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Teachers Respond To Impact Of Intelligent Mathematics Tutorial On Students’ Motivation And Engagement

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TEACHERS RESPOND TO IMPACT OF INTELLIGENT MATHEMATICS TUTORIAL ON STUDENTS' MOTIVATION AND ENGAGEMENT

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Abstract

Secondary school mathematics proficiency continues to be a point of concern, as the current National Report Cards continue to show insufficient change. For middle school students, grades six through eight are formative years, as they begin to shape emotional connections and make a decision about their ability and motivation to do mathematics. These early decisions are paramount to how they approach mathematics learning in later grades. Student motivation is a critical function of students' affective domain, engagement in the classroom, and their self-belief for learning. Teachers play a significant role in this process by providing supportive and effective learning environments to stimulate student motivation and engagement.

Through exploration and qualitative analysis, this exploratory case study examined the impact Adaptive Intelligent Tutorial Systems (AITS) has on the behaviors, beliefs, and motivation of students to learn mathematics in a local middle school, from the perspectives of the teachers. This study was guided by three research questions. The leading question examined the type of instructional approaches that affected middle school students' affective domain for learning mathematics. The second question explored the factors that affected middle school students' motivation and self-belief to learning mathematics when incorporating an Adaptive Intelligent Tutorial Intervention in the general education setting. The third question explored factors that affected middle school students' motivation and self-belief to learn mathematics when teacher-directed approaches were employed in the general education setting. The study design employed both pre- and post-surveys and focus group, investigating the perceptions of state certified mathematics teachers, the impact of AITS on middle school mathematics students' motivation and engagement.

The researcher learned that AITS was effective when combined with other instructional strategies to support students' learning needs. As a key component of the AITS, the instant feedback feature provided teachers with additional time to support students, as well as enabling them to self-regulate their learning, having a positive impact on their motivation and self-belief. This study provides recommendations to mathematics teachers and administrators on the value of AITS in the classroom. The researcher recommends that further studies be done with a broader student population over a longer timeframe.

Keywords: *Adaptive Intelligent Tutorial, student motivation, student engagement, student self-belief, middle school mathematics, teacher perspectives, blended instructional strategies*

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All those around me are the bridges to my success, so they are all important.

—Manny Pacquiao

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CHAPTER ONE:

INTRODUCTION

According to American College Testing (ACT) data, less than 20% of all current eighth graders are capable of college-level work upon graduation from high school ("The Forgotten Middle," 2008). In addition, more than 80% of eighth-graders lack the knowledge and abilities needed to enter high school programming based on achievement scores in English, mathematics, reading, and science ("The Forgotten Middle," 2008). In 2018, an ACT report shows students' national readiness scores, for science, technology, engineering, and mathematics (STEM) majors, dropping another .2% with scores from mathematics testing declining between .1 to .3% compared to the previous year ("The Condition of College and Career Readiness," 2018). Over the years, mathematics assessment scores have dropped dramatically in relation to English, reading, and science, according to the New England Common Assessment Program and Partnership for Assessment of Readiness for College and Careers standardized assessments, especially in areas of foundational knowledge, such as order of operations and problem solving.

Research shows that low achievement in mathematics is not an explicit outcome of students with learning disabilities alone, "but extend beyond this to include a large proportion of children who fail to achieve numeracy levels needed for everyday life" (Dowker, 2009; as cited in Simms, Gilmore, Sloan, & McKeaveney, 2017, p. 1). Mathematics achievement continues to be a growing concern across the United States. Research continues to show a decline in mathematics skill and problem solving with the United States ranking only 21 of 23 countries in mathematics (Beard, 2013). A decrease in students' ability was linked to changes in their motivation and self-belief for doing mathematics (Hughes & Riccomini, 2011). Changes were influenced by students' inconsistent and, at times, negative mathematics experiences, low self-belief in their ability (Hughes & Riccomini, 2011), and fear of failure (Pantziara & Philippou, 2015).

Empirical research shows that motivation and self-efficacy are connected and entwined but also remain separate constructs linked to academic engagement and academic achievement (Ackerman, 2018; Martin et al., 2015). Motivation is the desire to achieve while self-efficacy is the belief in one's ability to achieve (Ackerman, 2018). Research also shows that the self-efficacy of a student has a direct influence on his or her level of motivation, ability to learn, and overall achievement (American Society for Horticultural Science, 2011). Student motivation and student engagement are critical building blocks in the learning process, but research continues to show a large percentage of American students remaining unmotivated and unengaged in school (Sparks, 2014).

Students who struggle and lack motivation may benefit from early interventions intended to improve their mathematics ability and ultimately preventing subsequent failure (Gersten, Jordan, & Flojo, 2005). Empirical evidence shows that early intervention programs reinforced with technology-based tutorials have proven to increase middle school students' mathematics achievement by meeting their needs (Chappell, Arnold, Nunnery, & Grant, 2015; Clark & Whetstone, 2014; Cornelius, 2013). Many of the new technology-based tutorial systems are built on machine learning platforms, which monitor student performance and adapt or personalize the instruction based on learning style and current knowledge level. Adaptive and intelligent, these tutorial systems provide formative feedback (assessment), which has a positive influence on students' learning (Roschelle, Feng, Murphy, & Mason, 2016). With a focus on expanding the academic conversation regarding intelligent tutorial systems, the goal of this researcher was to investigate the influence of intelligent tutorial systems on middle school students' engagement, motivation, and self-efficacy to learn mathematics, from the perspective of the teachers.

Statement of the Problem

The National Assessment of Educational Progress (NAEP), also known as the Nation's Report Card, is the only assessment that measures U.S. students' academic performance in various subject areas since 1969. NAEP (2017) provides results in the areas of reading, science, writing, technology and engineering, literacy, arts, civics, geography, mathematics, economics, and U.S. history for grades 4, 8, and 12 (NEAP, 2017).

The National Report Cards released in 2015 indicated that students in grades 4, 8, and 12 were not proficient in areas of mathematics. The results showed fourth-graders at 40% proficiency, eighth-graders at 33% while the 12th graders performed at a 25% proficiency rate (NCES, 2015). For all college preparatory high schools that include charters, the "overarching goal is to prepare students for college" (Rumberger, 2011). According to a *Boston Globe* article, the mantra for today's high schools is "college ready for all." States and school districts across the country have added rigor to programs, raised high school graduation requirements, and added exit examinations (Rumberger, 2011). Changes to the graduation requirements have resulted in a 2% drop in graduation rates across the nation (Rumberger, 2011), and for those students who remained in high school, "only about a third of the U.S. high school seniors are prepared for college-level coursework in math and reading" (Camera, 2016).

High school graduates who enter STEM programs in college tend to struggle the most. Based on research completed by UCLA, "60% of all college students who intended to study STEM subjects end up transferring out" (Lloyd, 2016, para. 2). For those who remain, "the 6-year degree-completion rate of undergraduate science, technology, engineering, and mathematics majors at U.S. colleges and universities is less than 40%" (Toven-Lindsey, Levis-Fitzgerald, Barber, & Hasson, 2015, p. 1). One theory states that the STEM exodus is the product of students not acquiring adequate foundations in math, which is a vital skill in many science and technology curricula (Lloyd, 2016). Common Core State Standards (CCSS) goals were designed to address these falling rates, but progress has been slow.

