAM3 combine to serve as the theoretical framework in this study. Student engagement is often dependent upon students' belief in their mathematics abilities (Liu et al., 2018). Engagement is also largely dependent upon students' connection with technology and its cultural relevance (Chao et al., 2016; Emdin, 2016). UGT directly aligns with this notion because of its emphasis on motivation toward a particular medium based on the users' intent (Gallego et al., 2016; Pribeanu & Balog, 2017). The TAM3 also frames this study because students may feel supported in their learning by technology when they find it useful and user-friendly (Onal, 2017; Pribeanu & Balog, 2017). Students in my geometry core class already see the usefulness of their MacBooks for personal use; however, this study uncovers which technology tools they find useful toward their development of content knowledge. According to UGT and TAM3, implementing technology that students find gratifying, useful, and user-friendly will increase student engagement and reduce the number of low-achieving students. The theoretical framework of this study will be further discussed in Chapter 2.

PURPOSE OF STUDY

As noted above, research has shown a positive correlation between students' learning and engagement when technology is effectively implemented (Chao et al., 2016; Duebel, 2018; Simelane-Mnisi & Mji, 2017; Smith, 2017). However, existing research does not specifically provide what uses of technology students find most engaging and effective in a secondary virtual classroom. Additionally, existing research has not examined why students find specific techniques engaging or supportive of their development of new content knowledge. This action research study examined what students find engaging, beneficial toward their understanding of geometry, and supportive of their self-efficacy in geometry, as well as provided valuable data to influence the implementation of technology strategies.

Using student self-efficacy in mathematics, the UGT, and TAM3 theoretical models, the purpose of this study was to increase the engagement of my geometry core students. However, I also wanted to increase student engagement with technology tools that support students' understanding of geometry. To do this, I determined what technology tools students in my geometry core class find engaging, useful toward their development of geometry content knowledge, and supportive of their self-efficacy in geometry. I also asked students why they do or do not find these technology tools engaging and useful to uncover why students prefer specific technology uses over others. Consequently, I discovered what aspects of these technology tools students find most useful toward their development of content knowledge.

This mixed-methods action research study proposed to answer the following questions: 1) What uses of technology do students find engaging in a virtual mathematics class when developing a new understanding of geometry? 2) Why do students prefer their selected use of technology over others? 3) How is their selected technology tool useful for the development of geometry knowledge? 4) What uses of technology increase students' self-efficacy in geometry? These research questions were derived from previous research on the positive impact of technology strategies on student engagement and student understanding; however, this study also uncovered students' opinions on what technology tools they found most enjoyable and useful. Furthermore, the circumstances in which my students moved to a temporary eLearning setting in the wake of COVID-19 enabled me to examine what students found engaging and supportive in a virtual classroom.

POSITIONALITY

This action research study employed insider research in that I served as the practitioner and researcher (Herr & Anderson, 2015). I intended to discover what technology tools most effectively engage my own students and support their development of geometry content knowledge. This study also provided data on why students found specific tools engaging and supportive toward developing an understanding of geometry.

Furthermore, this study examined students' self-efficacy in geometry after engaging with technology learning strategies.

As the practitioner and researcher of this study, I must acknowledge and examine my positionality as an insider (Herr & Anderson, 2015). My mathematical progression through high school has influenced my decision to conduct action research on technology's effectiveness on student engagement. I attended high school in Princeton, New Jersey, which is comprised of an affluent population with high educational stature. Both of my parents and I are White and have each attended a four-year college. My fellow high school students were mostly high-achieving White and Asian students who were accepted into four-year colleges and universities. Throughout my public education experience, I learned math through traditional methods of instruction with a strong emphasis on rote memorization and algorithms in preparation for high-stakes standardized testing. Traditional methods of instruction included lectures and individual practice textbook problems. Although technology was present in the high school I attended, it was not used in mathematics and teachers did not put a strong emphasis on engaging students.

Traditional methods were highly effective in the high school I attended due to the population's intrinsic motivation to graduate and attend a four-year college or university. Because of my traditional education, when I first entered the classroom as a teacher, I was confounded by how many students in my core classes were not motivated to complete their work using traditional methods. Although half of the students were achieving a high grade while learning through traditional methods, I found the other half of the students were uninterested and gave up quickly. In my first year of teaching, I witnessed two of the seniors in my core class drop out of high school completely. Students' lack of engagement motivated me to find methods of instruction to increase engagement within my classroom.

Since then, I have differentiated instruction; however, using technology in mathematics has seemed daunting and misplaced to me. In the past, I have argued that mathematics and technology did not cooperate well together due to the handwritten work necessary to complete problems. Furthermore, I have always felt that technology was a disruption of the content taught in my classroom. As illustrated in my introduction, cell phones and the 1-to-1 devices our district supplies to students have often distracted students from their work in my classroom. Constantly redirecting students from their devices to lessons and classroom tasks has caused frustration for me toward technology in my classroom. It was not until my research on technology's effectiveness on student engagement and learning that I was more eager to use technology in my mathematics classroom. These predispositions toward technology in a mathematics setting may affect my research as the practitioner of my study. In addition to acknowledging my bias, I also strove to avoid sharing my negative perceptions of technology with the participants of my study, especially because research has shown students can determine a teacher's attitude toward technology (Smith, 2017).

My insider positionality as the teacher and researcher can also impact the study. While I conducted interviews or administered surveys, students may have been compelled to answer questions in a manner they believed was to my liking. Recognizing my positionality in the classroom while conducting the qualitative phases of my research, I strove to avoid collecting data from students that did not depict their true thoughts. To do this, I discussed with students that I wanted honest opinions from them and that their responses would in no way impact their grade or my opinion of them. Furthermore, I explained to students that their honest responses were important for the results of this study. Acknowledging my viewpoints on technology in a mathematics classroom and my positionality as a teacher in the study allowed me to identify my potential bias and select the correct methodology in the study (Herr & Anderson, 2015).

RESEARCH DESIGN

Action research methods were chosen for this study because the aim was to change the low engagement and achievement present in my geometry core class (Efron & Ravid, 2013). Mixed-methods research best suited this action research study, because researching the topic of technology learning strategies to increase engagement and support students' development of geometry content knowledge drew on the strengths of both quantitative and qualitative techniques. This mixed-methods action research study employed a triangulation design, where the qualitative and quantitative methods answer questions under the same paradigm (Creamer, 2018). Students' overall engagement while participating in technology activities and thoughts about the use of technology to develop their understanding of geometry were measured using both qualitative and quantitative methods. Their responses to why they prefer selected technology tools over others were measured qualitatively.

Students in my geometry core class served as the participants in this study. Over the past eight years, the core students I have taught have displayed a lower level of engagement when compared to my Honors and College Preparatory (CP) level classes. Similarly, the dropout rate of the core students is much higher than the Honors and CP level students. Through a comparison between my core and Honors level students, it is evident there is a wide gap of achievement and a higher rate of truancy among my core students. Furthermore, there are typically more students diagnosed with ADHD in my core classes when compared to my CP and Honors level classes. Implementing technology to support the core level students' learning in a virtual classroom had the potential to increase their achievement. For this reason, students enrolled in my geometry core class were chosen as the participants of this action research study.

Technology learning strategies were implemented in an eLearning setting throughout one two-week unit of study. Students used technology in different capacities each day and engaged with various tools through their MacBook Airs or personal devices. As noted above, the school district I am employed by is 1-to-1 and supplies a MacBook Air to each student throughout the school year. During the COVID-19 pandemic, all students had access to a MacBook Air at home, and the district also extended the Wi-Fi range of the high school to the parking lot. Students who did not have Wi-Fi access at home were able to park in the school parking lot to complete assignments. In our virtual setting, each student also had access to a graphing calculator, as Texas Instruments (TI) provided a 6-month free subscription to students during the COVID-19 pandemic.

In this study, different software programs were employed including ActivInspire, QuickTime and Desmos. Each day, students were asked to log into our classroom learning management page on Canvas. Technology strategies in this study included SRS, mathematics video gaming, CAI, and teacher-made screencasts. As I will explain in Chapter 2, these strategies were carefully chosen after an extensive review of literature on the positive results each strategy has yielded toward engagement in a mathematics classroom.

The quantitative instruments in this study are Likert-scale surveys that measure students' overall engagement, the technology tools' usefulness toward student development of new content, and self-efficacy with the geometry content. The Likert-scale surveys were administered to students each day technology was implemented throughout the study. The responses from the different Likert-scale surveys were compared to discover what technology tools students found most engaging and useful to their understanding of geometry, as well as which tools increased their confidence with the geometry content.

Qualitative instruments in this study included semi-structured interviews after the implementation of technology strategies and a mixed-methods survey after the 2-week unit. After the implementation of technology learning tools, semi-structured interviews were conducted with students regarding their opinion on student engagement and its impact on their understanding of geometry. As I gathered and analyzed the quantitative data, purposeful interviews were conducted based on student responses and opinions toward the different technology tools. Finally, at the end of the unit, students took a mixed-methods survey on their opinions of the technology tools' usefulness and impact on their engagement and self-efficacy. The survey had Likert-scale and ordinal quantitative questions, as well as open-ended qualitative questions. More information on the research design, data collection, and analysis is provided in Chapter 3.

TRUSTWORTHINESS AND VALIDITY

To ensure trustworthiness in this action research study, I engaged in member checking with students on my interpretation of their responses during their interviews and open-ended survey questions. Additionally, the data from the Likert-scale surveys, interviews, and the post-administration survey were blended. Triangulation strengthens the validity of the study, which also makes it more reliable for other teachers (Merriam & Tisdell, 2016). Chapter 3 will further acknowledge the trustworthiness and validity of this action research study.

SIGNIFICANCE OF DISSERTATION

Although there is research on the positive impact of technology strategies on student engagement and learning in a mathematics classroom (Boaler, 2016; Chao et al., 2016; Duebel, 2018; Simelane-Mnisi & Mji, 2017; Smith, 2017), there is not much research on students' opinions of what technology learning strategies they find most effective and engaging. Therefore, this study intentionally focused on the students' opinions. This is important because it provides a clear understanding of what technology tools secondary students are engaged with in the mathematics classroom and what they find helpful toward developing content knowledge and confidence levels in mathematics. Through action research, this study also provided me with a better understanding of what students find engaging and helpful, which I can then apply when I design future lessons that include technology.

Furthermore, as I learned during the COVID-19 shift to virtual instruction, communication in an eLearning setting is much more limited than in a traditional classroom setting. Student input on what they find useful and engaging was of more importance in this setting because I was unable to gauge their interest level in person. In the event another extended eLearning situation occurs, this action research study can also provide other teachers with data from my students and setting that can inform future eLearning curricular decisions.

In this action research study, I intended to increase my geometry core students' engagement, as well as support their understanding of the content through the use of technology. However, the results of this study can also benefit any teachers who also wish to increase student engagement and support students' development of new content knowledge. Furthermore, it depicts the opinions of students in tenth through twelfth grade in regard to what technology tools employed in this study they found most engaging and supportive toward their understanding of geometry. This study also examined the effects of technology tools on two of my students who have been diagnosed with ADHD. Thus, the results of this study provide teachers with the information they need to make effective technology instructional decisions to meet the needs of their students.

LIMITATIONS

The findings of this study may be limited due to the circumstances under which it took place. This study was conducted in a high school during the spring semester of the school year, which historically has led to decreased motivation among students. Furthermore, the COVID-19 pandemic put many of my students' families in stressful and difficult situations. Results may have been different in a traditional setting. Based on the outcome of this study, I may conduct this study in the fall semester to see if my results differ.

In the setting of this research, the attendance policy may have also affected the outcome. Students could complete their assignments at any time during the semester. While teachers are expected to create a pacing guide for students, students ultimately determine the rate at which they would like to complete their assignments. This negatively affected the participation in my study. Another limitation present in this study is the amount of data I was able to collect on students' use of the teacher-made screencasts. Each day, a video was provided for students to watch on the content of the lesson; however, some students did not use the teacher-made screencasts daily. This limited my data on students' usage of these tools to support their development of content knowledge and student engagement. In spite of these limitations, a majority of students engaged with the technology tools within the unit, responded to surveys, and participated in interviews. The limitations of this study will be discussed more extensively in Chapter 5.

ORGANIZATION OF DISSERTATION

This action research study is organized into five chapters. Chapter 1 has presented the problem of practice, theoretical framework, research questions, positionality, overall research design, significance, and limitations. Chapter 2 is a literature review and synthesizes scholarship on technology strategies' effectiveness on student engagement and achievement. Chapter 3 provides a more in-depth discussion of the instrumentation, methods of collection, and methods for analysis. Chapter 4 will show an analysis of the results of this study. Finally, Chapter 5 will provide a summary of the study, conclusions that were developed from the findings, and recommendations for further research.

DEFINITION OF TERMS

Attention-Deficit Hyperactivity Disorder (ADHD): A learning disability related to an individual's inability to focus on a given task (Graves et al., 2011).

Canvas: A digital learning management system used by schools to provide an eLearning environment for students.

Computer-Assisted Instruction (CAI): The use of computers to deliver instruction that aids students in remembering content. Facets of CAI include drill and practice programs, tutorials, or simulation programs.

COVID-19: An infectious disease caused by the coronavirus (World Health Organization, 2020). This disease was not discovered until an outbreak in China in December 2019.

Screencasts: Video recordings of activity on a computer screen that can include narrator audio (Jordan et al., 2012). In a mathematics setting, screencasts often include a real-time recording of handwritten notes with step-by-step solutions to problems (Jordan et al., 2012).

Student Response Systems (SRS): Commonly referred to as "clickers." Devices that teachers can use in the classroom to provide live interaction among students and teachers. SRS deliver responses to a range of fixed-response options.

Traditional Methods of Mathematics Instruction: A large group demonstration of skills followed by individual skill-based practice (Souter, 2002).

CHAPTER 2

REVIEW OF THE LITERATURE

The purpose of this study was to increase the student engagement of my geometry core students by determining what students find engaging and useful toward their development of geometry content knowledge. To design a study to achieve this purpose, a review of relevant literature on technology's impact on student engagement and achievement was essential. This chapter will discuss the literature on the history of technology in mathematics. It will also review technology instructional tools that have been used and why these tools did or did not engage students in mathematics. These instructional tools include the use of student response systems (SRS), computer-assisted instruction (CAI), mathematics video gaming, and screencasts. In this chapter, the theoretical framework that frames my problem of practice and how it influenced the interventions for this study will also be discussed. Finally, this chapter will cover the positive implications technology has had for students with attention-deficit hyperactivity disorder (ADHD), in alignment with my goal to promote equity for all students within my mathematics classroom.

PURPOSE OF THE LITERATURE REVIEW

A literature review is a written argument that builds a case from previous research (Machi & McEvoy, 2016). This literature review provides context and current knowledge about technology as a tool for engagement and content development in mathematics, drawing conclusions through triangulation of the results from multiple studies (Machi & McEvoy, 2016). In this study, the literature review is significant because it provides information on technology strategies that have worked in previous studies, as well as the reasons they have been successful. Although many of these studies have been conducted in elementary, middle school, and collegiate settings, they hold common themes that guided this action research study. The literature review also serves the purpose of reviewing the history of and factors contributing to low engagement in mathematics, as well as the history of technology's influence on student engagement in a mathematics setting. Moreover, this literature review provides evidence that students with ADHD have benefitted from the use of technology in mathematics.

For this literature review, I have used ERIC (EBSCO) to search peer-reviewed education academic journals for studies about technology in a mathematics classroom. I have also used the Business Source Complete search engine to find primary sources on the theories that frame this action research project. Finally, textbooks from within my library have been sourced to provide information about the purpose of literature reviews in an action research design.

THEORETICAL FRAMEWORK

As introduced in Chapter 1, this study encompasses three theoretical concepts, which are student self-efficacy in mathematics, Uses and Gratifications Theory (UGT), and the Technology Acceptance Model 3 (TAM3). These theories combine to form the theoretical framework in this study because of their impact on student engagement and perceived usefulness of technology in mathematics. Each of these theories is discussed in detail in the following subsections.

SELF-EFFICACY AND MATHEMATICS LEARNING

Historically, mathematics has been considered one of the most difficult subjects to master (Chao et al., 2016). Because of this, self-efficacy is critical in students' understanding of mathematics. Self-efficacy is defined as a robust belief in one's capabilities to succeed (Chao et al., 2016). Research has shown that students with higher levels of self-efficacy in math are more likely to accept challenges and persevere through problems (Liu et al., 2018). Also, high self-efficacy is conducive for students to develop learning strategies to increase engagement (Liu et al., 2018). This is why self-efficacy in mathematics serves as a framework within this study.

Because self-efficacy is vital to the understanding of mathematics, researchers have explored factors that support self-efficacy. One of the four main factors is mastery experiences (Bandura, 1997). Students who view their past math experiences as successful are more likely to approach future mathematics problems with a stronger belief in their ability to succeed (Chao et al., 2016). In my study, students could attain mastery experiences by using different technology tools. Each tool aligned with current geometry content and provided immediate feedback to students to construct the opportunity for mastery experiences and increase students' self-efficacy. This increased self-efficacy could, in turn, increase student performance and engagement.

USES AND GRATIFICATIONS THEORY

Uses and Gratifications Theory (UGT) is a "framework for explaining user motives for a particular media" (Gallego et al., 2016, p. 83). UGT accepts that technology use is intentional, and users seek to meet their individual needs through the use of technology (Gallego et al., 2016). Previous studies have used UGT to analyze participants' gratifications, including convenience, entertainment, socializing, status seeking, and information seeking (Gallego et al., 2016). In this study, the gratifications included information seeking, usefulness, convenience, and educational purpose (Pribeanu & Balog, 2017).

UGT has proven to be a useful framework for determining what gratifications participants obtain while using technologies (Pribeanu & Balog, 2017). Therefore, UGT helped me discover the gratifications students gain from the technology tools they find advantageous toward their understanding of geometry and overall engagement. Furthermore, some of the technology tools in this unit of study were optional for student use, including the teacher-made screencasts and supplemental CAI. Students had the option to meet their educational or information seeking needs using these technology tools and may have found them more convenient than conducting their own search.

UGT was introduced by Katz et al. (1974), who were interested in the gratifications people felt from political programs on television. The three tenets of UGT include the users' being goal-directed in their behavior with media, acting as active agents in media usage, and being aware of the media they select to gratify their needs. These tenets align with the design of this study, which sought for participants to acquire more geometry content knowledge, act as active agents while using the technology tools, and reflect on what tools best suit their needs in the understanding of course content and self-efficacy.

TECHNOLOGY ACCEPTANCE MODEL 3

The Technology Acceptance Model 3 (TAM3) emphasizes the importance of acceptance and usage of technology based on the factors of perceived usefulness and ease of use (Adetimirin, 2015). The original Technology Acceptance Model (TAM) was created by Davis (1989) and has been revised and broadened into both TAM2 and TAM3 (Onal, 2017). TAM2 and TAM3 have both contributed more factors than TAM, including perceived ease of use and usefulness (Venkatesh & Bala, 2008). Two of the factors that correlate to this study include computer self-efficacy and computer playfulness.

Computer self-efficacy is the degree to which a person believes they can perform a task on the computer (Venkatesh & Bala, 2008). Students who have a higher computer self-efficacy are more likely to accept the technology strategy based on its ease of use. In this study, students became familiar with the technology tools to moderate perceived ease of use, usefulness, computer anxiety, and behavioral intention. Some of my interventions, including teacher-made screencasts and SRS, were used frequently to provide experience to the participants in the study. Computer playfulness signifies the degree of spontaneity present when using a computer (Venkatesh & Bala, 2008). In this study, CAI allowed students to explore and increase their acceptance of the technologies.

The revisions in TAM3 include the level of experience with technology, computer anxiety, and behavioral intention. According to TAM3, experience with technology can moderate the perceived ease of use and perceived usefulness. TAM3 has proven to be a useful theoretical model in assisting researchers in explaining participants’ acceptance, use, and adoption of technology (Mosley, 2012; Onal, 2017; Wu et al., 2016). For this study, I examined students’ acceptance and usage, beyond classroom requirements, of the technology tools that I asked them to engage with. TAM3 has also been used to decide what factors influence the decision-making process for using technology (Mosley, 2012). Thus, in this study, students’ opinions toward the technology tools they believed best met their eLearning and engagement needs were examined. In turn, I was able to uncover which technology tools students found the most useful for developing content knowledge.

LOW ENGAGEMENT IN MATHEMATICS

Research has shown that engagement in mathematics declines for most students between the ages of 11 and 15 (Chao et al., 2016). This negatively impacts students' performance, because during this age range, math courses become more complex. For algebra teachers, unmotivated and disengaged students have been rated as the number one most challenging aspect of teaching (Chao et al., 2016). Engagement in mathematics is crucial because it impacts students' ability to retain more information, which could improve their academic performance (Simelane-Mnisi & Mji, 2017). Specifically, active learning classroom strategies have shown higher rates of retention and enjoyment for students (Kulatunga & Rameezdeen, 2014).

Studies have revealed the positive effects of technology instructional strategies on mathematics understanding (Ahmand et al., 2014; Chao et al., 2016; Ota & DuPaul, 2002; Pareto et al., 2012; Souter, 2002). Research has shown students tend to stay on task longer when the task is presented through the computer instead of through paper and pencil (Mautone et al., 2005). Similarly, children have responded well to technology mathematics games (Mautone et al., 2005). Reasons for increased engagement through the use of technology include immediate feedback, competition, collaboration, and usefulness (Gilliam et al., 2017; Light & Pierson, 2014; Pareto et al., 2012; Plass et al., 2013; Simelane-Mnisi & Mji, 2017; Walklet et al., 2016).

Although low engagement in mathematics is prevalent in many students, students with ADHD are especially prone to it (Mautone et al., 2005). This is attributed to the difficulty they have automatizing basic skills that help with complex problems (Mautone et al., 2005). Teaching through an eLearning setting provided me an opportunity to promote equity for these students because CAI has shown positive benefits for increasing engagement for students with ADHD due to its individualized instruction and immediate feedback (Mautone et al., 2005). Technology in the mathematics classroom has yielded positive results toward increasing student engagement and will continue to be examined throughout the remainder of this literature review (Chao et al., 2016; Light & Pierson, 2014; Ota & DuPaul, 2002; Simelane-Mnisi & Mji, 2017; Walklet et al., 2016).

HISTORY OF TECHNOLOGY IN MATHEMATICS

Educational computer usage in mathematics dates back to the 1950s (Habgood & Ainsworth, 2011). However, the use of technology to engage mathematics learners did not begin until the 1980s with the expansion of video games. In the 1990s, computers surfaced in mathematics courses, with the release of The Statistical Package for Social Sciences (SPSS), as well as popular computer algebra systems (Greenwald & Thomley, 2012; Pimm & Johnston-Wilder, 2005). This inspired the learning potential through a different modality (Habgood & Ainsworth, 2011).

Calculators have historically held a similar timeline to computers in a mathematics context. Scientific, hand-held, battery-powered calculators first surfaced in the 1970s (Pimm & Johnston-Wilder, 2005). Graphing calculators were pivotal in the history of technology in mathematics because they allowed teachers to introduce more difficult problems than in previous years (Souter, 2002). Students were able to model challenging functions through the use of the table, graph, and equation features on the graphing calculator.

Educational researchers have held high expectations for the implementation of technology in a mathematics setting (Souter, 2002). Technology has often been viewed as a solution offered to various problems present within a school system (Pimm & Johnston-Wilder, 2005). However, there has been controversy amid technology in a mathematics education setting. With the appearance of calculators, a curricular dispute concerning fractions versus decimals emerged among educators. Calculators frequently display results in decimal form, which minimized the prevalence of fractions in an academic setting. Consequently, students who interacted primarily with the calculator in a math classroom needed supplemental experience with fractions (Pimm & Johnston-Wilder, 2005).

Another controversy present with the emergence of calculators and computers in the classroom was the extent to which the technology or the handwritten computation of mathematics became the focus of the course (Greenwald & Thomley, 2012). Over the years, the overall consensus among mathematics experts has been that students should be provided with the opportunity to apply and develop their technical abilities in their study of mathematics and technology should only be used when deemed appropriate (Pimm & Johnston-Wilder, 2005). The general opinion among mathematics teachers is that technology needs to be employed carefully to ensure that students are still learning mathematics and are not just fluent with technology (Pimm & Johnston-Wilder, 2005).

In contrast, teachers who teach math courses that have exams where calculator use is limited have reduced the use of calculators in their classroom. Limiting the use of the calculator, specifically to prepare students for a test, restricts the valuable mathematical activity that can be derived from the use of the calculator (Pimm &

Johnston-Wilder, 2005). The calculator can allow students to view multiple representations of functions and make sense of more difficult problems (Souter, 2002).

The evolution of technology in mathematics has derived from real-world needs and allows the user to form connections (Greenwald & Thomley, 2012). Technology in mathematics education courses has been present since the 1980s and teachers will continue to implement technology in new and innovative roles in the future (Greenwald & Thomley, 2012; Pimm & Johnston-Wilder, 2005). Therefore, technology in mathematics courses must continue to be studied, as it has been in this action research study, which made extensive use of technology in an eLearning setting, with a keen focus on its support of student learning needs and classroom engagement.

CURRENT USES OF TECHNOLOGY IN MATHEMATICS

Research has often supported technology as an important tool in the mathematics classroom (Jones et al., 2018; Souter, 2002). Technology has been defined as a crucial part of STEM disciplines because it can help foster an environment of innovation, inspiration, and creativity (Jones et al., 2018). Technology's use in STEM subject areas can also positively improve students' perceptions of science and math (Jones et al., 2018). Furthermore, the implementation of technology in mathematics can influence the complexity of the problems chosen, as well as the way teachers teach mathematics (Souter, 2002). With graphing calculators and computers, students can model complex functions and focus on understanding and interpreting results, rather than graphing difficult functions by hand (Souter, 2002). Similarly, teachers can focus their attention on asking complex problems about the characteristics of functions, rather than spending valuable class time on graphing functions by hand. Although widely recognized as important, technology has been used in math classrooms throughout history with varying degrees of success.

Computers have been active in mathematics classrooms as gaming systems and as computer-mediated learning devices (Gilliam et al., 2017; Souter, 2002). Historically, graphing in a mathematics classroom has shown positive benefits that include helping students make sense of complex systems, rule structures, and social dynamics (Gilliam et al., 2017). Games allow players to confront problems that will build their skills and help them solve increasingly complex problems, as well as synthesize information to generate insights (Gilliam et al., 2017).

CAI has become prevalent in mathematics classrooms because it replaces worksheets and offers a more personalized, self-paced environment that can enhance student growth and understanding (Souter, 2002). Students are also provided with immediate feedback, which can help reveal mistakes they are making throughout their learning process.

SRS, or “clickers,” have also become common in mathematics settings (Simelane-Mnisi & Mji, 2017; Walklet et al., 2016). Similar to CAI, SRS provide immediate feedback to the user, which allows the teacher to correct students’ misconceptions (Walklet et al., 2016). This also provides an opportunity for teachers to modify and adjust instruction accordingly. Research suggests SRS can improve student achievement, attention to in-class material, and motivation, while promoting active learning (Walklet et al., 2016).

Although technology strategies have held positive implications in a mathematics setting, research has shown the importance of choosing tools that directly align with the content (Chao et al., 2016; Simelane-Mnisi & Mji, 2017; Smith, 2017; Star et al., 2014). Smith (2017) states, “it’s not just about the flashy graphics and characters. The activities must allow the students to experience a productive struggle to expand their understanding of the topic at hand” (p. 26). In previous research, mathematics teachers have often thought that the pure existence of technology within the classroom would provide a motivating environment for students; however, the technology learning strategies must align with students’ gratifications and academic content (Chao et al., 2016). Since technology strategies are often not aligned with academic content, the evidence regarding its motivational effectiveness has been mixed (Star et al., 2014).

Another reason technology has not proven effective toward supporting academic knowledge and engagement in the classroom is because the resources often explore motivation as an afterthought rather than a central component of the design process (Chao et al., 2016). As a result, educational researchers lack evidence about which types of engaging constructs of technology design are useful for a specific population of learners (Chao et al., 2016). Furthermore, the conditions for which technology strategies can enhance the learning of mathematics lacks clear support (Chao et al., 2016). Thus, this action research study examined what technology tools students found most engaging and supportive toward enhancing their understanding of geometry.

IMPACT OF TECHNOLOGY LEARNING STRATEGIES

Technology has been used in different modalities in the mathematics classroom and has had varied levels of success. Before conducting this action research study, I examined research on current uses and impact of including SRS, gamification, screencasts, and CAI. These technology strategies are discussed in the following subsections.

STUDENT RESPONSE SYSTEMS' IMPACT ON STUDENT ACHIEVEMENT AND ENGAGEMENT

SRS devices, such as computers, mobile devices, iPads, and clickers, can provide live interaction among students and teachers. Students can use SRS to deliver their answers to a range of fixed-response options (Walklet et al., 2016), so these devices bring about meaningful immediate feedback to the user and the instructor (Simelane-Mnisi & Mji, 2017). Research has suggested SRS can improve student achievement, attentiveness, and motivation while promoting active learning and critical thinking skills (Simelane-Mnisi & Mji, 2017; Walklet et al., 2016).

Walklet et al. (2016) explored how SRS influenced the learning experience of college students across different levels of their program. The students within their classes were provided with an SRS and were advised to discuss their answers to multiple-choice questions before answering. Their results indicated that the SRS have several positive impacts on student learning including enhanced engagement, active learning, peer interaction, and formative feedback. Another value added to the SRS was the anonymity component. This allowed all students the ability to participate in the classroom activity. Students were asked to share their opinion of SRS, and most students valued the devices in their learning experience (Walklet et al., 2016), supporting the claim that SRS promote student learning and increase student engagement.

SRS as an engagement tool in a mathematics classroom was also studied by Simelane-Mnisi and Mji (2017). Similar to Walklet et al. (2016), SRS were used in a mathematics classroom to respond to teacher-made questions. The college-level participants in the study felt SRS assisted them in paying better attention to what was happening in class. This is likely attributed to the active learning SRS promote. Students also felt SRS allowed them to think deeply about problems because they did not want to guess their answers incorrectly in front of their peers. The participants expressed their fondness of the immediate feedback and found the devices easy to use.

In addition to student engagement, King and Robinson (2009) also studied undergraduate students' perceptions of SRS on their learning and thoughts on the overall usefulness of the devices. A total of 250 participants were observed, took one-minute questionnaires, provided informal feedback, and completed the main questionnaire to provide the researchers with data on their perceptions. King and Robinson (2009) discovered that 80% of the students found the SRS useful and advantageous to their learning. Students also emphasized that they appreciated the immediate feedback embedded within the use of these devices. Although this study was conducted in an undergraduate setting, the results are still valuable because they supported the notion that students were more likely to participate in class while using SRS.

Although most research on SRS in mathematics has been conducted in a traditional higher education setting, the results have consistently shown that SRS have been effective toward student engagement. Results showed that students found SRS easy to use and enjoyed the immediate feedback (King & Robinson, 2009; Simelane-Mnisi & Mji, 2017).

There has been an abundant amount of research on technology-enhanced educational games in mathematics (Barreto et al., 2017; Chao et al., 2016; Gilliam et al., 2017; Light & Pierson, 2014; Pareto et al., 2012; Plass et al., 2013). Effective implementation of technology-enhanced games in the classroom has yielded positive results on students' ability to solve complex problems and synthesize information (Gilliam et al., 2017). Research on this topic has consistently shown that students, from elementary school to high school, respond well to educational games when they are challenging, aesthetically pleasing, and integrate content with gameplay (Barreto et al., 2017; Chao et al., 2016; Olson, 2010). Furthermore, students have expressed enjoyment in educational games that include a social component. This includes collaboration, teamwork, and competition (Gilliam et al., 2017; Olson, 2010; Pareto et al., 2012; Plass et al., 2013). Consistently, students have also appreciated educational video games that provide immediate feedback (Light & Pierson, 2014).

Unlike the research found on SRS, research on gamification has focused much more on elementary and middle school aged children. For example, Chao et al. (2016) explored how middle school students described their experiences when working with three different digital resources: an immersive digital environment, a web-based set of learning modules, and an educational film. Of the 88 fifth- through eighth-graders, a majority found the digital virtual environment most engaging because it resembled a video game, was aesthetically pleasing, and challenging. The researchers concluded that students do not relate as well to people discussing how math can be used, but instead by being pulled into a relatable narrative structure. Students' motivation was present in resources that challenged them and made them aware of accomplishing tasks.

A study by Light and Pierson (2014) yielded similar results about the factors of technology that students find most engaging. The researchers examined how teachers merge Khan Academy with their classroom practice. Khan Academy (2020) is an online learning platform that offers over 5,000 instructional videos, math exercises, and real-time data. Light and Pierson (2014) used interviews, focus groups, school walk-throughs, and classroom observations to document the types of teaching and learning practices teachers are developing with the help of Khan Academy (2020). Their results showed that students were most engaged with the game-like components and were motivated by the points and badges they could win to access a new avatar. Furthermore, the students enjoyed the immediate feedback they received within the game-like environment.

In a student-centered study, Barreto et al. (2017) studied the motivation and engagement levels of six children, aged seven to ten, while playing math video games. Data sources included interviews, observations, and video recordings of game playing. Conflicting with the other studies above, students within this study were not always motivated to play math video games and often sustained engagement for only seven to twelve minutes before seeking another game or activity. The results also showed that the mathematics content knowledge gained from the game was limited. The study revealed the motivational factors influencing children's play of the math video games were intellectual motivation, autonomy, and competence. Children in the study demonstrated signs of engagement when the math game presented challenges that involved achieving mastery and discovery moments. This study also found that math video games that situate and integrate academic content with gameplay have a better chance of increasing engagement and learning. This supports the idea that practitioners should select games that challenge the students and align with the content.

Research has shown the importance of aligning game-play with academic content to motivate students (Barreto et al., 2017; Chao et al., 2016; Habgood & Ainsworth, 2011; Light & Pierson, 2014), which provides students with discovery moments to increase their learning. Participants in research studies have supported the idea that the content should be challenging (Barreto et al., 2017; Chao et al., 2016; Olson, 2010). However, Habgood and Ainsworth (2011) add that the game-play should be challenging, yet achievable. Students should not find the math games too easy, but the games should also not be outside of their realm of understanding.

The impact of technology-enhanced mathematics games on student performance has also been studied. In a study conducted by Plass et al. (2013), the researchers sought to examine technology game-play to increase arithmetic fluency in 58 middle school students. There were three modes of play embedded within the study: individual, competitive, and collaborative play. The results showed that performance was higher for students in the competitive play group. Student interest, however, was highest in both the collaborative and competitive play groups. This supports the notion that social interaction during gameplay is engaging for students.

Pareto et al. (2012) also conducted a study that included social interaction in a mathematics game. They examined the effects of an educational math game on middle school students' attitudes and comprehension. The students in the game-playing group participated in 35-minute sessions, while the control group did not have any experience with the math game. The researchers found that, compared with the control group, the game positively affected students' math comprehension, but not their attitudes toward math. Additionally, they found that collaboration and competition carried a strong motivational influence for students to participate in the game.

Callaghan et al. (2017) also studied the impact of educational games on elementary students' math achievement. Throughout the study, teachers used the game in different ways, including referencing the game during class, reminding students the game aligned with class lessons, potentially bringing students' attention to the relevant math content, and identifying and reaching out to struggling students. The findings from the study indicated that two teaching practices had a positive statistically significant association with increases in student math achievement. The teachers who took the time to align the course and game content provided students with the in-depth practice they needed to truly grasp the mathematics material. This suggests aligning course content and technology is vital to increasing student performance.

Garneli et al. (2017) also analyzed academic performance after students played a mathematics video game, but also measured students' engagement. The researchers measured high school students' attitudes and learning performance after playing three different versions of math educational games. They compared the results from the students who played the video game with students who completed activities with paper and pencil. The data showed differences between genders for their academic achievement. Female students who needed more practice performed better after using traditional methods than playing the game. There was no difference among male students' performance after playing the games or using traditional methods; however, measures of student engagement yielded different results. Female students preferred traditional methods, whereas male students enjoyed playing educational video games. The male students also expressed that they felt the video games were more useful as a learning tool than female students. After analyzing data, the researchers found that the one-hour period for each game and traditional methods were insufficient to improve students' performance. These results support that duration and repetition in the learning process are important for student learning.