"While the K-8 common core mathematics standards have garnered praise… high school math standards have weaknesses that should be revisited" (Heitin, 2015, para. 1). Experts believe that the CCSS is the fix for a failed No Child Left Behind program (Karp, 2013/2014). Others warned that the development of the Common Core State Test (CCST) without the participation or input of K-8 educators is destined to fail students (McLaughlin, Levin, & Carlsson-Paige, n.d.). Adding to the concerns surrounding math proficiency, according to Chao, Chen, Star, and Dede (2016), the middle school years have seen a decline in student motivation to learn mathematics. For many schools, focusing on and addressing math assessment issues is paramount to students' current and future success.

Purpose of the Study

According to Goldberg (2014), "Middle school is an exciting time: adolescents' brains are transforming from reasoning concretely to understanding abstract concepts and ideas" (Goldberg, 2014, para.1). It is also an opportune time to introduce mathematics intervention programs to support learning in the classroom. Research studies have indicated, "additional practices may effectively improve students' mathematics performance" (Hanover Research, 2014, p. 4). According to Hanover Research (2014), these common methods should include dedicating 10 minutes to the review of arithmetic foundations, working on problem-solving techniques, and continuing to build confidence in one's math ability.

The purpose of this qualitative exploratory case study was to explore the impact of an Adaptive Intelligence Tutoring System (AITS) when applied as an instructional intervention tool to middle school mathematics. Middle school teachers of mathematics will offer their perspective of this instructional intervention tool and the possible link to the improvement of students' self-efficacy and motivation.

This researcher chose an intelligent online tutoring system, called ASSISTments as the instructional intervention tool for the study. Worcester Polytechnic Institute developed the ASSISTments platform, in collaboration with Carnegie Mellon, as a product for schools to use at no cost. Designed as an online tutorial for mathematics, science, English language arts, and social studies, ASSISTments combines the assistance of tutoring with the assessment feedback for both the students and teachers (Heffernan & Heffernan, 2014). This tutorial system is "designed to extend already proven effective teaching practices" while providing "real-time cognitively diagnostic data to teachers and students to improve student learning and to inform teaching" (Heffernan, Militello, Heffernan, & Decoteau, 2012, p. 92). Students receive instant feedback while being directed to their areas of weakness for additional practice (Heffernan et al., 2012).

The setting for this study was an independent charter middle school in Rhode Island. This Rhode Island Independent Charter middle school adopted a 1:1 laptop model for its students, a model providing a convergence of software and hardware, helping educators fully embrace technology while helping to increase student engagement (Mainelli & Marden, 2017). The hardware choice for the middle school was the Chromebook, a low-cost digital device providing all students with access to "productive, web-enabling learning tools" that for many schools is "driving new ways to teach" (Mainelli & Marden, 2017, p. 1) and learn. The addition of an online tutorial platform such as ASSISTments brings with it many benefits. As a parallel tool to classroom instruction, students can access the online tutorial at any time of the day or night. Teachers can assign homework and, according to Heffernan et al. (2012), teachers have the ability to monitor the progress of students while they do their homework during the evening. Adams (2011) stated that the use of effective teaching approaches and strategies can have a positive effect for some students, but many other students need additional support.

Hanover Research (2014) reported math intervention tutorial programs that were likely to significantly improve students' mathematics abilities include programs such as DreamBox Learning, Do the Math, and I CAN Learn Pre-Algebra and Algebra. All of these programs have a significant cost to school districts, which makes adoption difficult. While most of the extant research found inconclusive results concerning tutoring programs, other studies have provided evidence that these types of interventions produce definite improvement in student skillsets (Baker, Rieg, & Clendaniel, 2006; Calhoon & Fuch, 2003; Fuchs, Compton, Fuchs, Paulsen, Bryant, & Hamlett, (2005); as cited in Adams, 2011).

Research Questions

The current state of education in the United States has been the emphasis of many research studies regarding the factors that positively and negatively affect student learning. Studies in early mathematics intervention have produced results that show an increase in students' transfer of knowledge, but also showed little change in the students' persistence to learn (Watts, Clements, Sarama, Wolfe, Spitler, & Bailey, 2017). In the age of the "digital native" (Prensky, 2001), technology-supported learning is taking a more significant role in students' education, but what is its impact on the affective domain of students? To gain insight into its influence from teacher's perspectives, the following research questions were posed. The primary question was:

What instructional approaches to mathematics-based interventions do teachers believe impact middle school students' affective domain for learning mathematics?

The supporting questions were:

- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating Adaptive Intelligent Tutorial Intervention in a general education setting?
- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting?

Conceptual Framework

Motivation influences students' behaviors and is essential to their learning. Brophy (as cited in Liou & Kou, 2014) viewed motivation as a "critical component for stimulating students learning behavior" (p. 81). Factors such as attitudes, gender, culture, learning experiences (positive or negative), belief in one's ability (self-efficacy), feedback, and the learning environment can affect a student's level of motivation. Within the classroom, it is the teacher's job to create an educational environment that provides support for students' autonomy while establishing a mechanism for feedback and evaluation, placing emphasis on task importance, and nurturing their affective domain (Ko, Sammons, & Bakkum, 2015). Keeping students academically motivated and engaged is the key. Marzano and Pickering (2011) wrote that student engagement and motivation might "overlap in meaning and use" (p. 3) but are considered central to effective teaching and schooling. This study examined the use of technology, particularly AITS, as a means for motivating students and improving students' self-efficacy and self-worth (Heafner, 2004).

Motivation and Self-Efficacy

According to Maehr and Meyer (1997), motivation is a "personal investment" (p. 373), a construct that explains one's direction, intensity, persistence, and quality. Brophy (1986, 2004) stated that motivation exists when students are engaged in academic activities that are meaningful and worthwhile. His theory stated that a student's motivation is driven by cognitive engagement, not the time and effort he or she applies to learning. Hattie (2009) wrote that students' motivation is the highest when they have a greater sense of control over their learning. His synthesis of multiple studies associated with student motivation shows that the motivation levels are highest when they set goals, feel competent, and are provided positive affirmation and feedback. Researchers such as Bong and Skaalvik (2003) and Pintrich, Marx, and Boyle (1993) indicated that many motivational constructs affect students' performance in learning, one being self-efficacy.

Bandura hypothesized that self-efficacy affects the "choice of activities, effort, persistence, and achievement" (Bandura, as cited in Schunk, 1995b, p. 112). Bandura (2008) posited that self-efficacy can influence how one functions motivationally, emotionally, cognitively, and through decisional processes. Bandura (1982) further argued that an essential way to develop a strong sense of self-efficacy is through mastery experiences (actual performances). Other sources that influence one's self-efficacy include feedback based on observations, persuasion, and affective factors (Artino, 2012). According to John Hattie and Robert Marzano (as cited in Killian, 2015), students who believed in their ability saw positive academic achievement.