Although gamification has shown positive implications on student achievement and engagement, Rodriguez-Aflecht et al. (2017) conducted a study analyzing the novelty aspect of technology. They sought to explore the development of situational interest in a digital mathematics game and found that interest declined over time, due to the novelty effect. However, the results also showed that the game was able to maintain the situational interest of over half of the participants. Students who did not sustain interest showed a dramatic drop after the first session that steadily decreased throughout sessions. This is ultimately what brought down the mean scores of students' situational interest. The researchers believe that difficulties and poor performance in the game might be contributing factors to the dropped situational interest. The study conducted by Rodriguez-Aflecht et al. (2017) suggests that not all students will be engaged with math games in the classroom and some may lose interest almost immediately.

SCREENCASTS' IMPACT ON STUDENT LEARNING AND ENGAGEMENT

Screencasts are video recordings of activity on a computer screen that can include narrator audio (Jordan et al., 2012). In a mathematics setting, screencasts often include a real-time recording of handwritten notes with step-by-step solutions to problems (Jordan et al., 2012). Screencasts have shown evidence of supporting students' learning needs (Ahmand et al., 2014; Jordan et al., 2012; Light & Pierson, 2014). They can provide a flexible learning environment for students, enhance student understanding, provide a different method for reviewing material, and make mathematics more enjoyable for students (Ahmand et al., 2014; Jordan et al., 2012; Light & Pierson, 2014). Since this action research study took place in an eLearning setting, screencasts were used as the primary source of instruction for students.

Screencasts have shown multiple benefits for students in a mathematics setting. In a study conducted by Ahmand et al. (2014), the benefits of the instructors' use of self-developed screencasts for college students were explored. Specifically, the researchers sought information on how the screencasts supported students' learning needs. The study attempted to determine the percentage of screencast use and non-use among students, the reasons for non-use of the screencasts, students' perceptions of math screencasts, and how the screencasts had benefited the students. The findings showed that a majority of students used the screencasts for many different purposes and viewed the screencasts as an extremely useful tool that enhanced their learning of mathematics. Ten primary benefits emerged: offering flexible and personalized learning, supplementing lectures and enhancing understanding, facilitating exam revision and material review, providing multimodal support, helping students keep track with modules, providing a tighter match with course content, delivering a distanced learning experience, serving as a memory aid, filling in gaps in class notes, and making mathematics more enjoyable for students.

Jordan et al. (2012) also investigated the effectiveness of screencasts as an educational support resource for high school students. A calculus assessment was used to evaluate the participants on their performance before and after watching the screencasts. Additionally, the feedback was received from students regarding their beliefs on the helpfulness of the screencasts. After the administration of the calculus assessment, the data showed overwhelming evidence that the screencasts had improved performance. The results showed that students enjoyed mathematics screencasts to support their learning. They felt the screencasts helped enhance their understanding of mathematics and wanted the instructors to create more videos in the future. The students' overall enjoyment of the videos and performance on their assessment provided evidence that the screencasts were engaging and enhanced student understanding.

The results from Ahmand et al. (2014) and Jordan et al. (2012) suggested my high school students would find screencasts helpful and enjoyable to watch while enhancing their understanding of geometry. However, although existing research indicates students find screencasts both engaging and supportive of their content knowledge, there is little to no student data to explain why. In my study, student perspectives provided more information on what increases engagement and supports student understanding when students watch screencasts.

Although Ahmand et al. (2014) and Jordan et al. (2012) were focused primarily on support for students' learning, evidence emerged suggesting screencasts are also beneficial for student engagement. In both studies, students expressed that they found the screencasts enjoyable to watch. This solidified my decision to use screencasts as the primary method of instruction to help increase my students' engagement and academic performance.

COMPUTER-ASSISTED INSTRUCTION'S IMPACT ON STUDENT ACHIEVEMENT AND ENGAGEMENT

CAI is the use of computers to deliver instruction that aids students in remembering mathematical content, whether through drill and practice, tutorials, or simulation programs (Gross & Duhon, 2013). Through this method of instruction, the computer provides direct instruction, which has generated positive results for students' retention of math facts (Gross & Duhon, 2013). However, Hawkins et al. (2017) stress that successful implementation of CAI requires opportunities to respond, immediate feedback, instructional pacing, student engagement, and progress reports. CAI that rates strong in each of these categories is more likely to improve student mathematics achievement (Hawkins et al., 2017).

Another factor contributing to student success is the frequency of CAI in the classroom. De Witte et al. (2014) conducted a study to discover if more intense exposure to CAI programs led to higher test scores. The researchers analyzed the number of exercises participants completed with CAI and their achievement on a mathematics assessment. They found that students who used CAI more frequently than other students had higher test scores. This provides evidence that the CAI was effective in promoting student achievement in mathematics and could potentially increase student achievement in my study. Burns et al. (2012) also provided evidence that intense exposure to CAI will lead to higher mathematics achievement. Participants in their study used a CAI program to practice math facts for up to 15 weeks. The researchers sought to examine the effects of the program on the math skills of the participants in the study. The results showed that the CAI was effective in increasing the math skills of the participants. The results from

Burns et al. (2012) were similar to those from De Witte et al. (2014) because the data suggested that using CAI to increase the amount of practice with a particular skill would be an effective intervention for math. These results persuaded me to implement CAI as a technology strategy more frequently in my study when compared to CAI and SRS.

Another study, conducted by Wilder and Berry (2016), also analyzed the effects of CAI on student achievement. In this study, the results from a control group and a treatment group were compared to discover if CAI impacts student achievement and retention in algebra. Both classes took a 40-question open-ended algebra achievement test that measured students' knowledge of algebra 1 topics. This assessment was given to both classes in the first and second semesters. The results indicated that both groups were equally effective in improving student mathematics content knowledge. However, students who were in the CAI intervention group had significantly higher retention of content knowledge. Students in this group performed well on the assessment in the first and second semesters. The researchers discussed that this may have been attributed to the flexibility present in CAI for students to choose topics they wanted to learn.

Although CAI has been used primarily to improve the memorization of math facts, it has also shown positive implications for students' overall mathematics achievement. Gross and Duhon (2013) conducted a study to examine whether web-based CAI would increase math fact accuracy. The CAI was combined with an extrinsic reward procedure for exceeding the median performance from the previous day's lessons. The results showed that all of the participants reached their accuracy goal after using the CAI-based intervention. This provided evidence that incorporating CAI in this action research study could help motivate students and improve their understanding of basic math facts.

The effects of CAI on student engagement have also been studied. Schuetz et al. (2018) examined how a CAI program impacted second graders' engagement in mathematics. In this study, a control group completed paper and pencil activities and a treatment group completed activities through the CAI program. Both groups received an hour of math instruction from their teacher each day, followed by the math intervention 25 minutes each day. The results showed that the levels of engagement in both groups were statistically similar. In both groups, students were equally engaged in both interventions. However, students in the control group were more reliant on teacher help to maintain equal levels of engagement. Students within the CAI group were more independent, which is a positive factor for engagement. This influenced my decision that using CAI in this action research study would foster independence and student engagement, which could positively affect the climate within the digital high school setting of this study. Without a teacher present in the classroom, students can navigate CAI and make decisions pertaining to their individual learning needs. This would promote students' practicing becoming more independent and maintaining higher levels of engagement. Furthermore, the results from the CAI studies that examined student achievement suggested my students' academic performance and math fluency would increase after the use of CAI.

IMPLICATIONS OF CAI FOR STUDENTS WITH ADHD

Attention-deficit hyperactivity disorder (ADHD) is one of the most common behavior problems among school-aged children (Ota & DuPaul, 2002). Children with this disorder exhibit high levels of inattentiveness and difficulty with academic achievement (Ota & DuPaul, 2002). Specifically, children with ADHD often have problems completing independent seatwork, have problems with study skills, and perform lower on tests when compared to their non-ADHD peers (Mautone et al., 2005). While students with ADHD frequently exhibit mathematics underachievement, they tend to stay on task longer and complete more of a task when it is presented on the computer rather than on paper (Mautone et al., 2005). Thus, the technology strategies in this action research study were selected to increase student engagement and achievement for students with and without ADHD.

CAI has shown positive benefits for students with ADHD (Mautone et al., 2005; Ota & DuPaul, 2002). Specifically, the instructional features of CAI allow students to focus their attention on educational stimuli (Mohammadhasani et al., 2018). CAI can also improve students' academic achievement when students are provided with clearly designed content and well-structured learning units (Mohammadhasani et al., 2018). Students have enjoyed the immediate feedback and individualized instruction that CAI provides, and CAI has proven beneficial to attentiveness and mathematics fluency, specifically for students with ADHD (Mautone et al., 2005). Although CAI has been widely researched for students with ADHD, research has also shown math games have improved student engagement time and performance (Ota & DuPaul, 2002). An overview of the studies attributing success to CAI and math games for students with ADHD will be provided in this section.

In a study conducted by Mohammadhasani et al. (2018), the effects of CAI on mathematics learning for students with ADHD were examined. Specifically, pedagogical agents were used as a CAI instructional strategy. Pedagogical agents are virtual characters used in online learning environments to serve various instructional goals.

These lifelike characters presented on a computer screen take users through multimedia learning environments. The purpose of the pedagogical agents in this study were to help gain the attention of students with ADHD and increase their understanding of the mathematics content. The results of the study show that the pedagogical agent can improve ADHD students' performance in mathematics. Feedback from the participants showed that the pedagogical agent made them feel comfortable and more confident. Consequently, in this action research study, one of the CAI tools employed a pedagogical agent to engage students in the instruction.

Graves et al. (2011) also investigated the benefits of technology for students with ADHD. Specifically, they sought to discover whether asynchronous online access to course recordings was beneficial to students with ADHD. The factors the researchers examined were course clarity, organization, asynchronous access, convenience, achievement, and disability coping methods. After analyzing their results, they found that in the clarity category, the participants found asynchronous access of course materials helpful to reduce misconceptions and improve comprehension of the material. Most participants also enjoyed the organization of the course; however, several spoke out about wanting to have a tutorial from the instructor before accessing the course materials. The participants noted that the asynchronous access helped support their learning habits; however, this also was dependent upon the instructor's technological capabilities. This action research study intentionally paired CAI with teacher-made screencasts to provide students with multiple methods of instruction. In the convenience category, Graves et al.'s (2011) participants discussed how they enjoyed having the availability of class lectures and materials on demand. They felt better equipped to study independently and review course notes with more confidence at their own pace without the pressures of time constraints in a classroom. Participants felt their achievement would improve due to their different study habits. Finally, the participants expressed that asynchronous online information was helpful for them to self-accommodate their difficulties faced with ADHD. This is helpful for students to build skills that will last them throughout their education.

SUMMARY

The purpose of this literature review was to offer an overview of the significant literature published on technology instructional strategies' effects on student engagement and academic performance in math. The literature review included a discussion of the study's theoretical framework, historical perspectives on the topic of the study, related research, and application for students with ADHD.

Technology in mathematics courses has dated back to the 1980s and will continue to be prevalent in the future. The use of graphing calculators and computers over time has shown that technology needs to enhance students' ability to learn mathematics. With this history in mind, this action research study adopted self-efficacy in mathematics, TAM3, and UGT as theoretical models. Students' self-efficacy is important for their ability to persevere through difficult problems. TAM3 and UGT supported my efforts to uncover students' gratifications while using technology tools, as well as their acceptance of their favorite technology tools, and their perceived ease of use of each of the technology tools.

Existing studies on technology strategies have shown positive results for student engagement. SRS offer immediate feedback, active participation, and ease of use. Similarly, educational math games that have had successful outcomes on student engagement also provided immediate feedback, held a social component, were aesthetically pleasing, and were challenging. This proves that students are engaged by technology strategies that provide immediate feedback and competition, and that students find easy to use. In this study, I chose technology tools that encompassed each of these features with hopes to increase student engagement.

Technology has also shown positive results for students' mathematics performance. SRS have enhanced students' academic performance when used in a collaborative setting. Educational math games that align with course content have shown improvements for student achievement. Instructor-made screencasts have provided a more personalized learning experience, enhanced understanding, and filled in gaps for students. Finally, CAI has increased math fact fluency and enhanced student performance when paired with strong instruction. CAI and other strategies have been most effective when used intensively in the classroom. The synthesized research in this literature review informed the technology strategies employed in this study, as I sought to use tools that align to course content and allow students a more personalized learning experience to help increase achievement in geometry.

Two students in this study have been diagnosed with ADHD. Results from studies in this literature review show improved performance and engagement for students with ADHD through the effective use of technology, particularly with tools that provide immediate feedback, instantly reinforce content, and are self-paced. This study employed such technology tools in hopes of increasing engagement and math comprehension of students in this study who have ADHD. Improving the performance and engagement of students with ADHD, in turn, will foster a more equitable environment for students.

Although there is an abundant amount of research on the positive effects of technology strategies on student achievement and engagement in a mathematics classroom, studies have also suggested that technology tools can have a novelty effect and the level of engagement can decline. In this study, as explained in Chapter 3, I gathered frequent feedback from students to help combat this issue and to discover what components of technology tools students find engaging over time. Consistent with action research, the technology strategies used in this study were modified and adjusted to meet the needs of the learners in my classroom.

CHAPTER 3

METHODOLOGY

As reviewed in Chapter 2, the effect of technology strategies on students' engagement has been well documented by other researchers (Ahmand et al., 2014; Kulatunga & Rameezdeen, 2014; Ota & DuPaul, 2002; Pareto et al., 2012; Simelane-Mnisi & Mji, 2017; Souter, 2002). However, little research has been conducted in an eLearning secondary mathematics setting and through an action research design. Furthermore, students' feedback and opinions on technology strategies have not been widely researched. In my experience teaching geometry core as a secondary mathematics teacher, I have witnessed a lack of engagement with the content and low achievement in the course. This lack of engagement was likely to increase in an eLearning setting if students were not interested in the chosen methods of instruction. In this study, technology strategies were implemented with hopes of increasing student engagement and the development of content knowledge in a unit of study on quadrilaterals.

The purpose of this study was to increase the student engagement of my geometry core students by determining what students find engaging and useful toward their development of geometry content knowledge. Furthermore, this study examined the effects of technology on student self-efficacy in mathematics. Approval to conduct this study was attained from the University of South Carolina (UofSC) Institutional Review Board (IRB) and at the district level. This chapter provides an extensive explanation of my methodology. To begin, I will discuss the mixed-methods design for this study, the setting and participants of the study, data collection methods, and plans for data analysis. This chapter will also discuss why I have chosen mixed-methods action research to address the purpose of this study.

TECHNOLOGY STRATEGIES

Based on the literature review from Chapter 2, the technology strategies chosen for this action research study were student response systems (SRS), computer-assisted instruction (CAI), gamification, and teacher-made screencasts. Below, I explain the capacity and format in which each of these technology strategies was employed in my virtual classroom. Table 3.1 provides an overview of the daily usage of technology and the data collection method for each day of the 2-week unit. Table 3.2 provides details of each technology tool and Table 3.3 provides the rationale behind selecting each tool.

STUDENT RESPONSE SYSTEMS

On the first day of instruction, students engaged with SRS through a teacher-made Kahoot. Since this study was conducted in a virtual setting, students participated in a self-paced version of Kahoot where they answered questions about the Polygon Interior/Exterior Sum Theorems and earned an overall score at the end. Students were provided instant feedback after answering a question. Point values were awarded based on correct answers and the timeliness of student submissions. At the end of the activity, a leaderboard was provided for students to see where they ranked compared to their peers. This allowed students to compete with their peers in a fully virtual setting. I was able to gauge student participation with the technology by checking the leaderboard at the end of the semester.

CAI was implemented through various platforms on days two, five, and six of the two-week unit on quadrilaterals. Properties of quadrilaterals served as the learning objective for each of these days, which is often the most difficult concept for students in this unit. CAI allows students to practice problems, while also being provided additional instruction on the content; therefore, this technology strategy was chosen on the days where the content was most difficult for students. On day two, when developing an understanding of the properties of kites and trapezoids, students engaged with IXL Math (IXL Learning, 2020). In the IXL Math activity, students were asked questions about the properties of kites and trapezoids. As the students progressed through the questions, they are given a “smart score” that increased or decreased based on their responses. If students answered a question incorrectly, a summary of why their answer was incorrect was provided, as well as a description of how to solve the problem.

On day five, students participated in CAI through a Khan Academy (2020) activity. This method of CAI asked students seven questions about the properties of parallelograms. As students completed the questions, they received instant feedback on their answers, including a written and video explanation of how to correctly complete the problem for any incorrect answers. Students also received a total performance score at the end of the activity.

On day six, students participated in CAI using iknowit (2020), which asked students questions about special parallelograms. A pedagogical agent followed the students throughout the activity. If a student answered incorrectly, a summary of why their answer was incorrect was provided. Students navigated through 15 questions and their total score was provided at the end. After each CAI activity, students were asked to screenshot the final page and submit it through Canvas. This allowed me to gauge student participation with each CAI tool.

GAMIFICATION

Students engaged with Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) on the eighth day of the instructional unit on quadrilaterals. This mathematics video game asked students to shoot the correct quadrilateral with a virtual gun. For example, if the game asked students to shoot all of the parallelograms, students would shoot all squares, rectangles, rhombi, and parallelograms. As the game progressed, the speed that the quadrilaterals moved on the screen increased and students had to think quickly about which quadrilateral met the classification provided by the game. This method of gamification expected students to know the conditions for special parallelograms well enough to recall them quickly during the game.

During the game, students were provided points for correctly shooting quadrilaterals. A leaderboard was provided at the end for anyone who had engaged with the game. This included students who were not participants in this study. Students were asked to submit a screenshot of their ranking on the leaderboard in Canvas. This provided data on which students had participated in the Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) game.