Self-Regulation

In self-regulation theory, Zimmerman (1989) assumed that students could learn by directing their efforts in "acquiring knowledge and skills rather than depending on teachers, parents, and other agents of instruction" (p. 329). Over the 20 plus years of research, Zimmerman refined his self-regulated learning (SRL) model with the help of Dale Schunk (1998, 2001, 2003), focusing on student engagement through a series of feedback cycles that include planning, practice, and evaluation for improved learning (Everson, n.d.). Hattie (2012) stated it differently by relating self-regulation to personal learning strategies from the essential step of intentions to evaluating the strategies, effectiveness, and being consistent in their application across all tasks.

Despite the vast amount of literature written on the topics of motivation in education and self-efficacy, this researcher explored the impact of AITS through Brophy's (2004) foundational theories concerning student motivation to learn, Bandura's (1994) concept of self-efficacy, and Zimmerman's (1989) study on student learning through self-regulation. These theories are intertwined with the current conversations provided by John Hattie (2009, 2012) and Robert Marzano and Debra Pickering (2011), providing a set of lenses through which this researcher viewed this study.

Assumptions, Limitations, and Scope

The concepts of what is essential for a student in mathematics have changed significantly. This change is evident in the data provided by the 2015 and 2017 National Report Card published by the NAEP. The data show a sweeping decline in mathematics ability, reduction that has moved the United States from number 1 in the world for education just 20 years ago, to the current ranking of 38th of 71 countries in mathematics (Desilver, 2017). The most significant impact is to students who cannot get into college or remain in a STEM-based program because their mathematics ability is low. This researcher assumed that providing Internet-based tools to support a student's learning, assist parents with the mysteries of the "new math," and provide instant positive feedback would motivate students to learn and strengthen their self-belief to continue to learn mathematics. This assumption followed the research of Brophy (2004), Pintrich (2003), and Schunk (1995a, 1995b) regarding motivation as a critical component of a learner's behavior and performance.

Limitations of the present study included the product of the site under consideration. This study took place at a local charter middle school with a total population from grades 6 through 8, including 1 ninth-grade transitional mathematics class, of approximately 167 students. These students experienced the AITS implementation, but the study's participants consisted of four to five mathematics teachers, a small sample size. Another limitation was the scope of the study, which focused only on students' motivation and self-efficacy, and did not include any other impact variables, such as gender, age, socioeconomic status, culture, or student achievement.

Significance

Ericson, Silverman, Berman, Nelson, and Solomon (2001) stated that the charter school movement in the United States is one of the fastest-growing models for educational reform. Having autonomy allows charter schools to provide "families and students with another educational choice but also promotes change in the public education system as a whole, thus benefiting all students" (Ericson et al., 2001, p. 1). Charter school autonomy brings with it a higher level of accountability driven by standards-based reform, which holds these charter schools accountable for student progress on standardized tests (Hill, Lake, & Celio, 2002).

These standards include: (a) percent meets expectation (also called "proficiency" for short), for English language arts (ELA) and mathematics; (b) performance gaps (or "gap-closure"), for ELA and mathematics; (c) student growth (or "c growth") ELA and mathematics for elementary and the middle level only; and (d) high school graduation rates (or "graduation") high school level only.

Charter schools that do not meet the performance criteria, based on school level during a two to three-year timeframe, are considered failing and these data negatively influence their charter renewal (Rhode Island Department of Education, 2017). Osborne's (2012) investigation reported that failing charter schools are at much higher risk of closing than any traditional public schools classified as failing.

Leadership at charter schools needs to be transformative in the approach to building a thriving environment. Challenging the traditional bureaucracy theory of democratic accountability, independent charter schools do not need to implement policies or changes enabled by elected officials (Hill et al., 2002). Charter schools can react quickly with guidance from their private board. In this case, exploring options to enhance students' experiences and strengthening their ability to succeed through parallel online tutorials is a benefit of a charter school's autonomy. Standards-based reform starts at the top for traditional public schools. All charters begin at the grassroots of the system by creating freedom of action at the school level (Hill et al., 2002).

Most of the literature regarding math support programs references response to intervention (RtI), which uses a "universal screening process to identify students who need additional support in achieving academic success" (Hanover Research, 2014, p. 5). The significance of this study was to determine the benefits provided by continuous support, providing tutorial systems, such as the AITS, to all students with an end goal of strengthening students' affective domain for learning mathematics. Such a temperament can positively influence mathematics assessment scores and build on students' confidence and their ability to succeed, especially as students transition into college preparatory programs at the high school level and beyond (Mizelle & Irvin, 2007). Research has provided evidence that self-beliefs and attitudes are crucial to mathematics achievement (Hall, 2016). Other studies (Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Möller, Pohlmann, Köller, & Marsh, 2009) suggested that a relationship exists between the concepts of mathematical self-belief in ability, attitude, and achievement. As the two most researched constructs of academic motivation are self-concept and self-efficacy; according to research, self-efficacy is highly correlated to student performance (Pietsch, Walker, & Chapman, 2003; Bong & Skaalvik, 2003).

Definitions of Terms

For the purpose of this study, and to provide clarity to readers, the following definitions were used:

Affective domain: a learning domain that deals with factors such as student motivation, attitudes, perceptions, values, interests, and emotions (Krathwohl, Bloom, & Masia, 1973).

Autonomy: for a charter school: professional independence of schools when it comes to making decisions about how the school will operate and teach students (Autonomy, 2014).

Accountability: for charter schools, an entity being held to the same or greater outcome standards as other public schools ("Evaluation of public charter school program," 2004, para. 4).

Charter school: a charter school is an independently run public school granted greater flexibility in its operations, in return for greater accountability for performance (Uncommon Schools, n.d.).

Common Core State Standards: an educational initiative in the United States that details clear, consistent guidelines for what every student should know and be able to do in math and ELA from kindergarten through 12th grade in preparation for college and careers (“Read the standards”, 2019).

Digital native: students, K through college who have spent their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all other tools of the digital age (Prensky, 2001).

Direct instruction: instructional approaches that are structured, sequenced, and led by teachers (Direct instruction, 2013).

Formative assessment: refers to a wide variety of methods that teachers use to conduct in-process evaluations of student comprehension, learning needs, and academic progress during a lesson, unit, or course (Formative assessment, 2014).

Graduation rates: the percentage of a school’s first time, first-year undergraduate students who complete their program within 150% of the published time for the program (FAFSA, 2018).

General education: a program of education that typically developing children should receive based on state standards and evaluated by the annual state educational standards test (Webster, 2018).

Group work: an environment where students “teach” and explain concepts to each other (Center for Innovation in Research and Teaching, n. d.).

Instructional intervention: an instructional intervention is a specific program or set of steps to help a child improve in an area of need (Lee, n. d.).

Interventions: a strategy used to teach a new skill, build fluency in a skill, or encourage a child to apply an existing skill to new situations or settings (Methe & Riley-Tilman, 2008).

Local educational agency (LEA): a public board of education or other public authority legally constituted within a state for either administrative control or direction of, or to perform a service function for, public elementary schools or secondary schools in a city, county, township, school district, or other political subdivision of a state ("34 CFR 303.23 – Local educational agency," n. d.)