Table 3.1

Daily Outline of Data Collection

Day of Unit	Content Objective	Technology Strategies	Data Collection Method
1	Polygon-Angle Sum Theorems	- SRS - Screencast	- Likert-Scale Survey
2	Properties of Kites and Trapezoids	- CAI - Screencast	- Likert-Scale Survey - High-Engagement Interviews - Low-Engagement Interviews
3	Properties of Kites and Trapezoids	- Screencast	- High-Engagement Interviews - Low-Engagement Interviews
4	Properties of Parallelograms	- Screencast	- No Data Collection
5	Properties of Parallelograms	- CAI - Screencast	- Likert-Scale Survey
6	Properties of Special Parallelograms	- CAI - Screencast	- High-Engagement Interviews - Low-Engagement Interviews
7	Properties of Special Parallelograms	- Screencast	- Likert-Scale Survey
8	Conditions of Special Parallelograms	- Gamification - Screencast	- Likert-Scale Survey - High-Engagement Interviews - Low-Engagement Interviews
9-12	Chapter 6 Project	- Screencast	- Post-Administration Survey - Likert-Scale Survey - High-Engagement Interviews - Low-Engagement Interviews

Table 3.2

Details of Each Technology Tool

Day(s) of Unit	Technology Details
1	- Screencast: Created through QuickTime, a teacher-made screencast was provided to students explaining and explicitly providing examples of the Polygon-Angle Sum Theorems. - SRS: Students engaged with a teacher-made Kahoot. The Kahoot had 15 problems on the Polygon-Angle Sum Theorems. Each question had a time limit. At the end of the activity, students' names appeared on a leaderboard with their classmates.
2/3	- Screencast: Created through QuickTime, a teacher-made screencast was provided to students explaining all of the properties of kites and trapezoids. After an overview of the properties, the video provided worked out examples of how to use these properties to solve problems on kites and trapezoids. - CAI: Students engaged with IXL Math (IXL Learning, 2020) on day two of the unit. In this method of CAI, students were asked to solve problems on the properties of kites and trapezoids. If students answered a question correctly, their "smart score" increased. If students answered a question incorrectly, their "smart score" decreased and they were provided with an explanation of how complete the problem correctly.
4/5	- Screencast: Created through QuickTime, a teacher-made screencast was provided to students explaining each of the properties of parallelograms. After an overview of the properties, the screencast provided worked out examples of how to solve problems on parallelograms. - CAI: Students engaged with Khan Academy (2020) on day five of the unit. In this method of CAI, students were provided with short videos on the properties of parallelograms, followed by questions. If students answered a question incorrectly, they were referred back to a video of how to solve problems using the properties of parallelograms. At the end of the activity, they were given an overall score out of 15 questions.
6/7	- Screencast: Created through QuickTime, a teacher-made screencast was provided to students explaining each of the properties of special parallelograms. After an overview of the properties, the screencast provided worked out examples of how to solve problems on special parallelograms. - CAI: Students engaged with iknowit (2020) on day six of the unit. In this method of CAI, students were asked questions using the properties of special parallelograms. A pedagogical agent followed them through the duration of the activity. If students answered an question incorrectly, they were provided with an explanation of how to complete the problem correctly. Students were given a score out of 15 at the end of the activity.

8	- Screencast: Created through QuickTime, a teacher-made screencast was provided to students outlining the conditions of special parallelograms. - Gamification: Students engaged with Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) on day eight of the unit. In this game, students were asked to identify and shoot parallelograms based off of the description. For example, if students were asked to shoot “parallelograms”, they would shoot all squares, rectangles, rhombi, and parallelograms; but, not any other quadrilaterals that appeared on the screen. This fast-paced game had a time limit each round and students were provided with an overall score at the end. Students’ names appeared on a leaderboard that showed them their ranking compared to all participants of the game.

TEACHER-MADE SCREENCASTS

Before the statewide quarantine, teacher-made screencasts were made and uploaded onto Canvas daily for students to use if they were absent or needed to review a problem from class; however, during days 1-9 of the study, the screencasts were the primary source of information from me to the students. In these screencasts, I used QuickTime to record myself working out problems in a lesson while explaining the steps. In each module, students were asked to watch the screencast first before moving to the additional technology activity. The screencasts provided information that would help the students increase their performance with the technology tools. In a virtual setting, instruction through the teacher-made screencasts was optional and I was unable to gauge how many students watched the videos. A survey on screencast usage was given to students on day nine of the unit to assess how many students viewed the teacher-made screencasts.

Table 3.3

Rationale for Each Technology Tool

Day(s) of Unit	Rationale
1	- The teacher-made screencast provided direct instruction for the students on the Polygon-Angle Sum Theorems. This served as the primary method of instruction on day one. - The Polygon-Angle Sum Theorem problems were short and allowed for multiple choice responses; therefore, SRS was chosen as the technology tool for this day.
2/3	- The teacher-made screencast provided direct instruction for students on the properties of kites and trapezoids. Paired with CAI, these tools served as the method of instruction on days two and three. - IXL Math (IXL Learning, 2020) allowed students to practice problems on the properties of kites and trapezoids. Properties of quadrilaterals are often difficult for students, and CAI provides additional reinforcement for students who need extra assistance. Therefore, CAI was chosen as a technology tool for day two.
4/5	- The teacher-made screencast provided direct instruction for the students on the properties of parallelograms. Paired with CAI, these tools served as the method of instruction on days four and five. - Khan Academy (2020) provided instruction on the properties of parallelograms, as well as practice for students on this topic. The properties of parallelograms are one of the most difficult concepts for students to master in the unit on quadrilaterals. If students answered a question incorrectly, they were referred back to an instructional video, which reinforced the content from the teacher-made screencast. Therefore, CAI provided students with extra assistance and reinforcement on day five of the unit.
6/7	- The teacher-made screencast provided direct instruction for the students on the properties of special parallelograms. Paired with CAI, these tools served as the method of instruction on days six and seven. - iknowit (2020) provided an opportunity for students to practice what they knew about the properties of special parallelograms. If a student answered a question incorrectly, a correct explanation was provided. This gave students extra assistance on the properties of special parallelograms, which is a geometry topic that students often need additional reinforcement with.
8	- The teacher-made screencast provided direct instruction for students on the conditions of special parallelograms. This served as the primary method of instruction on day eight of the unit. - In Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020), students were able to practice their understanding of the conditions of special parallelograms. This tool was chosen because of the

fast pace of the game, which expected students to quickly recall the conditions for each type of parallelogram. In turn, this would make it easier for students to use the properties of parallelograms to solve problems.

MIXED-METHODS AND RATIONALE

This study used mixed-methods action research to gain insight into what technology strategies students prefer to use in an eLearning geometry setting, why students prefer these strategies, and how the technology is useful toward their development of and self-efficacy with the content knowledge. Action research is often used to improve students' learning and improve practice for the researcher (Efron & Ravid, 2013; Herr & Anderson, 2015). Therefore, action research methods were chosen for this study because the aim was to change the low engagement and understanding of geometry present in my core classroom (Efron & Ravid, 2013). Furthermore, my practice was likely to improve through the use of technology strategies in this action research study. Based on the results of this study, I am more likely to implement technology in future lessons.

Mixed-methods studies employ both qualitative and quantitative data in response to the research questions (Creswell & Creswell, 2018). Mixed-methods research holds advantages over solely quantitative and qualitative research because problems within the study can be triangulated through multiple types of data. Quantitative research holds strengths in generalizability, while qualitative research provides the opportunity for researchers to delve into a more comprehensive analysis of data (Creswell & Creswell, 2018). In this study, I employed mixed-methods because I could draw on the strengths of both qualitative and quantitative methods. This mixed-methods action research study used a triangulation design, where the qualitative and quantitative methods are integrated to answer questions under the same paradigm (Creamer, 2018). The questions that this action research study intended to address are:

1) What uses of technology do students find engaging in a virtual mathematics class when developing a new understanding of geometry?
2) Why do students prefer their selected use of technology over others?
3) How is their selected technology tool useful for the development of geometry knowledge?
4) What uses of technology increase students' self-efficacy in geometry?

Participants' thoughts about the technology tools they found most engaging and supportive of their development of content knowledge and self-efficacy were measured quantitatively and qualitatively. Measuring student engagement and thoughts on usefulness through both methods allowed me to draw on different perspectives and draw from different data sets (Creswell & Creswell, 2018). Drawing on both qualitative and quantitative methods for seeking students' opinions and understanding through the use of technology triangulated the data and provided a more robust description of the impact of technology in a geometry setting. Therefore, a mixed-methods approach to inquiry provided a sophisticated method to more thoroughly investigate participants' experiences than employing qualitative or quantitative methods alone.

TRIANGULATION DESIGN

For this study, a triangulation design was used to best answer research questions about students' engagement with technology, the perceived usefulness of technology tools, and student self-efficacy. A triangulation design is a mixed-methods approach to research where both qualitative and quantitative data are collected simultaneously (Creamer, 2018). In a triangulation research design, the researcher sets out to find agreement or convergence between results from different sources of data (Creamer, 2018). Accordingly, quantitative data collected through surveys and qualitative data collected through the post-administration survey and interviews were gathered throughout the study and analyzed together. The quantitative data from the Likert-scale surveys were triangulated by follow-up interviews with students to ensure the results were accurate. Results regarding students' overall engagement, perceived usefulness of technology, and self-efficacy were integrated throughout the data collection process. Furthermore, a post-administration survey that consisted of quantitative and qualitative questions provided a complete description of the participants' opinions toward the technology tools and its usefulness toward their development of content knowledge.

SETTING AND PARTICIPANTS

This study took place during the spring of 2020 in a rapidly growing high school in the southeastern portion of the United States. This school is comprised of 2,197 students. The participants of the study were my geometry core students. Permission to work with these students was obtained through a student and parent consent letter indicating the purpose of the study, why the study is important, and the potential benefits for students who are willing to participate in the study. This consent letter can be found in Appendix A. It was ultimately up to the students and their parents/guardians if they were willing to participate in my action research study.

This course had 17 students who range from tenth to twelfth grade. Of these 17 students, 14 returned their consent letters and agreed to participate in the action research study. Out of the 14 students, only 10 participated in this eLearning unit of instruction. The other 4 students were satisfied with their passing grade and did not complete the eLearning coursework for this unit of instruction when the school closed due to COVID-19. Of the 10 student participants, two students (20%) are female, seven (70%) are male, and one student is non-binary (10%). The sample of students consists of one Black student (10%), one Hispanic student (10%) and eight White students (80%). In many geometry core classes, there is a higher population of students who have ADHD than in College Preparatory (CP) or Honors level courses. There are two students (20%) who have been diagnosed with ADHD in this study. In addition to ADHD, one of these students (10%) also has Asperger's.

As stated in Chapter 1, my school setting, which served as the research site, is 1-to-1 in that each student has been provided with a MacBook Air. This technology allowed students to engage with the SRS, play math video games, learn through CAI, and access the screencasts on Canvas. Therefore, the perspective of all participants played a valuable role.

DATA COLLECTION

As stated in Chapter 1, multiple methods of data collection generated qualitative and quantitative datasets to thoroughly document experiences and students' opinions relevant to the study. The quantitative instruments were teacher-made Likert-scale surveys, which were administered daily within the six days when technology strategies were employed. Qualitative instruments in this study were semi-structured interviews throughout the study and an open-ended survey at the end of the 2-week unit. Student data on engagement with technology, perceived usefulness, and self-efficacy were gathered through quantitative surveys, semi-structured interviews, and an open-ended survey. Student data on preferences of technology tools were gathered through semi-structured interviews and the post-administration survey. An overview of the summary and timeline of all data collection methods is provided in Table 3.4. Table 3.5 provides an overview of the data collected to address each research question.

Table 3.4

Summary and Timeline of Data Collected

When	Data Collection Method	Type of Data	Purpose
Throughout study	Likert-Scale Surveys	Quantitative	Gauge students' ratings on engagement with the technology tools, student perceived effectiveness on the development of geometry knowledge, and student self-efficacy after engaging with the technology tool.
Throughout study	Semi-Structured Interviews	Qualitative	Provide detailed descriptions of students' opinions on engagement with the technology tools, student perceived effectiveness on development of geometry knowledge, and self-efficacy after engaging with the technology tool.
Conclusion of study	Post-Administration Survey	Qualitative Quantitative	Provide student reflection on technology tools' effectiveness on engagement and content knowledge development, provide student ratings on what technology tools were most engaging, as well as insight into what technology tool increased student self-efficacy. Gauge students' opinions on the teacher-made screencasts.

Table 3.5

Data Collection for Research Questions

Research Question	Data Collected
What uses of technology do students find engaging in a virtual mathematics class when developing a new understanding of geometry?	• Daily Likert-Scale Question 1 • High-Engagement Interview • Low-Engagement Interview • Post-Administration Survey
Why do students prefer their selected use of technology over others?	• Daily Likert-Scale Question 3 • High-Engagement Interview • Low-Engagement Interview • Post-Administration Survey
How is their selected technology tool useful for the development of geometry knowledge?	• Daily Likert-Scale Question 2 • High-Engagement Interview • Low-Engagement Interview • Post-Administration Survey
What uses of technology increase students' self-efficacy in geometry?	• Daily Likert-Scale Question 4 • High-Engagement Interview • Low-Engagement Interview • Post-Administration Survey

LIKERT-SCALE SURVEYS

At the end of each lesson when students engaged with technology, data were collected quantitatively through the Likert-scale surveys in Appendix B. Likert-scale surveys are questionnaires that provide pre-determined responses for participants (Efron & Ravid, 2013). In this study, the four response choices ranged from strongly agree to strongly disagree. An even number of responses forces the participants to share their thoughts on one side versus another, rather than having a neutral opinion (Efron & Ravid, 2013). For this study, the participants provided data that supported their positive or negative opinions of the technology tools.

A Likert-scale survey was administered for each of the six days of the unit when technology was employed during instruction. This survey measured students' engagement with the technology tools used in the module, the tools' perceived usefulness toward understanding geometry, and students' self-efficacy after engaging with the technology tools. The Likert-scale survey at the end of each lesson provided students with the opportunity to voice their opinion on the technology tools that were employed and generated quantitative data in alignment with my research questions. Surveys were administered on students' MacBook Airs through Google Forms.

SEMI-STRUCTURED INTERVIEWS

After implementing the technology learning strategies, I conducted semi-structured interviews with students to elicit their opinion on their engagement, technology's impact on their understanding of geometry, and their self-efficacy. Semi-structured interviews are the most common questioning style in mixed-methods research and are employed when the researcher is familiar enough with the topic to be able to create a comprehensive list of questions but cannot foresee all of the answers to those questions (Morse, 2012). For each semi-structured interview, I used the basic list of interview questions in Appendix C and Appendix D, and additional questions were added depending on the participants' responses. The interview protocol in Appendix C was used for students who expressed high levels of engagement on their Likert-scale surveys, and the interview protocol in Appendix D was used for students who expressed low levels of engagement. Semi-structured interviews were chosen for this action research study so I could expand on student responses on a particular topic. This allowed me to delve deeper into specific areas.

As noted above, I purposefully selected students to be interviewed based on their Likert-scale data. After analyzing the survey data each day, I selected two interviewees: a student with a high percentage of positive responses and a student with a high percentage of negative responses. If only one student exhibited positive or negative responses during multiple activities, then that student was selected for all applicable interviews. Otherwise, different students were chosen based on their responses to the Likert-scale surveys.

These interviews were conducted through WebEx on a day following students' submission of the Likert-scale survey. WebEx is a video conferencing tool integrated with the district's Canvas learning management system. The participants who were interviewed met with me through WebEx to clarify their answers on their Likert-scale surveys and provide a more complete understanding of their thoughts and experiences. This provided more accurate data and triangulated the data with students' quantitative responses. Student responses were recorded and later transcribed. The data were coded soon after each interview.

POST-ADMINISTRATION SURVEY

After the two-week unit, students took a mixed-methods survey on their opinions of the technology tools' impact on their engagement and overall usefulness of the technology tools. The mixed-methods survey, located in Appendix E, provided a numerical representation of the students' opinions, as well as qualitative data on why they chose their Likert-scale responses. Data were blended to provide a complete description of the participants' opinions toward the selected technology tools.

DATA ANALYSIS

This section will discuss the methods of data analysis for the data sources described in the previous section. Quantitative and qualitative data merit different forms of analysis, yet in alignment with my mixed-methods design, the data were also blended to answer the research questions.

QUANTITATIVE DATA

At the end of each module featuring a technology strategy, the Likert-scale survey raw data were displayed in a data table and the mean for each question was calculated. The quantitative data were then analyzed with the qualitative data collected in the study. On the final day of the unit, the responses for the different technology tools were compared to discover what technology tools students found most engaging, useful to their understanding of geometry, and beneficial to their self-efficacy.

QUALITATIVE DATA

Qualitative data obtained through semi-structured interviews were coded immediately after each technology strategy was implemented. Throughout the study, I employed the grounded theory method of analysis by comparing and analyzing different data sets to determine themes (Merriam & Tisdell, 2016). Grounded theory involves breaking down the qualitative data into smaller subsets and evaluating them for relevant components. In this study, those components included student preferences of technology tools, each tool’s usefulness toward the development of content knowledge, and student self-efficacy after using technology tools. I then determined dominant and lesser themes in the qualitative data (Saldaña, 2013).

As I gathered more qualitative data, I continued comparing and categorizing the data to align with the purpose of the study and the theoretical framework (Merriam & Tisdell, 2016). The qualitative data were triangulated with the Likert-scale quantitative data to discover convergence among the different forms of data toward a common theme (Creamer, 2018).

The final mixed-methods survey was analyzed after the intervention. All other qualitative and quantitative data from this study were already coded, and the data obtained from this survey were analyzed and coded.

Initial Coding

Initial coding allows for the researcher to divide the data into smaller parts and for each part to receive its code (Saldaña, 2013). Data were divided into different groups based on similar themes. This process allowed me to remain open to the direction of the data, without predetermined themes.

Axial Coding

After initial coding was complete, the axial coding process began. In this step, codes that were created during the initial coding phase were combined, where appropriate. Codes were not changed by altering the meaning or context of the data; however, the codes were designed to create an organization of ideas and overarching themes (Saldaña, 2013). At this stage, all codes from interviews and open-ended survey questions were merged to formulate axial codes.

Theoretical Coding

The final step in coding was the development of theoretical codes. These codes show a relationship or connection among the axial codes and theoretical framework

(Charmaz, 2014). As stated in Chapters 1 and 2, student self-efficacy in mathematics, Uses and Gratifications Theory (UGT), and TAM3 serve as the theoretical framework in this study. Student self-efficacy is students' belief in their ability to succeed, which can positively impact their engagement (Chao et al., 2016; Liu et al., 2018). The UGT accepts that technology use is intentional, and users seek to use technology to meet their individual needs (Gallego et al., 2016). TAM3 acknowledges that when users believe technology is easy to use and useful toward their intent, they are more likely to use the technology regularly (Onal, 2017). I categorized axial codes through the lenses of student self-efficacy, the UGT, and TAM3. The results of this process will be presented in Chapter 4.

ETHICAL CONSIDERATIONS

This action research study employed insider research because I served as the practitioner of the study (Herr & Anderson, 2015). I have a rapport with the participants in the study and had taught these students for fourteen weeks before conducting this action research study. Because of this, students may have felt compelled to respond to questions in a manner that would be to my liking. To combat this, I discussed with students, before semi-structured interviews, that I wanted honest responses from them.

Another ethical consideration in this study was the privacy of the participants. Pseudonyms were used instead of participants' names. This ensured the confidentiality of the participants in the study when analyzing and discussing data. The participants were reassured that their responses would remain anonymous when necessary.

This action research study had the potential to benefit the students, as well as my practice. Technology strategies were implemented to potentially increase student engagement, self-efficacy, and understanding of geometry. This action research study employed techniques that qualify it as high-quality action research. These included measures to triangulate data and multiple forms of data collection. Ethically, quality action research must be conducted for valid results.

QUALITY CONSIDERATIONS

Multiple methods of data collection ensured triangulation for data related to student engagement, self-efficacy, and usefulness of the technology strategies toward content knowledge development. In triangulation, researchers use additional evidence from their study to support their findings (Plano Clark & Creswell, 2010). Triangulation also helps clarify meaning for the researcher. In terms of student engagement, Likert-scale surveys, semi-structured interviews, and an open-ended survey were used for triangulation. Similarly, each of these data collection methods were used to provide a rich description of students' opinions on the usefulness of the technology tools toward their self-efficacy and understanding of geometry.

Action research is considered valid when it generates new knowledge and is relevant to the setting (Herr & Anderson, 2015). In this action research study, students' opinions toward technology strategies in an eLearning environment provided new insight into their engagement. This generated new knowledge on student engagement in an eLearning secondary mathematics setting that may be useful in other settings. This action research study is relevant to my setting because of the lack of intrinsic motivation from the majority of students in core level mathematics courses. Collecting and analyzing data to discover what technology tools students found most engaging and useful toward their understanding of mathematics provided insight for other core mathematics teachers in the setting of the study.

SUMMARY

Chapter 3 discussed the mixed-methods design for this action research study and the rationale for choosing mixed-methods. It also provided background about the setting and participants of the study. The data collection methods, which include Likert-scale surveys, semi-structured interviews, and the post-administration survey, were discussed in their entirety. Finally, the methods for data analysis and other considerations were provided. Chapter 4 will analyze and reflect on the data collected in this action research study.

CHAPTER 4

DATA ANALYSIS

The purpose of this study was to increase the student engagement of my geometry core students by determining what students find engaging and useful toward their development of geometry content knowledge. Chapter 3 discussed the data collection and analysis plan for this mixed-methods action research. This chapter will convey the findings from the data collected throughout the intervention, which encompassed the following technology strategies: gamification, student response systems (SRS), teacher-made screencasts, and computer-assisted instruction (CAI). These were implemented through Canvas, the school district's learning management system. Quantitative data were collected through Likert-scale surveys and a post-administration survey. Qualitative data were collected through student interviews using WebEx, an online video conferencing tool, and open-ended questions on the post-administration survey. As indicated in Chapter 3, data were blended through a triangulation design.

The study was conducted over the course of a two-week instructional unit on quadrilaterals. As discussed in Chapter 3, a statewide quarantine occurred during the data collection phase of this study; therefore, I collected all data virtually, guided by the research questions of this action research study: 1) What uses of technology do students find engaging in a virtual mathematics class when developing a new understanding of geometry? 2) Why do students prefer their selected use of technology over others? 3)

How is their selected technology tool useful for the development of geometry knowledge? 4) What uses of technology increase students' self-efficacy in geometry?

In the following sections, I will present the mixed-methods data on students' perception of SRS, gamification, CAI, and teacher-made screencasts. As explained in Chapter 3, students used SRS during one day of instruction, gamification methods during one day of instruction, CAI during three days of instruction, and teacher-made screencasts during nine days of instruction. The teacher-made screencasts were used more frequently because the served as the primary source of instruction throughout the COVID-19 quarantine.

MIXED-METHOD RESULTS

In each subsection below, the Likert-scale survey data and interview question data are discussed using the triangulation design. For each technology strategy, the quantitative Likert-scale data were collected first, followed by the qualitative interview data. Both qualitative and quantitative data were analyzed simultaneously to find an agreement among the data (Creamer, 2018). The mixed-methods data for SRS, CAI, gamification, and the teacher-made screencasts are provided below.

STUDENT RESPONSE SYSTEMS

Students used SRS on the first day of the instructional unit on quadrilaterals. After students engaged with the SRS activity, they completed a Likert-scale survey (Appendix B) that measured their enjoyment when participating in the activity and the activity's contribution toward their understanding of the Polygon Interior/Exterior Sum Theorems. Furthermore, using the Uses and Gratifications Theory (UGT), the Likert-scale survey measured students' perceptions of the Kahoot activity's ease of use. Table 4.1 presents the statements, responses, and average for each statement in the Likert-scale survey. Students who selected a response of 1 said they "Strongly Disagreed" with the statement, 2 said they "Disagreed" with the statement, 3 said they "Agreed" with the statement, and 4 said they "Strongly Agreed" with the statement.

Table 4.1

SRS Likert-Scale Data

Statement	1	2	3	4	*M*
I found the Kahoot activity enjoyable today.	0	2	3	5	3.30
I found the Kahoot helpful toward my understanding of polygon angle sums.	0	1	3	6	3.50
I found the Kahoot activity user-friendly (easy to use).	0	0	3	7	3.70
I feel more confident in how to find the sums of angles in a polygon.	0	0	6	4	3.40

Each of the Likert-scale questions averaged between (3) "Agree" and (4) "Strongly Agree." After analyzing the Likert-scale data, I purposefully selected two students to participate in an interview based on their positive or negative experiences with SRS. The data were coded using the grounded theory method of analysis. After the initial coding and axial coding phase referenced in Chapter 3, I coded student responses to high- and low-engagement interview questions and the post-administration survey questions into four categories that helped me remain focused on answering the research questions and theoretical framework. In Table 4.2, the codes and examples for each research question are provided.

Table 4.2

SRS Codes Used for Analysis

Code	Meaning	Example
STES	Aligning with UGT, students' thoughts on engagement with SRS	"It's really fun"
SES	Aligning with TAM3, students' experience with SRS and perceived ease of use	"I did not like the time limit"
STDS	Aligning with TAM3 and UGT, students' thoughts on usefulness to develop content knowledge with SRS	"The answers after each question gave me information on if I correctly completed the problem"
STSS	Students' thoughts on SRS and self-efficacy	"I felt more confident in my learning of the material and that the Kahoot was a good way of testing what I learned"

COMPUTER-ASSISTED INSTRUCTION

Students engaged with CAI on days two, five, and six of the instructional unit on quadrilaterals. On day two, students engaged with IXL Math (IXL Learning, 2020) when developing an understanding of the properties of kites and trapezoids. On day five, students participated in CAI through Khan Academy (2020), and on day six, students participated in CAI using iknowit (2020).

After engaging with each CAI activity, students completed a Likert-scale survey. Table 4.3 is specific to day two of the instructional unit, Table 4.4 is specific to day five of the instructional unit, and Table 4.5 is specific to day six of the instructional unit. Each table provides the Likert-scale survey questions and data. Finally, Table 4.6 provides the overall Likert-scale survey data for all of the CAI lessons.

Table 4.3

CAI Day 2 Likert-Scale Data

Statement	1	2	3	4	*M*
I found the IXL Math instructional program enjoyable.	2	2	3	3	2.70
I found the IXL Math instructional program helpful toward my understanding of the properties of kites.	0	2	4	4	3.20
I found the IXL Math instructional program user-friendly (easy to use).	0	4	4	2	2.80
I feel more confident in my understanding of kites.	0	2	5	3	3.10

Table 4.4

CAI Day 5 Likert-Scale Data

Statement	1	2	3	4	*M*
I found the Khan Academy activity enjoyable today.	0	0	3	7	3.70
I found the Khan Academy activity helpful toward my understanding of the properties of parallelograms.	0	1	3	6	3.50
I found the Khan Academy activity user-friendly (easy to use).	0	0	1	9	3.90
I feel more confident in my understanding of the properties of parallelograms.	0	0	2	8	3.80

Table 4.5

CAI Day 6 Likert-Scale Data

Statement	1	2	3	4	*M*
I found the online activity enjoyable today.	1	1	5	3	3.00
I found the online activity helpful toward my understanding of the properties of special parallelograms.	0	2	5	3	3.10
I found the online activity user-friendly (easy to use).	1	0	5	4	3.20
I feel more confident in my understanding of the properties of special parallelograms.	1	2	5	2	2.80

Table 4.6

CAI Cumulative Likert-Scale Data

Statement	1	2	3	4	*M*
S-1: Engagement	3	3	11	13	3.13
S-2: Understanding	0	5	12	13	3.27
S-3: Ease of Use	1	4	10	15	3.30
S-4: Self-Efficacy	1	4	12	13	3.27

After analyzing the Likert-scale data each day, I purposefully selected two students (i.e. six students total) to participate in an interview based on their positive or negative experiences with CAI. As explained in Chapter 3, the data were coded using the grounded theory method of analysis by initial coding, axial coding, and finally theoretical coding. I coded student responses to high- and low-engagement interview questions and the post-administration survey questions into four categories that aligned with my theoretical framework and helped me remain focused on answering the research questions. In Table 4.7, the codes and examples for each research question are provided.

Table 4.7

CAI Codes Used for Analysis

Code	Meaning	Example
STEC	Aligning with UGT, students' thoughts on engagement with CAI	"The little guy would do tricks which made me want to keep playing"
SEC	Aligning with TAM3, students' experience with CAI	"I do not like that IXL math times you"
STDC	Aligning with TAM3 and UGT, students' thoughts on usefulness to develop content knowledge with CAI	"I found it useful. The explanations were very helpful"
STCS	Students' thoughts on CAI and self-efficacy	"I felt more confident, because even if I got it wrong IXL would explain how to fix it easy"

GAMIFICATION

Students engaged with Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) on the eighth day of the instructional unit on quadrilaterals. After students engaged with the geometry game, they completed a Likert-scale survey (Appendix B) that measured their enjoyment when participating in the activity and the contribution toward their understanding of special parallelograms. These Likert-scale surveys also aligned with UGT and measured perceived ease of use while playing the game. Table 4.8 presents the statements, responses, and average for each statement for the Likert-scale Survey. Students who selected a response of 1 said they "Strongly Disagreed" with the statement, 2 said they "Disagreed" with the statement, 3 said they "Agreed" with the statement, and 4 said they "Strongly Agreed" with the statement.

Table 4.8

Gamification Likert-Scale Data

Statement	1	2	3	4	*M*
I found the Call of Geometry game enjoyable today.	1	0	2	6	3.44
I found the Call of Geometry game helpful toward my understanding of the properties of special parallelograms.	0	2	2	5	3.33
I found the Call of Geometry game activity user-friendly (easy to use).	1	2	2	4	3.00
I feel more confident in my understanding of the properties of special parallelograms	0	2	3	4	3.22

After analyzing the Likert-scale data, I purposefully selected two students to participate in an interview based on their positive or negative experiences with Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020). Once again, the data were coded using the grounded theory method of analysis as I developed initial, axial, and theoretical codes. I coded student responses to high- and low-engagement interview questions and the post-administration survey questions into four categories that aligned with the theoretical framework and helped me remain focused on answering the research questions. In Table 4.9, the codes and examples for each research question are provided.

Table 4.9

Gamification Codes Used for Analysis

Code	Meaning	Example
STEG	Aligning with UGT, students' thoughts on engagement with gamification	"Call of Geometry is a fun game"
SEC	Aligning with TAM3, students' experience with gamification	"I enjoyed the functionality"
STDG	Aligning with TAM3 and UGT, students' thoughts on usefulness to develop content knowledge with gamification	"It helped me understand the material, but I did not enjoy it at all"
STGS	Students' thoughts on gamification and self-efficacy	"I feel more confident that I know the shapes"

TEACHER-MADE SCREENCASTS

Teacher-made screencasts were used during nine days of the instructional unit to provide instruction and information to the students. On the final instructional day of the unit, students were asked to complete a Likert-scale survey (Appendix B) that measured their usage, engagement, content knowledge development, and ease of use with the teacher-made screencasts. Table 4.10 presents the statements, responses, and average for the Likert-scale survey. Students who selected a response of 1 said they "Strongly Disagreed" with the statement, 2 said they "Disagreed" with the statement, 3 said they "Agreed" with the statement, and 4 said they "Strongly Agreed" with the statement.

Table 4.10

Teacher-Made Screencasts Likert-Scale Data

Statement	1	2	3	4	*M*
I use the teacher-made screencasts on Canvas.	2	1	2	5	3.00
I find the teacher-made screencasts engaging.	1	3	0	6	3.20
I find the teacher-made screencasts helpful toward my understanding of geometry.	0	1	4	5	3.40
I find that accessing the teacher-made screencasts on Canvas is easy.	0	1	0	9	3.80
I feel more confident in my ability to understand geometry after watching the teacher-made screencasts.	0	1	1	8	3.70

Qualitative data for the teacher-made screencasts were collected through the post-administration survey. The data were coded into four different categories to align with the theoretical framework and research questions. In Table 4.11, the codes and examples for each research question are provided.

Table 4.11

Teacher-Made Screencast Codes Used for Analysis

Code	Meaning	Example
STET	Aligning with UGT, students' thoughts on engagement with teacher-made screencasts	"I found the screencasts engaging because they helped me understand"
SET	Aligning with TAM3, students' experience with teacher-made screencasts	"Using the screencasts helps me understand my work more because I can rewind the video and have a better understanding"
STDT	Aligning with TAM3 and UGT, students' thoughts on usefulness to develop content knowledge with teacher-made screencasts	"It was helpful because if I didn't understand something I could go back to the video and re-learn it"
STTS	Students' thoughts on teacher-made screencasts and self-efficacy	"I felt more confident in learning the material using the screencasts. I enjoyed the activities more because I could test what I learned"

POST-ADMINISTRATION SURVEY

After the implementation of all technology strategies, students were asked to complete the Post-Administration Survey (Appendix E). This survey was comprised of an ordinal question, four qualitative questions, and three quantitative questions. The qualitative data were coded and blended with the data from the high- and low-engagement interviews. The first question asked students to rate the technology tools in order from their favorite (1) to their least favorite (5). The results from this question are in Figure 4.1.

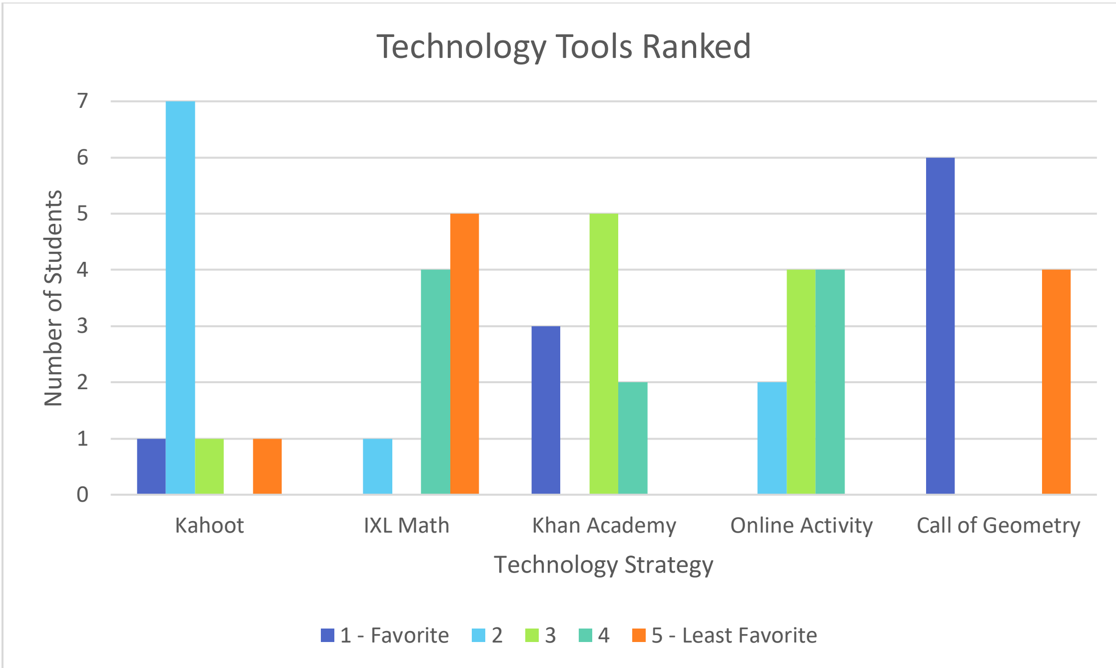

Figure 4.1 Student Rankings of Technology Tools

A majority of students (60%) selected the Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) game as their favorite; however, the other 4 students (40%) selected this as their least favorite. Khan Academy (2020) received the second most votes for favorite technology tool (30%). IXL Math (IXL Learning, 2020) earned the highest percentage (50%) for least favorite technology tool.