Middle school or middle level: middle school or middle-level schooling is the transitional period between elementary school and high school; commonly designated as grades six through eight, specific districts have excluded sixth grade while others include ninth grade (O'Donnell, 2017).

Modeling: an instructional technique where a teacher demonstrates a concept for students and the students learn from observing or imitating (Haston, 2007).

Motivation: the desire or willingness to do something (Motivation, n.d.).

Online tutorials: a self-study activity designed to teach a specific learning outcome. (University of Bristol, n. d.).

Principal or school-based administrator (these terms are interchangeable): the person responsible for managing the school and overseeing all educational aspects of its students (Inclusion BC, n. d.).

Remediation: the effective re-teaching of material not previously mastered when it was initially taught (Abbott & McEntire, as cited by Neel, n. d., para. 2).

Self-efficacy: people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives (Bandura, 1994).

Standardized test: any form of test that requires all test takers to answer the same questions, or a selection of questions from common banks of questions, in the same way. The tests are scored in a "standard" or consistent manner, which makes it possible to compare the relative performance of individual students or groups of students (Standardized test, 2015).

STEM: a curriculum based on the idea of educating students in four specific disciplines —science, technology, engineering, and mathematics (Hom, 2014).

Teacher certification: a teaching credential or teaching license conferred by a state agency to teachers who have completed state-mandated requirements, such as, coursework, degrees, tests, and student teaching experience ("What is teacher certification?", 2018).

Think-pair-share: a collaborative learning strategy where students work together to solve a problem or answer a question about an assigned reading ("Think-Pair-Share", n. d.).

Conclusion

According to Chappell et al. (2015), "Instructional tutoring has an extensive history in American education" (p. 38). The Every Student Succeeds Act (ESSA) and Common Core State Standards (CCSS) have become the driving forces for accountability models and in their current context are focused on advancing college-and-career-ready outcomes (Reyna, 2016). Laws still require states "to meaningfully differentiate the performance of their schools on an annual basis" (Reyna, 2016, p. 2). Recent National Report Cards from NAEP show student performance declining. Change in traditional public schools is similar to a monopolistic bureaucracy that struggles to keep up with the changing times and economies (Slade, 2016).

One advantage of charter schools is their ability to adapt quickly to specific circumstances for the benefit of students' success.

This researcher hopes to use the results from this study to expand a plane of knowledge that supports the need for parallel online tutorials beyond the intervention models that populate today's literature. Delving into research literature in Chapter Two to understand how a student's motivation and belief in their ability to learn mathematics can contribute to increased assessment scores and build a strong foundation to support the continued need for online tutorial platforms.

CHAPTER TWO

LITERATURE REVIEW

This study was designed to examine the effects of an adaptive intelligent tutorial as an instructional intervention on the self-efficacy and motivation of middle school students who are learning mathematics. The review of related literature encompasses a variety of sources that have influenced and contributed to the current research involving mathematics proficiency in secondary schools. The content for this literature review was collected from well-respected sources in the areas of mathematics achievement and the related topics that affect student performance, motivation, and self-efficacy. These sources include academic journals, research studies, dissertations, research publications, educational reports, and books. These selected sources were also chosen based on the relevance to this study and begin with the current state of mathematical achievement and the factors that affect mathematics achievement, such as anxiety, gender gaps, and motivation to learn. The literature review then examines the benefits of intervention, technology, the impact of differentiated instruction, the role education technology plays in student achievement, the value of adaptive intelligent tutoring systems (AITS), and formative assessment. The review then provides conversation regarding the importance of the teacher in students' ability to learn, as well as the power of their learning proposition to technology implementation. The literature review closes with the presentation of the conceptual framework that guided the study.

Current State of Mathematical Achievement

The NAEP, also known as the Nation's Report Card, is the only assessment that measures U.S. students' academic performance in various subject areas, including mathematics, since 1969. According to the 2015 and 2017 National Report Cards, 34% of eighth and 25% of

12th graders meet proficiency standards (National assessment of educational progress, 2017). Currently, the mathematics ability of many middle and high school students continues to decline. CCSS were put into place to address these falling rates, but progress has been slow. Heitin (2015) stated that K-8th grade Common Core mathematics standards garnered praise since their launch, but weakening high school mathematics standards have raised serious concerns that need to be addressed. For years, it has been evident that high school mathematics curricula are not working. Many students leave their high schools unprepared to enter college, especially in STEM programs, and unequipped to meet the needs of a career (Larson, 2016). The impact of low mathematics proficiency manifests again in college, as 60% of all college students who intended to study STEM subjects transfer out or change degree programs (Lloyd, 2016). One theory states that the STEM exodus is the product of students not acquiring adequate foundations in mathematics, a vital skill in many science and technology curricula (Lloyd, 2016).

With math proficiency scores continuing to fall nationally (NAEP, 2015, 2017), new forms of intervention are required at the secondary school level to offset this decline. Richard Rusczyk (as cited in Lloyd, 2016), the co-author of the “Art of Problem Solving,” stated that failure in math is not about students getting too little math; it is about how it is being taught in K-12. Improving mathematics achievement requires addressing the needs of the students and the factors that affect success, such as gender, race, peer relationships, and the affective domain (Farooq, Chaudhry, Shafiq, & Berhanu, 2011).

This literature review develops a framework of the current research regarding the problems surrounding students’ mathematics achievement in secondary schools. The following section addresses the variables that affect student success, such as math anxiety, gender, race, and motivation. The next sections examine the value of all types of interventions, and the role technology plays in the intervention process. The review of related literature concludes with an examination of a critical element to student success, the teacher.

Factors That Impact Mathematics Achievement

Volumes of literature exist to address student factors that have an impact on mathematics achievement. Most of the research studies focus on specific elements, but very few studies examine the combination of these factors and what can be done to address their impact. Geary (2011) hypothesized that the persistence of low mathematical performance is a product of learning difficulties and disabilities and is not attributable to intelligence. Such problems can be the result of the learning environment, supporting resources, working memory, and poorly constructed and biased standards (Cowan, 2014; Relevant Strategies, 2011).

Anxiety

Al-Mutawah (2015) completed a study that focused on the relationship between mathematics anxiety and how it affects math achievement. Al-Mutawah posited that students have lower anxiety when exposed to positive math experience and support. Harari, Vukovic, and Bailey (2013) conducted a similar study with first graders and arrived at the same conclusion. Negative experiences at the foundational concept levels increase students' anxiety and have lasting effects on future performance (O'Leary, Fitzpatrick, & Hallett, 2017). The Trends in International Mathematics and Science Study (TIMSS) has shown that over successive years, there is a definite correlation between student attitudes and math achievement (Provasnik et al., 2016). Kulkin (2016) wrote that there is a need to continue to nurture math potential grounded in real-life experience, and teachers must develop ways to overcome math anxiety by creating learning opportunities based on student interests. Budget cuts across school districts make it difficult for teachers to find the resources to develop programming, either in the classroom or with the use of technology to address anxiety.