Students were asked to decide which of the five technology tools they thought benefited them most in developing an understanding of geometry. Student responses to this question are provided in Figure 4.2. No students selected Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020), IXL Math (IXL Learning, 2020), or iknowit (2020) as their preferred way to develop their content knowledge. Khan Academy (2020) and Kahoot were split with 5 votes each as the most beneficial technology tool for developing an understanding of geometry.

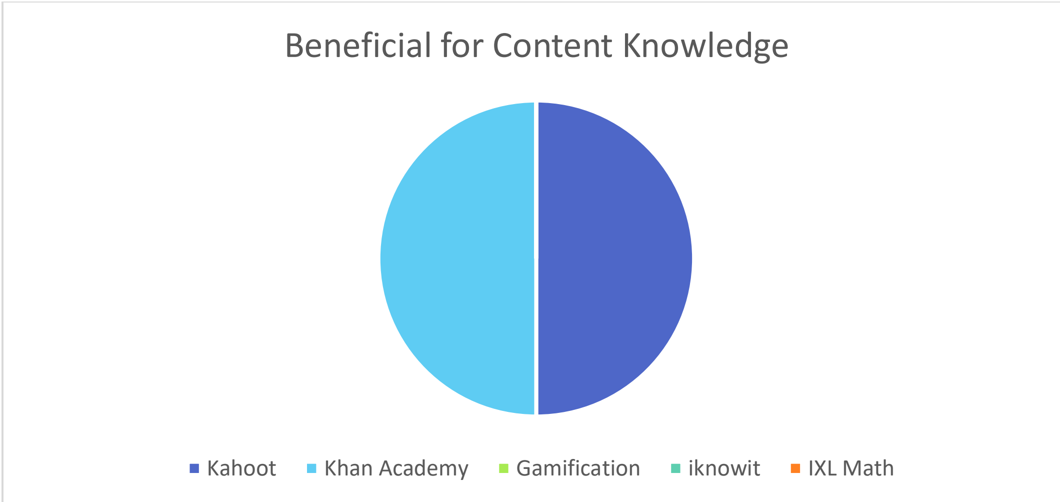

Figure 4.2 Students' Selected Technology for Content Knowledge Development

Lastly, students were asked which technology tool made them feel the most confident in their understanding of the material. Student responses to this question are provided in Figure 4.3. Khan Academy (2020) was selected as the technology tool that raised students' self-efficacy the most with 5 votes. Kahoot was voted the second most with 3 votes, and Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) was third with 2 votes. IXL Math (2020) and iknowit (2020) did not receive any votes for increasing students' self-efficacy.

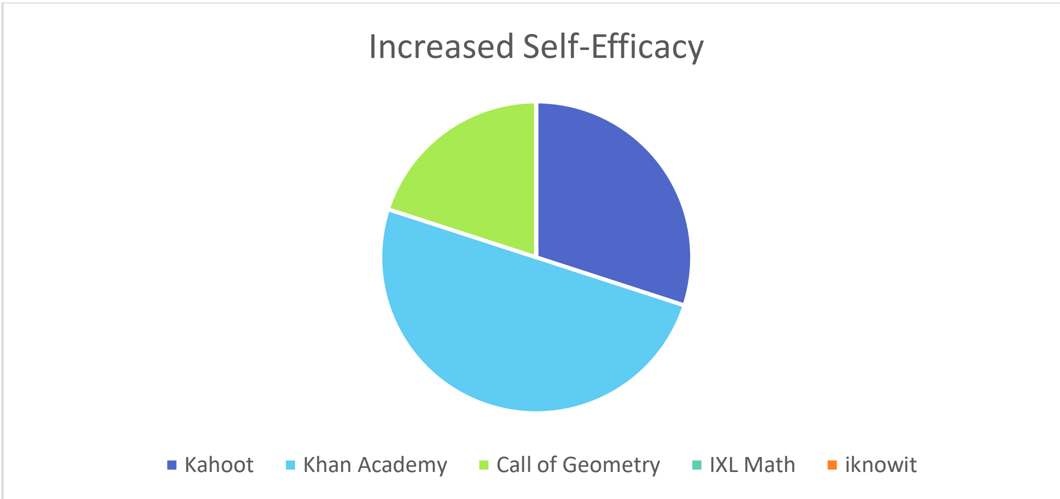

Figure 4.3 Students' Selected Technology for Increased Self-Efficacy

DISCUSSION

After collecting and analyzing the data from each of the days when students engaged with the technology tools, I began the second phase of data analysis to answer the research questions. Data from the Likert-scale surveys, interviews, and post-administration survey were separated by research question and blended. The following subsections show the data analysis process for each research question. In addition, a final subsection provides data from the two students in this study who have ADHD.

RQ1: STUDENT ENGAGEMENT

Student engagement with each technology tool was measured through each of the Likert-scale surveys, the high- and low-engagement interviews, and the post-administration survey. Each Likert-scale survey had a question pertaining to students' level of enjoyment with the technology. This question was used to assess if students were engaged with the technology tool. Table 4.12 displays the technology tool and the mean for each of the Likert-scale surveys.

Table 4.12

Engagement Likert-Scale Data

Technology Tool	*M*
Kahoot	3.30
IXL Math	2.70
Khan Academy	3.70
iknowit	3.00
Call of Geometry	3.44
Teacher-Made Screencasts	3.20

Except for IXL Math (IXL Learning, 2020), all of the technologies had an average between 3 (Agree) and 4 (Strongly Agree) in the Likert-scale surveys. Khan Academy (2020) had the highest average for student engagement. Students expressed that they enjoyed Khan Academy, especially when compared to the other methods of CAI. Six out of ten students expressed engagement with Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020). Every response from students who enjoyed the math video game used the word fun. When asked why it was fun, Peter said, “I liked that it was like a video game.” In a high-engagement interview, Jerry said he was engaged with the game because although he knew the shapes, he was expected to think quickly while playing. Other students noted that the game had similarities with Call of Duty, because of the name and because they were shooting at quadrilateral targets. Pedro said he liked Call of Geometry: A Quadrilateral Warfare the best because he was able to compete with his friends and with students across the world on the leaderboard. Kim, a student who rarely engages with math activities, also expressed that she was engaged with the game because, “It made me feel like I wasn’t doing math.” Ali said that although it is fun, it is also a great way to learn about the properties of quadrilaterals.

Kahoot had the third-highest average for student engagement. Kit rated Kahoot as the most engaging technology in their post-administration survey, stating “It’s really fun because it’s interactive and helps me learn.” As with gamification, students also expressed that they enjoyed competing against their friends on the leaderboard. Pedro said, “Even though I can’t see my friends, it’s cool that I can still compete against them with Kahoot.”

Students who found all methods of CAI engaging thought it was interactive, easy to use, and encouraging. When Luke was asked why he found IXL Math (IXL Learning, 2020) engaging, he said, “The activity helped me understand what to do in an easy fashion,” although he went on to say that “IXL Math is a great website to use for math, but is not as fun when compared to Kahoot.” When Ali was asked what she found engaging about IXL Math, she said she enjoyed the positive reinforcement from the website; however, she did not like there was a timer for each question.

When compared to the other technology tools, the teacher-made screencasts had a lower overall average for student engagement. However, in the post-administration survey, eight out of ten participants said they were engaged with the screencasts because it helped them understand the content better. Jerry spoke on his experience in other courses where he did not find the teacher-made screencasts engaging; however, he found my screencasts engaging because, “She explains things so that they are easy to understand.” Students were engaged with the teacher-made screencasts to learn the content but did not find them as fun as the other technology tools. Pedro stated, “The videos help when I’m in the mood to watch one. They are not as exciting as the activities.”

RQ2: STUDENT PREFERENCE

Student preference of technology was measured through each of the Likert-scale surveys, the high- and low-engagement interviews, and the post-administration survey. Using TAM3, each Likert-scale survey had a question about the ease of use with the technology. Table 4.13 displays the technology tool and the mean for each of the Likert-scale surveys.

Based on the averages, students rated Khan Academy as the easiest technology to use. Although Khan Academy had the highest average, almost every technology had an average above 3, which fell between “Agree” and “Strongly Agree” on the Likert-scale surveys. IXL Math (IXL Learning, 2020) was the only technology tool that fell below “Agree”.

The teacher-made screencasts had the second-highest average for students’ perceived ease of use. TAM3 expresses that students are more likely to enjoy a user-friendly technology. The teacher-made screencasts were uploaded into a module on Canvas each day for students to access, so students were more likely to be familiar with these technology tools. Pedro enjoyed that the screencasts were easy to access, stating, “I like that the screencasts are already on Canvas and that I know I won’t have any technology issues.” In the post-administration survey, all students said they enjoyed the teacher-made screencasts because they were helpful and easy to use. Two of the five students expressed that they were able to re-watch the videos if they had difficulty during a technology activity.

Table 4.13

Ease of Use Likert-Scale Data

Technology Tool	*M*
Kahoot	3.70
IXL Math	2.80
Khan Academy	3.90
iknowit	3.20
Call of Geometry	3.00
Teacher-Made Screencasts	3.80

Kahoot had the third-highest ranking for ease of use. Kit expressed that Kahoot was their favorite use of technology because they found it fun and interactive, although Peter ranked Kahoot as his least favorite technology. In the post-administration survey, he stated that it was his least favorite because of the time limit. Pedro also discussed that he did not prefer this over the methods of CAI, stating, “I did not like that there was not an explanation to get the right answer. I would answer the question, get the wrong answer, and did not have time to relearn to get the right answer.” In a traditional setting, time in between questions can be used by the teacher to alleviate this issue; however, in a virtual setting, students would have to take it upon themselves to relearn the content in between questions.

Although Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) received a low average for perceived ease of use, Figure 4.1 showed students’ favorite (1) to least favorite (5) technology tools ranked, where six out of ten students ranked the game as their favorite technology tool. Using UGT, the post-administration survey asked why their top-ranked technology tool was their favorite. Students who chose Call of Geometry: A Quadrilateral Warfare expressed that they found the game engaging and easy to use. Peter stated, “I enjoyed the functionality,” while Ali and Luke said that it was a fun way to learn. Jerry did not rate the game as his favorite; however, he did state, “It went a little fast, but it made me think on my feet. Once I slowed down and paid attention, I did better.” Kit rated the game as their least favorite technology tool, explaining, “it’s way too difficult to understand and see the shapes.” Kit also went on to say that video games are not of interest to them.

The iknowit (2020) and IXL Math (IXL Learning, 2020) uses of CAI were the least favorite for a majority of students. When asked in the post-administration survey why it was the least favorite, students expressed that it was not as fun and that they did not like the time limit. Pedro stated, “It was like taking a quiz using technology,” and he did not like that he would have to go back and relearn the material to do well in the activities. Kim also discussed how she did not like IXL Math because she had used it too many times before this class, stating “I’m sick of using IXL Math. We used it all of the time in middle school.” Although it may not have been as engaging for students, four out of ten students commented on the fact that it was easy to use.

RQ3: USEFULNESS TO CONTENT KNOWLEDGE

Student opinions on the technology tools they found most useful to developing their knowledge were measured through each of the Likert-scale surveys, the high- and low-engagement interviews, and the post-administration survey. Using TAM3 and UGT, each Likert-scale survey had a question pertaining to how useful they felt the technology tool was to meet their individual learning needs. Table 4.14 displays the technology tool and the mean for each of the Likert-scale surveys.

Table 4.14

Usefulness of Technology Likert-Scale Data

Technology Tool	*M*
Kahoot	3.50
IXL Math	3.20
Khan Academy	3.50
iknowit	3.10
Gamification	3.33
Teacher-Made Screencasts	3.40

On average, students rated each of the technology tools as useful toward their development of content knowledge between “Agree” and “Strongly Agree.” Kahoot and Khan Academy (2020) had the highest average from students. Ali discussed that she found Kahoot helpful because “The instant feedback gave me information on if I correctly completed the problem.” She also said that this helped her understand the Interior Angle Sum Theorem more than she had at the beginning of the lesson. Similarly, Pedro said he found Kahoot helpful because “I could see if the answers were wrong right away and figure out how to fix it.” Pedro elaborated that if the answers were wrong, he knew he had to quickly determine how to effectively complete the problems to end up with a high score.

Although the average of all CAI tools was not as high, Khan Academy (2020) was tied with SRS as the highest, with an average of 3.50. Students mostly expressed that they found the Khan Academy activity useful toward their development of content knowledge. After engaging with Khan Academy, Luke stated, “The explanations were very helpful” and that the activity helped him better understand the content. Mike agreed that the Khan Academy activity was helpful, saying, “It reinforced what I learned in the module.” Cheyenne rated Khan Academy as the most helpful because she could use the teacher-made materials along with the Khan Academy materials to have a stronger understanding of the content.

The teacher-made screencasts were the second-highest rated tool for students to develop their content knowledge. In the post-administration survey, six of the ten students used the word helpful in their response to their opinion on the screencasts' usefulness to their understanding of the content. Ali said she found them useful, because "If I didn't understand something, I could go back in the video and relearn it." She particularly found this useful while engaging with the technology activities after watching the screencasts. In the modules, it was recommended that students watch the teacher-made screencasts first before engaging with the technology tools. Pedro discussed that although he found the teacher-made screencasts helpful, they were less engaging than some of the other technology tools, stating, "The videos help when I'm in the mood to watch one." I followed this up with a question regarding whether he watched the videos before engaging with the technology tools, and he said he would sometimes skip straight to the activity if he did not want to watch the screencast and go back to the screencast if he was struggling.

On average, gamification was rated third as the most effective technology strategy for content knowledge development. In interview questions and the post-administration survey, students had mixed emotions toward Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020). Kit expressed that the game was helpful, but that they did not enjoy engaging with it at all. Jerry also briefly stated, "I think it was useful in practicing the shapes," but he spoke more about how the game was engaging. Cheyenne did not find the game useful toward developing content knowledge, stating, “I didn’t feel like I was getting much information out of it because it moved so fast.”

Overall, iknowit (2020) and IXL Math (IXL Learning, 2020) had the lowest average from students when questioned about the usefulness of the technology supporting their development of content knowledge. When asked his thoughts about the iknowit (2020), Pedro stated, “I know more about the ones I got wrong, but I did not do well in the activity.” He elaborated that although explanations were provided for the problems he completed incorrectly, the explanations for those problems were unhelpful for different problems. This differed from the Khan Academy activity, which provided supplemental questions on the problems that students completed incorrectly.

RQ4: STUDENT SELF-EFFICACY

Students’ self-efficacy after engaging with the technology tools was measured through each of the Likert-scale surveys, the high- and low-engagement interviews, and the post-administration survey. Each Likert-scale survey had a question about their confidence level in their understanding of the content after engaging with the technology tools. Table 4.15 displays the technology tools and the mean for each of the Likert-scale surveys.

The data show that students agreed that their confidence level increased after engaging with each of the technology tools, except for with iknowit (2020). On average, students found Khan Academy increased their confidence level with the content the most. Kit expressed that Khan Academy made them feel more confident because “It helped me with explanations about how to correct my work.” When asked about IXL Math (IXL

Learning, 2020), Pedro said “I feel a little better about the lesson, but I don’t feel as good as when I used Khan Academy.”

Students also expressed that the teacher-made screencasts increased their confidence in the content. Students discussed that they felt more connected to their peers, teacher, and the course while watching the teacher-made screencasts. When asked about the teacher-made screencasts, Jerry stated, “I feel like I am back in the classroom when I hear Ms. Knapp talking on the video.” This sense of normalcy helped his self-efficacy with the content. Kahoot had the third-highest average from students. Ali said she felt more confident with the teacher-made screencasts aligned with Kahoot, stating “I felt more confident in my learning of the material and the Kahoot was a good way of testing what I learned.”

Table 4.15

Self-Efficacy Likert-Scale Data

Technology Tool	*M*
Kahoot	3.40
IXL Math	3.10
Khan Academy	3.80
iknowit	2.80
Gamification	3.22
Teacher-Made Screencasts	3.70

Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) had the fourth-highest average for student self-efficacy. Kit expressed that they felt less confident because of the fast pace of the game. Jerry hesitantly expressed in his high-engagement interview that he “thinks” he feels more confident with his knowledge of the shapes. When speaking with students about the game, it was clear that they thought it was fun, but did not feel as confident when compared to Khan Academy (2020), the teacher-made screencasts, and Kahoot.

IXL Math (IXL Learning, 2020) and iknowit (2020) were ranked the lowest for students' self-efficacy. Mike said he did not feel as confident when engaging with IXL Math because of the "smart score," stating, "If it's not high, I don't feel smart." However, Luke expressed that he felt more confident after using IXL Math, saying, "Even if I got it wrong, IXL would explain how to fix it easy." Although iknowit (2020) had the lowest overall average, Ali expressed that she found a little character in the activity encouraging while engaging with the technology tool. Ali said, "The little guy would do tricks when I got one right and that was encouraging to me because it let me know I was doing good."

STUDENTS WITH ADHD RESULTS

Two students in this study, Peter and Cheyenne, have been diagnosed with ADHD. Peter has also been diagnosed with Asperger's and expressed apprehension about participating in an all-virtual setting during the quarantine. After speaking with him individually, he decided he would feel comfortable piloting an all-virtual setting with a plan put in place to receive paper and pencil materials if necessary. After the implementation of technology, Peter expressed that he was very happy with all of the technology tools and was surprised that he did as well as he did in an all-virtual setting. Peter and Cheyenne's rankings of their favorite technology tool to least favorite technology tool is shown in Figure 4.4.

The results show that Peter and Cheyenne had different opinions on Kahoot and Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020). However, both students ranked all of the methods of CAI above their least favorite technology tool.

Peter and Cheyenne both stated on their post-administration survey that they watched the teacher-made screencasts and found them beneficial to their understanding of the content. These results align with the study conducted by Graves et al. (2011) because students were able to re-watch and use the screencasts to clarify their understanding of the course content.