Gender Gaps

Arroyo, Burleson, Tai, Muldner, and Woolf (2013) and Catsambis (2005) provided evidence that both female students and minority students have a high rate of developing negative feelings toward mathematics. Arroyo et al. (2013) posited that each gender's style of learning and affective predisposition toward mathematics influence math achievement. Niederle and Vesterlund (2010) argued that the difference in math achievement is correlated with boys' early development of superior spatial skills and a proclivity for competition over girls. In an earlier study by Niederle and Vesterlund (2007), results showed that girls/women shy away from competition but outperform boys on more tactile tasks. Many reasons contribute to the gender gaps in mathematics achievement; new approaches in teaching and intervention are needed to reduce gender biasing associated with perceptions of ability (Riegle-Crumb & Humphries, 2012).

With many factors, including those noted in the previous paragraphs, affecting mathematics ability and student achievement, raising achievement to higher levels, and closing student achievement gaps are priorities in schools and communities at all economic levels, and in urban, rural, and suburban settings (National Education Association, 2017).

Motivation to Learn

Brophy (2004) stated that motivation is a crucial component to learning behavior, but "schools are boring and frustrating" (p. 1). Sorensen (2006) believed, "academically motivating our students and keeping them motivated can be one of the greatest challenges the classroom teacher ever has in their career" (p. 3). In an era of standards-based educational accountability, it is becoming more evident that student self-assessment is becoming the catalyst for improved student motivation, heightened engagement, and a stronger belief in their learning (McMillan & Hearn, 2008). Bandura and Schunk (1981) theorized that students' self-motivation relies on "an intervening process of goal setting and self-evaluation" (p. 586). Interventions such as technology-based systems, "when used appropriately, can influence academic motivation" (Olsen & Chernobilsky, 2016, p. 4). Lin-Siegler, Dweck, and Cohen (2016) hypothesized that instructional interventions have tremendous value when the activities "target the beliefs or perceptions that hamper students' motivation to learn" (p. 295). Supported by a collection of articles from current researchers on motivation and learning, Lin-Siegler et al. (2016) also provided evidence that application of motivational theories across the ever-changing instructional activities of schools, whether with technology intervention or other platforms, can lead to new motivation principles in education.

The Benefits of Intervention and Differentiated Instruction

According to TIMSS, secondary school students continue to lag behind their international counterparts in understanding the mathematical skills necessary to support the 21st-century global workplace (Provasnik et al., 2016). Cornelius (2013) stated that, over the past 20 years, research has revealed small improvements in math proficiency, but the growth has slowed and many students still struggle with many mathematical concepts (p. 2). Practices such as RtI, implemented early in middle and high school, have seen success (Fuchs, Fuchs, & Compton, 2010). According to Riccomini and Witzel (2010), RtI is a current process for schools to improve learning through "evidence-based instruction, assessment, and interventions" (p. 1).

Current research shows that when used correctly, RtI practices have a positive influence on the math achievement of students. Hanover Research (2014) identified several credible math tutorial instruction and intervention programs, such as Hot Math Tutoring, Number Rockets, and focusMATH Intense Intervention, that can “significantly improve students’ mathematical ability” (p. 3). These technology-based tutorial systems provide scalable value to meet the needs of the three tiers of intervention associated with RtI. Specific studies, such as Chappell et al. (2015), suggested that tailoring the technology-based tutorials for individualized intervention (RtI-tier III) is highly useful for low-achieving students. Riccomini and Witzel (2010) wrote that the primary guiding principle of the RtI model, the belief system, is the most critical facet in improving student learning. The authors’ conviction further supports the research by Al-Mutawah (2015) proving that positive experiences in the learning of mathematics have a lasting effect on students’ confidence, attitude, and level of anxiety. Early intervention programs reinforced with technology-based tutorials have proven to increase middle school student mathematics achievement (Chappell et al., 2015; Cornelius, 2013). Gersten, Jordan, and Flojo (2005) also supported these theories in their study about early identification and intervention with students who struggle with mathematics. In the Gersten et al. (2005) study, the evidence did not suggest any single way of building mathematical proficiency in students because of the differences in the variables encountered. The researchers did support the need for differentiated instruction that best meets an individual student’s need(s). Differentiated instruction is not a new way of thinking or a new trend in education. It is based on best practices and strategies to manage the varying abilities and learning needs of the students (Heacox, 2012). It is essential to support a well-designed intervention program with a core mathematics curriculum of high quality. Sundling (2012) stated that any quality core should include differentiated instruction designed to teach mathematics according to the individual needs of the learners. However, Barnett and Farah (2018) wrote that in a traditional classroom, differentiation is seen as a tool for special needs students, but in the self-paced classroom, differentiation "occurs in terms of time and support rather than content" (para. 4).

Technology: A Tool for Differentiated Instruction

In recent years, the advancement in digital technology, such as the $300 Chromebooks and iPads for students, has provided school districts with affordable options that allow students and teachers with ever-present access to one-to-one (1:1) computing and opportunities for "personalized instruction and enriched curriculums" (Downes & Bishop, 2015; Graham, 2018; Hansen, 2012, p. iii). This kind of technology is transforming how students learn and influencing the affective domain of a student. Access to technology is changing, and the research has shown the positive effects of 1:1 laptop-supported learning for middle school student achievement and significant increases in standardized achievement scores and motivation (Doran & Herold, 2016; Dunleavy & Heinecke, 2007; Harris, Al-Bataineh, & Al-Bataineh, 2016; Silvernail, Pinkham, Wintle, Walker & Bartlett, 2011; Stephens, n.d.).

Dunleavy and Heinecke (2007) suggested that the 1:1 laptop treatment had a more substantial impact on the achievement of males over females. The results of the Arroyo et al. (2013) investigation provided evidence for gender variance, stating that the affective components of these differences are based on theories that girls, throughout K-12, increasingly display more negative attitudes toward mathematics. These attitudes translate into low self-esteem with regard to their mathematics performance (Royer & Walles, 2007).

Other forms of differentiated instruction can include face-to-face tutoring programs that can be personalized based on student needs. This type of intervention also proved valuable, as results of the research conducted by Rothman and Henderson (2011) showed students who attended formal tutoring programs outperformed all other groups in both mathematics and science. Their results further indicated a positive correlation between the teacher and the tutee when classroom teachers using current classroom curriculum staff the tutorial session. In the development of differentiated instruction, many variables must be considered. Teachers in face-to-face tutorial sessions can adapt to student differences, such as intellectual capacity, gender, low achievement, learning styles, and anxiety. An understanding of the cognitive domain is essential, but a combined effort to address the affective domain of both sexes would help to close the gaps associated with mathematics achievement (Arroyo et al., 2013; Niederle & Vesterlund, 2010).

Understanding the relationships of the affective domain of students with their mathematical ability was the focus of Hemmings, Grootenboer, and Kay's (2010) research. They hypothesized that an individual's disposition toward mathematics is a critical factor in a student's mathematical achievement. Their findings identified various groups of variables associated with students' ability to achieve in mathematics, prior aptitude, gender differences, attitude, and an enabling environmental setting. The results of the study showed that personal attitudes, both positive and negative, had the most significant influence on a student's ability.