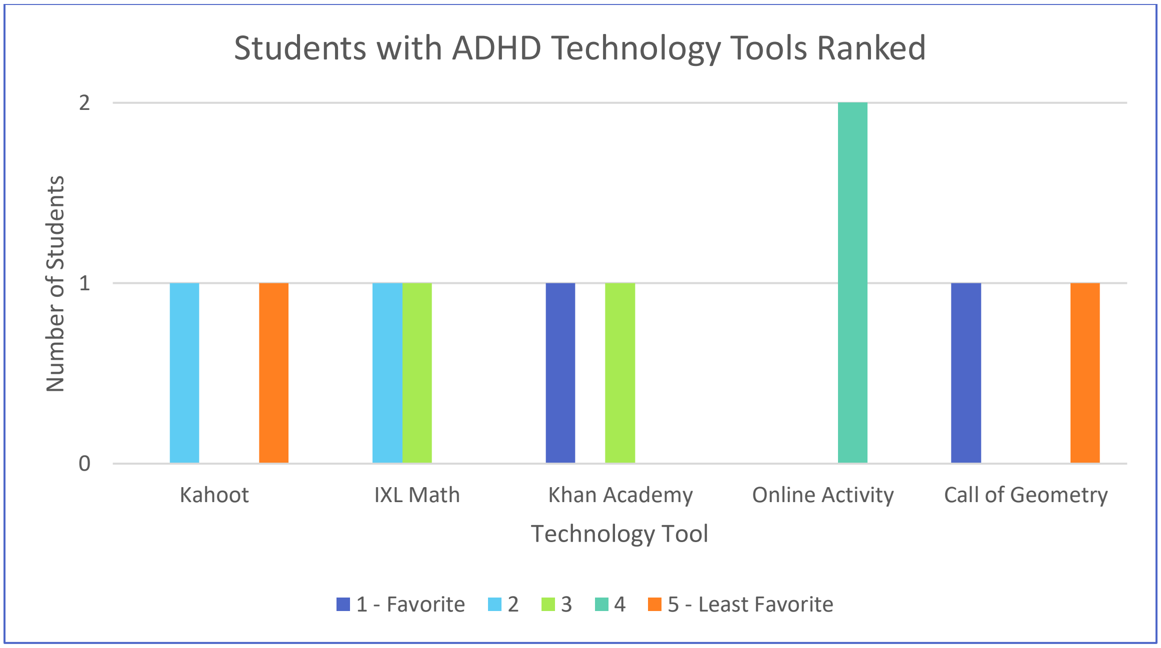

Figure 4.4 Students with ADHD Rankings of Technology Tools

In their post-administration survey, Peter and Cheyenne both detailed that they found Khan Academy (2020) most useful to their understanding of the course content and self-efficacy. This aligns with previous research on the impact of CAI for students with ADHD (Mautone et al., 2005; Mohammadhasani et al., 2018; Ota & DuPaul, 2002). Based on their rankings, it is clear both students found value in all of the CAI tools.

When asked why Peter ranked Kahoot lowest, he said that he did not like the time limit. In an interview, I asked Peter why he enjoyed Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020), which moved at a fast pace, but not the time limit in the Kahoot, and he replied, “I did not like getting questions wrong because of the time limit but I was okay with missing shapes because the game moved fast.” Cheyenne said she did not enjoy the game because of the fast pace and because she did not feel that she got as much of an understanding of geometry. When asked why she ranked Khan Academy (2020) highest, she said, “I found it the most helpful when paired with the video.” Although Peter and Cheyenne did not choose the same technology tools as their favorite and least favorite, their responses show that they found CAI to be useful to their development of content knowledge and that they did not enjoy having time restraints in some of the technology activities.

SUMMARY

During the two-week instructional unit, quantitative and qualitative data were collected to investigate student opinions of SRS, CAI, gamification, and teacher-made screencasts on their engagement, technology preference, benefits to their content knowledge development, and self-efficacy. Quantitative data were gathered to provide numerical values of students’ opinions. Qualitative data provided a more robust description of how students felt while engaging with each technology tool.

Results on student engagement with the technology tools show that students had strong feelings, both positive and negative, toward Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) Students also showed a high level of engagement with Kahoot. Students did not find all of the methods of CAI as engaging and did not find the teacher-made screencasts as engaging as Call of Geometry: A Quadrilateral Warfare, Khan Academy (2020), and Kahoot.

Student preferences on their preferred technology tool yielded mixed results. Viewed through the lens of TAM3, students found Khan Academy (2020), the teacher-made screencasts, and Kahoot the easiest to use. However, students' most preferred technology tools were gamification and Kahoot. Although gamification had the most votes for students' preferred technology, it also had the second-highest votes for students' least favorite technology tool. Similarly, student opinions on CAI exhibited variance depending on the platform. Most students favored Khan Academy over iknowit (2020) and IXL Math (IXL Learning, 2020).

Overall, students felt that Khan Academy (2020), Kahoot, and the teacher-made screencasts were the most helpful to their development of course content knowledge; however, three students noted the benefits of pairing the teacher-made screencasts with each of the technology tools as a daily technology strategy. They felt this form of instruction was beneficial to help reinforce their understanding of the content.

In terms of student self-efficacy, students felt most confident after engaging with Khan Academy (2020) or watching the teacher-made screencasts. Yielding similar results to students' opinions on usefulness toward developing content knowledge, students expressed that they felt confident after reinforcing the content from the screencasts by using the different technology tools. These results show that students feel much more comfortable and confident with the course content after watching the teacher-made screencasts, followed by participation with a technology activity to provide feedback, reteach information, or allow them to informally test their understanding of the material.

The results from the two students in this study who have ADHD align with previous research on CAI. Both students chose a method of CAI as the most beneficial to their understanding and self-efficacy. Students also used the teacher-made screencasts to gain an initial understanding of the course content.

Chapter 5 will provide more insight into the implications of the data analyzed in this chapter. Furthermore, it will suggest implications for potential future eLearning scenarios. I will also discuss the limitations in this study, as well as implications for future research.

CHAPTER 5

DISCUSSION

This mixed-methods action research study sought to increase the student engagement of my geometry core students, by determining what technology tools students find engaging and useful toward their development of geometry content knowledge. Furthermore, this study examined the effects of technology on student self-efficacy in mathematics. Although the original intent of this action research study was to increase student engagement in a traditional setting, the results of this study provided me with an insight into what students found engaging in a virtual setting which may transfer to a traditional setting. Furthermore, many students during the COVID-19 quarantine were not engaged with the eLearning experience. This study provided an understanding of what students found engaging and useful toward their development of geometry content knowledge.

The research from the literature review in Chapter 2 influenced my decision to use student-response systems (SRS), computer-assisted instruction (CAI), gamification, and teacher-made screencasts throughout a two-week unit of study on quadrilaterals. The research questions that guided this study were as follows: 1) What uses of technology do students find engaging in a virtual mathematics class when developing a new understanding of geometry? 2) Why do students prefer their selected use of technology over others? 3) How is their selected technology tool useful for the development of geometry knowledge? 4) What uses of technology increase students' self-efficacy in geometry? To answer the research questions, I employed both quantitative and qualitative measures to capture a variety of data regarding what students thought and how they felt after using each technology tool.

Each day a technology tool was employed, students completed a Likert-scale survey that measured the technology tool's impact on their engagement, self-efficacy, support of understanding of the course content, and overall ease of use. After analyzing the results, I purposefully selected two students to interview to gain a deeper understanding of their Likert-scale responses: one high-engaged student and one low-engaged student. Quantitative and qualitative data were collected separately and were blended using the triangulation method. This chapter provides an interpretation of the quantitative and qualitative results on each of the four research questions in this study. This chapter will also discuss the implementation of technology in an eLearning setting, the study's limitations, and implications for future research.

DATA IMPLICATIONS

This action research study examined students' opinions on their engagement, understanding of content knowledge, self-efficacy, and preference of technology after engaging with each of the technology strategies. Each of the following subsections will address data implications from the data analyzed in Chapter 4 for each of the four research questions.

RQ1: STUDENT ENGAGEMENT

Using UGT, this action research study determined students' gratifications while using different technology tools (Gallego et al., 2016). The results from this study show that students found Khan Academy (2020) the most engaging. Students found the activity engaging because it was easy to use, fun, and met their educational needs. Although Khan Academy was the most engaging for students, the other methods of CAI had the lowest averages for student engagement. Many students explained that they were engaged while using CAI and the teacher-made screencasts because they understood the instructional support they offered; however, they did not find them as exciting as the Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020), Khan Academy, or Kahoot. Similar to results from Ahmand et al. (2014) and Jordan et al. (2012), students did find the screencasts enjoyable to watch. Results also showed that students were engaged by components of CAI that had game-like attributes, such as characters or point values. These results resemble those in the study conducted by Light and Pierson (2014), in that students enjoyed the game-like attributes and characters in Khan Academy.

Consistent with previous research (Barreto et al., 2017; Chao et al., 2016; Olson, 2010), many students found gamification engaging in an eLearning setting. Students expressed that they had fun while engaging with the Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) in this study. Previous research also showed that male students were more engaged with gamification than female students (Garneli et al., 2017). These results are mirrored here, with six males (60%) rating Call of Geometry: A Quadrilateral Warfare as their favorite technology tool and two females (20%), one non-binary student (10%), and one male (10%) rating gamification as their least favorite technology tool.

Previous research has highlighted how student engagement increases when students do not find math games too easy, yet also within their realm of understanding

(Habgood & Ainsworth, 2011). Many students did not find Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) easy to use, but did find it engaging. The results from this action research study support the idea that math games should be challenging, but achievable.

Aligning with prior research on technology that includes competition (Gilliam et al., 2017; Olson, 2010; Pareto et al., 2012; Plass et al., 2013), students also found the component of Kahoot that allowed them to compete with their peers engaging. Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) and Kahoot both had a leaderboard at the end of the activity that showed students where they ranked in their class, as well as their ranking with players around the world. Several students in this study enjoyed competing with their peers and engaged with the activity more than the course requirements. This shows that students are engaged with technology that allows them to compete with their peers.

RQ2: STUDENT PREFERENCE

In the post-administration survey, students were asked to rank their favorite to least favorite technology tools and explain their reasoning. A majority of students (60%) chose Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) as their favorite technology tool, followed by Khan Academy (30%). Students who chose Call of Geometry: A Quadrilateral Warfare as their favorite technology enjoyed that it was competitive, fast, and engaging. Aligning with tenets from TAM3 and UGT, students who chose Khan Academy as their favorite thought it was easy to use and helpful to their understanding of geometry.

TAM3 illustrates how people are more likely to enjoy technology when it is easy to use (Mosley, 2012; Onal, 2017; Wu et al., 2016). My results show that students found Khan Academy (2020), the teacher-made screencasts, and SRS easiest to use in this study. Students were more likely to be familiar with each of these technology tools in a virtual setting because students accessed the teacher-made screencasts daily, and Khan Academy and Kahoot are often used in secondary mathematics classrooms. Although Kahoot did not receive as many votes for students' favorite technology tool (10%), it did notably receive the most votes for the second favorite (70%). Consistent with previous research (Walklet et al., 2016), students who enjoyed SRS liked the immediate feedback and competition between their peers. Differing from the results of other studies, students did not enjoy the time limit during the SRS activity or gamification activity. Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., (2020) had the lowest average for ease of use because of how quickly the game moved. Although students preferred this technology tool the most, they did not feel that engaging with the technology was as easy when compared to the other technology tools.

Methods of CAI has had many positive implications for students with ADHD, including maintaining their attention on educational content (Mautone et al., 2005; Mohammadhasani et al., 2018; Ota & DuPaul, 2002). In this study, the two participants who have been diagnosed with ADHD ranked methods of CAI high in their post-administration survey. These two participants also said they found the teacher-made screencasts helpful when paired with the other technology tools. These results are consistent with the results from Graves et al. (2011), whose participants with ADHD enjoyed having access to class lectures paired with CAI. Graves et al. (2011) also found that students with ADHD were less likely to feel the pressures of the time restraints in the classroom. In a fully virtual setting, my students with ADHD seemed to have the same opinions on CAI and the teacher-made screencasts. One of the participants with ADHD said he did not enjoy Kahoot because of the time limit. Therefore, the results of this study affirm that students with ADHD enjoy technology tools that provide flexibility and do not have limited time constraints. Although one participant with ADHD did not enjoy the time limit in Kahoot, he ranked Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) as his favorite technology tool because of his increased engagement with the activity. This is consistent with previous research conducted by Ota and DuPaul (2002), who found that math games have increased student engagement and achievement of students who have ADHD.

Research has shown that situational interest with technology from students can decline over time, due to the novelty effect (Rodriguez-Aflecht et al., 2017). In this study, two students expressed that they did not enjoy IXL Math (IXL Learning, 2020) because they had used it frequently in middle school. This supports the idea that the overuse of a platform can decrease students' interest in the technology tool over time. Most of the tools employed in this study were only used during the two-week instructional unit on quadrilaterals; however, students were asked to watch a teacher-made screencast daily during the eLearning period that began before this unit of instruction. Furthermore, Kahoot was used in my classroom before the quarantine and students expressed that they had engaged with Kahoot in other courses. Students had not engaged with Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020), iknowit (2020), or Khan Academy (2020) in my classroom before the study. Students' opinions on what technology tools they found engaging overtime differed depending on the technology tool. Students did not find IXL Math as engaging as Kahoot after multiple uses.

This action research study was unique in that it was solely conducted in a virtual setting. The results for this research question showed that students enjoyed engaging in technology that was familiar to their traditional classroom setting, easy to use, and allowed them to compete with their peers. The communication barrier present in a virtual setting may have positively impacted their drive to compete with their peers through gamification, CAI, and SRS.

RQ3: USEFULNESS TO CONTENT KNOWLEDGE

Using TAM3 and UGT, this research question examined what students found most beneficial to their understanding of course content. The data show that students found Kahoot and Khan Academy (2020) the most helpful toward developing their understanding of geometry. Specifically, the instant feedback was most helpful to their development of content knowledge because they were able to correct their thinking immediately. The results of this study align with previous research on the impact of SRS in a traditional classroom setting (Simelane-Mnisi & Mji, 2017; Walklet et al., 2016). Students also said that they went back and re-watched the teacher-made screencasts if they were not performing well in the SRS activity. Previous research conducted by Walklet et al. (2016) also showed that students were more likely to pay attention to the in-class material while engaging with SRS. Although solely in a virtual setting, the results of this study were similar.

Many students expressed that the explanations and videos provided in Khan Academy (2020) were useful and that they were able to test what they had learned from the teacher-made screencasts during the Khan Academy activity. Similar studies have shown that CAI positively impacts students' achievement in mathematics (Gross & Duhon, 2013; Wilder & Berry, 2016). Students' opinions on Khan Academy support the notion that their achievement in geometry could increase after engaging with this method of CAI. Although Khan Academy was rated the highest for helping students develop content knowledge, students did not find all methods of CAI or gamification as helpful toward their development of content knowledge. The pace of Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) was likely to negatively impact their ability to process and understand the geometry content it was supporting.

Kahoot and Khan Academy (2020) had the highest average from students; however, the teacher-made screencasts were the second most helpful for students. Consistent with previous research on teacher-made screencasts (Ahmand et al., 2014; Jordan et al., 2012; Light & Pierson, 2014), students were provided flexibility to use the screencasts at any time during the instructional unit and found them useful to enhancing their understanding. Aligning with UGT's tenet that people receive gratifications from technology when acting as active agents of change, students commented on the fact that they were able to re-watch the videos if they were struggling in the SRS, CAI, or gamification activities.

Students also expressed that they found value in the teacher-made screencasts aligned with the other technology tools because they were able to reinforce what they learned in the screencast in a new context. This supports my curricular decisions for this unit of instruction to provide students with a teacher-made screencast followed by a different technology tool to reinforce course content. Furthermore, research conducted by

Schuetz et al. (2018) showed that students were more independent and took ownership of their learning when engaging with CAI. In this study, students used the teacher-made screencasts, CAI, and SRS to meet their educational needs and personalize their learning experience.

RQ4: STUDENT SELF-EFFICACY

Overall, students said they felt the most confidence in their understanding of the course content after engaging with Khan Academy (2020). Specifically, students expressed that their confidence level was higher after engaging with technology strategies that provided them with instant feedback and an explanation of how to correct their mistakes. Khan Academy, as well as all methods of CAI, had this component embedded in the technology tool. Students expressed that this is what ultimately increased their confidence level the most.

In a virtual setting, CAI provides instant feedback and allows students to address their misconceptions. Unfortunately, in an eLearning setting, this method of instruction is unavailable with SRS; however, in a traditional classroom setting, SRS allows the teacher to pause in between each question and correct student misconceptions. Students can also be split into groups and discuss their answers before responding. As seen in the study conducted by Walklet et al. (2016), this was helpful to increase student confidence in their understanding of the content. In a traditional setting, SRS may have shown more benefits to students’ self-efficacy in geometry.

Students rated the teacher-made screencasts second as a tool to increase their self-efficacy in geometry. As discussed in the RQ2 subsection of this chapter, students felt more connected to their peers, teacher, and their coursework while viewing the teacher-made screencasts. After analyzing the data, it is clear that this is important to students in an eLearning setting. Specifically, during the COVID-19 pandemic, students may have needed a sense of normalcy that the teacher-made screencasts provided. Students said they were more likely to engage in the coursework after watching the teacher-made screencasts or participate in an interview with me through WebEx. Many students also felt more comfortable when the teacher-made screencasts were paired with a technology strategy that allowed them to formatively assess their understanding of the content. Specifically, students felt that the teacher-made screencasts paired with Kahoot or Khan Academy (2020) were most effective in their overall confidence. The increase that these technology platforms provided to students' self-efficacy can motivate them to accept and persevere through more challenging problems in the future (Liu et al., 2018).

The results showed that the positive reinforcement embedded in some of the technology strategies made students feel more confident in their understanding. Some students discussed how seeing their scores increase or seeing the character in the iknowit (2020) activity jump around motivated, encouraged, and made them feel more confident. These results are consistent with the results from Mohammadhasani et al. (2018), where students expressed they were more comfortable and confident with a pedagogical agent helping them navigate through instructional technology tools. Conversely, a student discussed that while engaging with IXL Math (IXL Learning, 2020), they did not feel as confident when their "smart score" decreased. The terminology here may harm student perceptions of their self-efficacy. Correlating the word "smart" with their development of new content could make them feel less intelligent and negatively impact their self-efficacy in geometry.