Another component associated with the affective domain of a learner is students' confidence and self-efficacy in their ability to achieve. Van Veggel and Amory (2014) supported the importance of small group tutorials as a tool for enhancing students' confidence in mathematics, as well as its impact on improved student performance. Tutorials that support students' capacity to self-regulate their learning have positive effects on the motivation of a student and self-efficacy beliefs (Ramdass & Zimmerman, 2008). According to Ramdass and Zimmerman (2008), self-regulation is the process where individuals activate and sustain areas of the affective domain to attain learning goals.

The middle school years are a critical phase of students' learning. CCSS raise the bar with learning goals that students are expected to achieve within each grade level to prepare for success either in college or in the workplace. What CCSS do not address is the variations in how students learn, as well as the factors that influence the learning process (Benjamin, 2017). With disparities in student learning well documented, it is difficult for teachers to meet the needs of all the students. Tutorial support is a vital tool to support student learning and the teachers striving to manage the classrooms of today. Technology-based tutorials such as AITS can adapt to the needs of the students.

Educational Technology—Equity, Access, and Impact on Student Achievement

With the majority of the research supporting the effectiveness of computer-assisted (technology-based) intelligent systems, educational technology in the classroom remains questionable. According to De Witte, Haelermans, and Rogge (2015), multiple stakeholders with diverging interests; such as parents, teachers, students, administration, policymakers, and educational experts; are now involved in the process. Along with the diverse opinions of the stakeholders, equity, adequacy, and access still plague many districts across the United States. A 2008 National Education Association policy brief reported that technology implementation in many school districts is slowed due to competing priorities, lack of resources, and expertise. De Witte et al. (2015) indicated that in many school districts, significant funds are spent on hardware and software to support educational technology, which includes computer-assisted intelligent tutorial systems, providing ammunition for cynics who do not see the cost-benefit of educational technology and question whether this approach offers an advantage to students' knowledge and achievement. Placing immediate costs over the long-term benefit of transforming teaching that leads to increased student engagement, motivation, and accelerated learning ("Use of Technology in Teaching and Learning," n.d.). The majority of the experts involved in the educational technology debate agreed that when technology is a significant part of teaching and learning, students and the teachers are increasingly engaged and motivated (National Education Association, 2008). The Partnership for 21st-Century Learning, formerly known as the Partnership for 21st-Century Skills, is an organization formed through the collaboration of the business community, educational leaders, and lawmakers to promote the importance of 21st-century readiness. At the epicenter of discussion is K-12 education, with the greatest need for equitable access to technology (Partnership for 21st Century Learning, 2018). Supporting this belief, the U.S. Department of Education published a report in 2016 stating that the expectations of students, as outlined in the P21 framework, demonstrate the need for students to have equitable access to technology, not just to close the digital divide, but also to prepare them for the future (Anders, 2017).

In 2014, Julie Evans, CEO of Project Tomorrow, a non-profit organization focused on changing the lives of children through science, math, and technology education, asserted that while all K-12 and college students have familiarity with technology, "the leading edge of the truly digital native students were at the 8th grade level" (Humes, 2014, p. 2). Today these same eighth graders are graduating high school and have been exposed to or have taken full advantage of how technology has supplemented education (Humes, 2014) with a higher level of self-confidence. In comparison, the early digital natives have come to age and comprise "the new generation of early career teachers" (Orlando & Attard, 2015, p. 107). Orlando and Attard (2015) saw this change in the demographics of teachers as a positive concerning the effective implementation of all forms of technology in the classroom, especially for the teaching of mathematics.

Technology-based learning systems (TLS) benefit school districts in addressing the many factors involved with students' learning. The computer-assisted intelligent and adaptive tutorials are one of the TLSs that can assist individual students with learning at their own pace. According to the National Educational Technology Plan of 2017, technology-assisted learning allows students to tap into resources that expand their opportunities and provide greater equity of access to the historically disadvantaged student (Office of Educational Technology, 2017). Arroyo et al. (2013) reported that the use of computer-assisted intelligent and adaptive tutorial/learning systems have an encouraging influence on students' academic accomplishment and attitudes toward mathematics. The positive effects of intelligent learning systems are driven by an instruction that is personalized and tailored to a student's pace, ability, gender variances, and learning environment (Brasiel, Martin, Jeong, & Yuan, 2016).

Technology and Adaptive and Intelligent Tutorial Systems

Existing research focuses on computer-based tutorials of the classroom, and shows it to be an effective model during regular school hours (McDonough & Tra, 2017). However, the adaptive intelligent tutorial also provides a platform that is portable and effective at home. Roschelle et al. (2016) not only discussed the importance of practicing mathematics but also addressed the concerns of parents related to the value of school homework. CCSS mathematics has made it difficult for many parents to help their children with their homework, creating negative experiences that influence learning. Roschelle et al. (2016) hypothesized that mathematics homework could be improved if immediate positive feedback is available to the student at home and in school. Studies show that online educational technology tools increase student learning, mainly by "enabling timely formative assessment practices related to homework" (p. 2).

Online tools such as ASSISTments and Odyssey® Math provide an intelligent and adaptive platform tailored to individual student needs, providing the necessary hints and feedback that are beneficial to student learning (Roschelle et al., 2016; “What works clearinghouse intervention report: Odyssey© math,” 2017). ASSISTments, a product developed by Worcester Polytechnic Institute in collaboration with Carnegie Mellon, was designed as an online math homework and classroom tutorial to provide instant feedback to the student. Research by Roschelle et al. (2016) examined test scores of 2,850 seventh graders in 43 Maine public schools. Those students using ASSISTments scored close to 75% higher than students not using the online mathematics tutorial (Duffy, 2016). The online tutorial design provided a formative assessment by using data collected from the students’ independent work. Teachers who adjust the instruction based on individual student needs (Escueta, Quan, Nickow, & Oreopoulos, 2017) also used these data.

In a 2009 What Works Clearinghouse intervention report provided by the Institute of Education Science, Odyssey Math, an Internet-based K-8 mathematics curriculum and assessment tool by CompassLearning, has positive effects on mathematics achievement in grades K-8 (What Works Clearinghouse Intervention Report, 2009). In a 2007 study by Judy Dileo, 280 fifth graders in a single school district in Pennsylvania were exposed to the Odyssey Math software. The results showed a positive impact and academic gains in achievement scores.

Another essential aspect of the intelligent and adaptive tutorial (online or in class), is the ability to emulate the classroom teaching and current curriculum (Rothman & Henderson, 2011), providing consistency and alignment to standards. The integration of AITS software with the growing application of 1:1 computing, such as a Chromebook, a low-cost alternative to standard laptops, has provided a platform that has helped to personalize a student’s instruction both at home and in the classroom (Paiva, Ferreira, & Frade, 2017; Stephens, n.d.). These technology-based systems and software are not a replacement for excellent teaching, but instead, provide students with timely formative feedback that is important to their learning.

Formative Assessment

Formative assessment is a process where immediate feedback is provided to students, along with suggestions to help them make the appropriate corrections and improve their learning (Walsh, 2013). Hattie, Fisher, and Frey (2017) stated that formative assessment is about collecting real-time data on student progression and using the data to inform the direction of instruction. Providing informative feedback is an essential factor in motivating learning in various instructional environments, including technology-supported learning applications (Hattie & Timperley, 2007; Hattie & Gan, as cited in Narciss, 2013). Hattie and Timperley (2007) also stated that the right type of feedback is critical to students' learning process. It needs to be the right information to fill the gaps in one's understanding, not just the task at hand, and stimulates the self-regulatory process (Hattie & Timperley, 2007). In a meta-analysis on the applications of formative assessments conducted by Kingston and Nash (2011), two implementations, professional development, and computer-based systems were more effective over other implementations, with mean effect sizes of .30 and .28 respectively.

AITS incorporate an interactive and informative feedback model, a model that provides formative assessment and feedback beyond the scope of just a correct answer to stimulate the learning process and help students' master learning tasks (Narciss, 2013). Research has also shown that formative assessment, either with or without the support of technology, can have a positive impact on student self-efficacy, influencing motivation and achievement (Cauley & McMillian, 2010; Narciss, 2004).

The Teacher Quotient

In 1933, the *Elementary School Journal* printed an article written by L.C. Day entitled "The Teaching Quotient." The article focused on measuring teacher success. As time goes on, districts continue to assess those dedicated individuals who help to educate the new generation of student learners. Hattie (2012) wrote that teachers are the "activators and evaluators" of student learning, and their method of teaching is based on "judgment, listening, and expertise" (p. 96). These elements of teaching are essential in dealing with change. Change is a constant in education, from No Child Left Behind to the CCSS of today, teachers must be adaptive and flexible to meet the needs of their students. Technology has played a large part in the changing educational landscape, and teachers again play a critical role in the "successful implementation of new technologies in the classroom" (Tilton & Hartnett, 2016, p. 79). Concerns still exist among teachers about how technology, such as laptops in the classroom, impact them personally (Donovan, Hartley, & Strudler, 2007). Tilton and Hartnett (2016) have hypothesized that there is a link between teachers' beliefs and attitudes toward technology and the subsequent integration for student achievement. Their mastery, experiences (positive or negative), levels of coaching, and training influence teachers' self-efficacy. Tilton and Hartnett (2016) stated that coaching is the verbal encouragement of trusted individuals on the merit of technology integration. This form of reinforcement is vital to teachers' acceptance of change.

Donovan et al. (2007) wrote that understanding the importance of change can reduce the selfishness of the teachers. Critical to the change process is allowing the teachers' voices to be heard. Donovan et al. (2007) also stated that acknowledging teacher concerns helps those implementing the change to support the teachers throughout the process. These issues are not just a product of American education. Investigating the digital technologies implementation across New Zealand schools, Stuart Armistead (2016) provided evidence that supports the

theory that technology innovation in the classroom “change the way students learn, the way teachers teach, and where and when learning takes place” (p. 9). This change is strengthened by the beliefs and attitudes of the teachers, providing positive experiences to the students.
De Bruyckere, Kirchner, and Hulshof (2016) argued that providing positive experiences is crucial once one can reach the *digital natives*, the young people who have been immersed in technology all of their lives. For teachers, technology is another factor that shapes the way they teach and how students learn. Teachers continue to have the most significant impact on students’ achievement and have the most substantial number of obstacles to overcome.

Teaching with Technology

In the current 21st-century classroom, technology is becoming a more significant learning and teaching tool, and an integral part of our everyday lives (Costley, 2014). Such tools can provide the means to enable students to learn at their own pace, giving teachers the time to work individually with students of varying levels of ability (Cox, n.d.). The role of the teacher also changes, in the classroom, as one transitions from a teacher-centered information provider to supporting students one-on-one and in groups, providing support and feedback (Dhanda, 2015; Schreurs & Dumbraveanu, 2014). Throughout the years, student-centered learning approaches in the classroom have been on the rise (Baeten, Dochy, Struyven, Parmentier, & Vanderbruggen, 2016). However, according to Chang and Chang (2010), many students prefer the use of both teacher-centered and student-centered approaches. Donnely (2010) showed that blending instructional approaches, direct instruction, group work, and one-on-one, especially with technology, helps teachers to motivate and engage students in their comfort areas.

As the role of technology in the classroom continues to change from the one computer classroom of the past to the integrated technology classrooms of today, teachers are burdened with new requirements of effectively integrating the technology and adapting their teaching methods to meet the needs of their student (Hanover Research, 2014). Professional development primarily focused on changing technologies, is essential, especially for those versed in the traditional classroom delivery methods. Inan and Lowther (2010) showed that teachers experienced barriers beyond their own beliefs that influenced their decisions about technology-supported instruction. The most significant barriers included the lack of professional development, administrative support, and technical support (Inan & Lowther, 2010). In 2014, a national survey of over 600 k-12 teachers, nearly half of these teachers reported a lack of training and support when integrating and using technology in their classrooms (Willen, 2014). In a meta-analysis conducted by Timperley, Wilson, Barrar, and Fung (as cited in Hattie, 2009), professional development was more effective when school leadership supported the process, providing access to the relevant expertise and the sharing of new information in a timely manner.

Teacher Perceptions—Middle School Students

Teachers' perceptions of middle school students begin with the understanding of the challenge that their students face, especially at the onset of the middle-level journey. Megan Mead (2014) reported that the landscape of middle schools has unique challenges, "that combine students' physical and emotional changes with new and difficult content" (para.1). Middle school is a time when students seek independence, a period of transition for "taking ownership of their learning" (Mead, 2014, para. 3). For middle school students, grades six through eight are also formative years, as they begin to shape emotional and social connections, as well as, "conclusions about their mathematical ability, interest, and motivation that will influence how they approach mathematics in later years" (Protheroe, 2007, p. 52).

Middle school teachers are sensitive to the changes in their students, knowing that the transition can be a stressful time for many students (Schielack & Seeley, 2010). Research on the elementary school to middle school transition has shown significant declines in students' academic achievement (Alspaugh, as cited in Schielack & Seeley, 2010). Researchers such as Simmons and Blyth (1987), Wigfield, Eccles, MacIver, Reuman, and Midgley (as cited in Rathunde & Csikszentmihalyi, 2005), agreed that during the transition from elementary school, middle school students begin to build a reluctance to learning, have lower motivation, and lack confidence in their ability to succeed. These factors, coupled with diverse student populations and changes to classroom environment driven by the CCSS movement, create significant concerns for the middle school teachers. From the perspective of the teacher, all he or she can do is to create a classroom culture, a climate, and a curriculum that stimulates students' motivation to learn (Kohn, as cited in Davis & Forbes, 2016). Hattie (2012) stated that one of the mindsets that teachers need to grasp is that they are change agents, and must have the confidence to facilitate positive change in student learning.