Students expressed that their self-efficacy increased with the technology tools that were more heavily focused on geometry content. These tools include the teacher-made screencasts, Khan Academy (2020), and Kahoot. Students also felt more confident when positive reinforcement and feedback from the technology tool or their teacher was provided while engaging with the different technology strategies.

IMPLICATIONS FOR FUTURE TECHNOLOGY IMPLEMENTATION

This study examined the impact of SRS, CAI, gamification, and teacher-made screencasts on students' engagement, content knowledge development, and self-efficacy. The results of this study show that overall, students in my classroom agree that all of the different technology tools maintained their engagement, helped them understand the course content, and increased their confidence in their understanding.

In three of the WebEx interviews with students, the interviewees explained that they found the setup of the course modules beneficial to their understanding. In each module, students were provided a teacher-made screencast to watch first before engaging with the technology tools. Students found this effective because they were able to learn from their teacher in the screencast before reinforcing the content in the technology activities. Based on the results of my action research study, I would encourage teachers to use a similar format when teaching mathematics in a virtual classroom. Although my students found this method of instruction beneficial in an eLearning setting, students may still prefer traditional methods of direct instruction in a traditional classroom setting and are likely to only use the teacher-made screencasts as supplemental support. Before the quarantine, I created teacher-made screencasts and uploaded them on Canvas for all students each day instructional content was taught. Students used these screencasts when they were absent, to study, or if they needed to relearn course content taught in class.

The findings from this action research study show that students found benefits from each of the four technology strategies. Overall, students were most engaged with Khan Academy (2020) and gamification. Kahoot was ranked the most helpful, when paired with the teacher-made screencast, for students to develop an understanding of the geometry content. Consistent with the research in Chapter 2, the results from my two students with ADHD showed that CAI holds benefits for students who have ADHD. Furthermore, all of my students enjoyed Khan Academy as a method of CAI to reinforce the content taught in the teacher-made screencasts. Finally, most of my students commented that the teacher-made screencasts were helpful and consistently watched them. This was their preferred method of initially learning the content in each module. For future virtual learning scenarios, using each of these modalities could maintain students' engagement and continue their education throughout the eLearning period. However, excessive use of a digital platform may decrease students' engagement due to the novelty effect (Rodriguez-Aflecht et al., 2017). Students expressed that they did not enjoy IXL Math (IXL Learning, 2020) as much because they used it often in middle school. Therefore, I would suggest differentiating technology tools to maintain students' engagement and support their development of content knowledge.

With the possibility of future eLearning in the immediate future during the COVID-19 pandemic, the findings from this study may benefit teachers in my school district, administration, and fellow math teachers in my department. I plan on sharing my results with these stakeholders to potentially increase their students' engagement, understanding of content knowledge, and self-efficacy. This can influence curricular decisions during future potential eLearning scenarios or for homebound instruction. The results for some of the research questions also hold implications in a traditional setting. The way I employed CAI and gamification in an eLearning setting is closely aligned to how I would have implemented them in a traditional classroom. Students' opinions on these technology strategies are likely to be consistent in a traditional classroom.

It is also my hope to support other teachers in moving their instruction effectively on a digital platform. I also plan to continue using SRS, CAI, gamification, and the teacher-made screencasts in future eLearning situations, or as supplemental materials in a traditional classroom for students to use to reinforce their understanding of the course content.

LIMITATIONS

Limitations in this study included a small sample size of ten participants from one geometry core class in the setting of this study. This study was an action research study where I served as the practitioner and researcher; therefore, the sample size was expected to be smaller, as the results are not intended to generalize beyond my local population (Efron & Ravid, 2013). Of the seventeen students in this class, only ten participated in this two-week unit of study; thus, I was only able to glean a very limited view of students' opinions of the technology strategies employed in this study. Results may have been different with a larger sample size in my local setting or a large sample in a traditional educational research design.

Another limitation may be the circumstances under which this study took place. This study was conducted during the COVID-19 pandemic when students were quickly transitioned to a virtual setting. Many of the students' families may have found themselves in stressful and difficult situations or may have relied on my students to provide childcare for their younger siblings. Furthermore, some of the participants in my study worked a full-time job during the eLearning period to help support their families. Results may have been different if students and their families were aware and able to prepare for the eLearning period.

This action research study was initially intended for a traditional classroom setting. Due to the COVID-19 pandemic, this study was conducted in an eLearning setting. Results may have been different if students engaged with the technology in a traditional setting. Students may have been less likely to use the teacher-made screencasts, which served as the primary source of instruction during eLearning and may have found other methods more beneficial after engaging in traditional classroom instruction. The SRS may have been more beneficial for students in a traditional classroom because the teacher can pause in between questions to clarify students' thinking or misconceptions. Students may have also been able to engage with CAI and SRS in teams or pairs to collaborate with their peers.

Another limitation of the eLearning setting was my inability to observe possible off-task behavior with the implementation of technology. As discussed in Chapter 1, this was one of my hesitations about implementing technology in the classroom. In this setting, students were able to complete assignments and activities at their own pace. In a traditional classroom setting, activities would have had time limits and students may have been tempted to use their MacBook Airs for activities other than the ones assigned in this unit. This may have altered the results or made it more obvious which technology strategies students found the most engaging or preferred in a traditional setting.

A final limitation of this study was the lack of an attendance policy during the eLearning process. Students were able to complete their assignments at any time during the semester. Students who did not complete the assignments during the two-week study timeline were less likely to be chosen for an interview compared with the students who consistently handed in coursework. Furthermore, this negatively affected the participation of my study, because some students who were satisfied with their grade did not complete the two-week unit of study. Because of this, I had to alter the length of my study to the end of the semester to ensure I had collected all of my student data. Instead of a two-week long data collection phase, the data collection ultimately lasted six weeks.

IMPLICATIONS FOR FUTURE RESEARCH

In this study, eLearning was unplanned, and I created course content for students quickly. If I were allowed to create course content for an eLearning class again, I would plan on using teacher-made screencasts daily for instruction paired with SRS, CAI, and gamification. At the beginning of the eLearning period, I used teacher-made screencasts for instruction but relied on worksheets for students to complete after watching the videos. I found that students had a better understanding of the course material and higher engagement with the technology strategies than with the teacher-made worksheets. Based on the results from my action research study, if a future eLearning scenario occurs, I would encourage math teachers to integrate their course content with technology platforms, rather than relying on traditional methods of formative assessment in a virtual setting.

Action research often consists of continued cycles of inquiry (Herr & Anderson, 2015). In the future, I plan on employing these technology strategies in a traditional classroom setting to examine and compare students' opinions to those collected in an eLearning setting. Instead of limiting myself to a two-week study, I would provide students with the opportunity to engage with different technology platforms throughout the school year. This would allow me to uncover more about what technology tools engage and best support students' content knowledge development. I also plan on using these technology strategies with my future honors and CP classes to determine their opinions on the technology strategies and compare them with the results of this study. I would encourage other researchers to examine the benefits of these technology strategies in a traditional and eLearning setting.

This study was an action research study where I acted as the practitioner and researcher of the study to address my problem of practice. The results of this study are not generalizable outside of my local setting (Efron & Ravid, 2013). I would suggest for future traditional researchers to conduct this study on a larger scale to determine if these results would extend to different groups of students. This study was composed primarily of male (70%) students. The opinions from students on these technology strategies who are not male could provide different insights. Furthermore, the majority of the students in this study were White (80%). Conducting this study in a school or classroom that is not primarily White could yield different results.

Another suggestion for future research would be to explore the effectiveness of different technology strategies for content areas outside of mathematics. A different study could determine students' opinions on SRS, CAI, gamification, and teacher-made screencasts in English, social studies, or science. Students may find that they have different gratifications and uses of technology in different courses.

Lastly, due to the eLearning time restraints, this study was only two weeks long. Additional research could be conducted within a greater timeframe to explore students' opinions over time and potential novelty effects with the technology strategies. Additional research is needed to determine if student engagement can last over time.

CONCLUSION

The purpose of this study was to increase the student engagement of my geometry core students by determining what students find engaging and useful toward their development of geometry content knowledge. There were ten participants in this study that was conducted in a southeastern high school. Students participated in this study with the intent to answer each of the four research questions on student engagement, preference of technology, opinions on technology to develop their content knowledge, and self-efficacy. This action research study used a mixed-methodology with quantitative data, in the form of Likert-scale survey questions, and qualitative data, in the form of student interviews and open-ended survey questions.

Consistent with previous research, students in this action research study expressed engagement with all of the technology tools in this study but especially enjoyed Khan Academy (2020) and gamification. Students also agreed that all of the technology tools benefitted their development of content knowledge but found the teacher-made screencasts paired with Kahoot and Khan Academy the most helpful. In terms of student preference, students preferred Call of Geometry: A Quadrilateral Warfare (vBulletin Solutions Inc., 2020) and Kahoot the most out of each of the technology tools. However, students expressed increased self-efficacy after watching the teacher-made screencast and engaging with Khan Academy. Overall, students voiced that they enjoyed all of the technology tools and found most of them easy to use.

In the future, I plan on sharing my results with my colleagues and the school district to provide more insight into curricular decisions in an eLearning setting. Future research should examine student opinions of these strategies in a traditional classroom and with a larger sample size. Future research could also examine students' opinions of these technology strategies in different courses. Despite its limitations, I believe this action research study enabled me to achieve my goal of gaining a better understanding of what technology strategies students prefer when learning mathematics. In addition, this study succeeded in fulfilling a gap in the existing literature because it was implemented in a fully virtual setting. I hope that this study will help guide math instructors who want to use multiple forms of technology in an eLearning setting and additionally inspire additional research on the benefits and limitations of each of the technology strategies in an eLearning setting.

Before conducting this action research study, I saw technology as a distraction in my classroom and was apprehensive about implementing technology tools and strategies into my classroom. Students' engagement with technology motivated me to teach in a fully virtual classroom during a COVID-19 quarantine. After collecting and analyzing my data, I have seen the benefits of implementing technology toward students' engagement, content knowledge development, and self-efficacy. As a practitioner of this action research study, I feel much more comfortable and confident in using technology in both a traditional and virtual classroom. In the future, I plan on continuing to use these technology strategies in both an eLearning and traditional classroom and continuing to examine students' opinions on what they find most engaging and useful toward their development of mathematics content. I also plan on continuing to implement technology strategies that are relevant to students and course content to increase student engagement and learning. In turn, I am hopeful that student engagement and achievement will increase in my classroom.

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APPENDIX A

PARENT AND STUDENT CONSENT FORM

Dear Student and Parent/Guardian,

My name is Allison Knapp and I am your child's/your Geometry teacher this semester. I am a doctoral candidate in Curriculum Studies at the University of South Carolina. I am conducting a research study as part of my degree requirements, and I would like for your son or daughter/you to participate. I anticipate conducting this research study in our quadrilaterals unit, April 20th-April 30th, 2020.

I am studying the effects of technology on student engagement, as well as students' opinions on these technology strategies to support their development of geometry content knowledge. Implementing technology in the mathematics classroom has been widely researched and has held positive results for student engagement. In this study, the MacBook Air will be used as a student response system to provide live interaction among the students and myself. This will allow me to assess if the students are grasping the geometry content. Computer-assisted instruction consists of the students using their devices to help deliver instruction and allow the students to practice individually. Mathematics video games will also be employed in this study with the intent to increase student engagement and understanding of the content.

Implementing technology in the mathematics classroom has been widely researched and has held positive results for student engagement. Participating in this study has the potential to increase your son or daughter's/your engagement and understanding of geometry. If you decide to/have your son or daughter participate, you/they will be asked to fill out several surveys and potentially be interviewed about your/their engagement and opinions on technology tools. In an interview, the session will be audiotaped so that I can accurately transcribe what has been discussed. The audio files will only be reviewed by me and will be erased upon completion of the study.

Data associated with participation is confidential. Study information will be kept in a secure location at the University of South Carolina. The results of the study may be published or presented at professional meetings, but the identity of the participants will not be revealed. Participation, non-participation or withdrawal will not affect your son or daughter's/your grades nor the quality of your son or daughter's/your geometry instruction in any way.

I will be happy to answer any questions you have about the study. You may contact me at Allison.Knapp@Clover.k12.sc.us. Thank you for your consideration. If you would like to participate, please sign on the line below. When you are done, please hand this form into me.

Thank you,

Allison Knapp

For student: I consent to participating in this research study

_____________________________ __________________________

Signature Date

For parent/guardian: I consent to my child participating in this research study (sign below).

_____________________________ __________________________

Signature Date

APPENDIX B

DAILY LIKERT-SCALE SURVEYS

Day 1 Likert Survey:

1. I found the Kahoot activity enjoyable today in class.

Strongly Agree Agree Disagree Strongly Disagree

2. I found the Kahoot helpful toward my understanding polygon angle sums.

Strongly Agree Agree Disagree Strongly Disagree

3. I found the Kahoot activity user-friendly (easy to use).

Strongly Agree Agree Disagree Strongly Disagree

4. I feel more confident in how to find the sums of the angles in a polygon.

Strongly Agree Agree Disagree Strongly Disagree

Day 2 Likert Survey:

1. I found the IXL Math instructional program enjoyable.

Strongly Agree Agree Disagree Strongly Disagree

2. I found the IXL Math instructional program helpful toward my understanding of the properties of kites.

Strongly Agree Agree Disagree Strongly Disagree

3. I found the IXL Math instructional program user-friendly (easy to use).

Strongly Agree Agree Disagree Strongly Disagree

4. I feel more confident in my understanding of kites.

Strongly Agree Agree Disagree Strongly Disagree

Day 3 Likert Survey:

1. I found the Khan Academy activity enjoyable today.

Strongly Agree Agree Disagree Strongly Disagree

2. I found the Khan Academy activity helpful toward my understanding of the properties of parallelograms.

Strongly Agree Agree Disagree Strongly Disagree

3. I found the Khan Academy activity user-friendly (easy to use).

Strongly Agree Agree Disagree Strongly Disagree

4. I feel more confident in my understanding of the properties of parallelograms.

Strongly Agree Agree Disagree Strongly Disagree

Day 4 Likert Survey:

1. I found the online activity enjoyable today in class.

Strongly Agree Agree Disagree Strongly Disagree

2. I found the online activity helpful toward my understanding of the properties of special parallelograms.

Strongly Agree Agree Disagree Strongly Disagree

3. I found the online activity user-friendly (easy to use).

Strongly Agree Agree Disagree Strongly Disagree

4. I feel more confident in my understanding of the properties of special parallelograms.

Strongly Agree Agree Disagree Strongly Disagree

Day 5 Likert Survey:

1. I found the Call of Geometry game enjoyable today in class.

Strongly Agree Agree Disagree Strongly Disagree

2. I found the Call of Geometry game helpful toward my understanding of the properties of special parallelograms.

Strongly Agree Agree Disagree Strongly Disagree

3. I found the Call of Geometry game user-friendly (easy to use).

Strongly Agree Agree Disagree Strongly Disagree

4. I feel more confident in my understanding in the properties of special parallelograms.

Strongly Agree Agree Disagree Strongly Disagree

Day 6 Likert Survey:

1. I use the teacher-made screencasts on Canvas.

Often Sometimes Rarely Never

2. I find the teacher-made screencasts engaging.

Strongly Agree Agree Disagree Strongly Disagree

3. I find the teacher-made screencasts helpful toward my understanding of geometry.

Strongly Agree Agree Disagree Strongly Disagree

4. I find that accessing the teacher-made screencasts on Canvas is easy.

Strongly Agree Agree Disagree Strongly Disagree

5. I feel more confident in my ability to understand geometry after watching the teacher-made screencasts.

Strongly Agree Agree Disagree Strongly Disagree

APPENDIX C

HIGH ENGAGEMENT SEMI-STRUCTURED INTERVIEW PROTOCOL

Time, Date and Setting: ___________________________

Interviewee Name: ________________________________

Interviewee Demographic Information: ____

Introduction: Today I am interviewing you about your positive responses on yesterday's survey. Your responses may be used in the study I am conducting to provide me with data on why you found that technology activity engaging and if it supported your development of geometry content knowledge. I am going to ask you several questions regarding your opinion on yesterday's technology activity.

Interview Questions

1. What did you find most engaging about yesterday's technology activity?
2. Tell me about the experience of using yesterday's technology activity.
3. Did you find the technology activity useful toward your understanding of yesterday's lesson? Why or why not?
4. Would you want to engage in that technology activity again?
5. Did you feel more or less confident in your ability to complete problems from yesterday's lesson after the activity? Why?
6. Is there anything else you would like to add?

APPENDIX D

LOW ENGAGEMENT SEMI-STRUCTURED INTERVIEW PROTOCOL

Time, Date and Setting: ___________________________

Interviewee Name: ________________________________

Interviewee Demographic Information: ____

Introduction: Today I am interviewing you about your responses on yesterday's survey. Your responses may be used in the study I am conducting to provide me with data on why you did not find that technology activity engaging and if it supported your development of geometry content knowledge. I am going to ask you several questions regarding your opinion on yesterday's technology activity.

Interview Questions

1. What did you not enjoy about yesterday's technology activity?
2. Tell me about the experience of using yesterday's technology activity.
3. Did you find the technology activity useful toward your understanding of yesterday's lesson? Why or why not?
4. What type of technology activity do you find engaging in the classroom? Why do you find that selected technology activity engaging?
5. Did you feel more or less confident in your ability to complete problems from yesterday's lesson after the activity? Why?
6. Is there anything else you would like to add?

APPENDIX E

POST-ADMINISTRATION SURVEY

1) Please rate the following technology tools in order from your favorite activity (1) to your least favorite activity (5).

Triangle-Sum Kahoot _________

IXL Math _________

Khan Academy _________

Quadrilateral Online Activity _________

Call of Geometry Game _________

2) Why did you select your number 1 technology tool as your favorite?

3) What did you like least about the technology tool you rated 5th?

4) Which technology activity did you find the most useful toward your understanding of geometry?

5) Which technology activity made you feel the most confident in the material?

6a) Select one of the following options for this statement:

I watched the teacher-made videos on Canvas for this unit.

Frequently Occasionally Infrequently Never

6b) If you watched the teacher-made videos, did you find them useful toward your understanding of the course content? Explain.

6c) If you watched the teacher-made videos, did you find the videos engaging to watch? Explain.