Another critical factor for a teacher is having a voice that contributes to the discussions and provides essential insight into the adoption of standards that drive education (Glaus, 2014). From the perspective of the classroom, their voices are the feedback vehicle that shares the observation of changes as they occur, helping to document the failures and the successes, to move students to their learning goals effectively and stimulate their engagement and motivation (Glaus, 2014). Continued professional development is the key, not just to successful implementations of standards or the execution of a technology application, but informs educators about the intricacies of teaching and learning.

Conceptual Framework

The conceptual framework for this study was designed to determine the impact of AITS on middle school students' self-efficacy and motivation for learning mathematics. The researcher utilized the foundational works of Brophy's (2004) theories on student motivation to learn, Bandura's (1994) concepts of self-efficacy, and touched on Zimmerman's (1989) cognitive views and models of SRL, and their connection to motivation and student engagement. The viewpoints from Hattie (2009, 2012), Marzano and Pickering (2011), and Dweck (2010) are also included to expand the current conversation of the classrooms. These connections are evident in the conceptual framework model (see Appendix A), which illustrates the links between the foundational theories and the current conversationalists. The outer ring begins with the classroom context, where teachers review and select appropriate instructional strategies. These instructional strategies provide a level of feedback that can influence students to become more responsible for their learning, which in turn, provides input to the teacher to help adjust his or her approach. The level of support from the outer ring influences the inner constructs of student motivation, engagement, and self-belief, constructs that are connected and have a bidirectional impact on each other. The level of engagement influences the level of motivation and self-belief and vice versa.

Student Motivation to Learn

According to Brophy (2004), student motivation originates from students' own experiences. These experiences influence the students' disposition about whether to engage in their learning. Students can be motivated from within, known as *intrinsic motivation*, because they are interested and enjoy what they are learning. Also, motivation for other students is driven by reward or reinforcement, such as a teacher's praise or a good grade, referred to as *extrinsic motivation*. In his synthesis of a meta-analysis on motivation, Hattie (2009) posited that students who take control of their responsibility for learning have stronger internal beliefs that are associated with higher academic achievement. These forms of motivation are important, but to Brophy (2004), expanding all students' motivation to learn is about cognitive motivation, which includes sense-making, the processing of information, and strategies that stimulate students' inspiration to learn, strategies that guide teachers to shape students' behaviors and help them appreciate their learning opportunities while providing the appropriate tools, adaptations, and interventions for successful learning in the classroom.

Brophy (2004) viewed the classroom as a complex environment of continuous change that challenges the teachers' ability to inspire and maintain the motivational and engagement levels of students. It is the teachers' role to support and inspire their students and use strategic teaching goals to provide deliberate interventions to assist with the students' cognitive change (Dweck, 2010; Hattie, 2012). According to Goodenow (as cited in Marzano & Pickering, 2011), this type of teacher support is the leading "predictor of motivation among students in sixth through eighth grades" (p. 6).

Student Self-Efficacy

Since the early 20th century, the role of self-beliefs dominated the conversation in American psychology from the early writings of William James, the works of psychoanalysts such as Sigmund Freud and Carl Jung, and through the years of behaviorist and humanistic influences (Pajares & Schunk, 2001). In the mid- to late 20th century, educators took an interest in information processing and cognitive processes in learning, driven by the advancement of technology, instead of focusing on students' self-beliefs in learning (Pajares & Schunk, 2001).

In 1986, Bandura's social learning theory of 1960 was revised into SCT, which hypothesized that learning could occur through the social interaction of people, their experiences, and behaviors. Based on Bandura's (1986) Social Cognitive Theory (SCT), people are self-aware of their capabilities, which are core to how humans function. Influenced by these personal beliefs, or self-efficacies, individuals have the confidence to impact their own lives, experiences, and events, not just under normal circumstances, but also during challenging situations (Bandura, 1977, 1986, 1994, 1997).

Over the past 20 years, research on academic motivation and student achievement has seen a renewed focus on student self-efficacy (Artino, La Rochelle, & Durning, 2010). In the synthesis of a meta-analytic study, Hattie (2009) postulated a strong relationship between self-concepts of ability and achievement. However, the measures of self-concepts of ability are more "self-estimates of ability than self-concepts of ability, which should also include concepts of pride, worth, and confidence" (p. 47). As a self-measure, a strong sense of confidence has shown to be the most powerful influencer of positive achievement in schools (Hattie, 2009). He also highlighted in his research that self-efficacy and achievement have reciprocal effects; higher self-efficacy leads to higher achievement and vice versa.

Self-regulation with Technology

Zimmerman's (1989) social cognitive theory (SCT) of self-regulated academic learning (SRL) recognizes the value of SRL as a vehicle for improving student-learning achievement. It is a way of allowing students to control emotions, monitor their situations and behaviors, and become masters of their learning processes (Hattie, 2012; Zimmerman, 1989). It is about developing intentions or strategies to achieve academic goals and is linked to perceptions of self-efficacy (Hattie, 2012; Zimmerman, 1998).

Today, technology as a learning tool has opened doors to new and innovative applications of teaching and learning (Ford & Lott, 2011). Intelligent, adaptive tutorials can help students self-regulate their knowledge through practice and reinforcement (feedback). Each learner has his or her methods to acquire understanding and experiences to build knowledge, all of which affect the learning process (Aldoobie, 2015). Zimmerman's (1989) SCT of self-regulated academic learning recognizes the value of SRL as a vehicle for increasing engagement and improving student-learning achievement. As a pioneer of SRL, Zimmerman's (2002) model uses a series of feedback cycles that allow students to evaluate their performance and use the feedback to improve their learning. Technology-based tools, such as the AITS, provide formative feedback that assists in the self-evaluation and improvement of learning. Research has shown positive correlations among the self-regulation of student learning, their self-efficacy, and academic achievement (Agustiani, Cahyad, & Musa, 2016). However, literature regarding students' attitudinal perceptions of technology seems to be limited according to the works of Liou and Kou (2014).

Conclusion

Currently, student achievement is modeled after a complex multi-variable equation, where the balance between these variables is critical to its success. The United States continues to lag behind many developed and developing countries in mathematics and science proficiency during an age when technology is reshaping the classrooms, not only with facilities and equipment, but also as a "new mindset of teaching through technology" (Blair, 2012, p. 10), which depends on an essential shift in the role of the teacher and the student.

This literature review provided an examination of the current research surrounding the forms of timely intervention that have yielded positive results in classes across multiple demographics. However, the research fell short of portraying the combined perceptions, attitudes, behaviors, and self-efficacy of students and, in some cases, those of the teachers when technology becomes part of the teaching and learning process. As the U.S. Department of Education strives to find ways to address the continuing decline in student proficiency with new reform efforts, the teacher, who is central to the success of any reform effort, must remain flexible and be able to adapt quickly to this change (Christenbury, 2010). Finding the right blend of technology and pedagogy in an era of standardized testing to help students succeed is a formidable task.

Motivating students to learn is only part of the equation; helping to strengthen their belief and ability (self-efficacy) is critical to formulating a solution for future achievement. Chapter Three provides the framework and methodology to seek further understanding to the research questions and provide data to determine the impact of technology, especially AITS, on middle school students' motivation and self-efficacy in mathematics through the observations and perceptions of mathematics teachers.

CHAPTER THREE

METHODOLOGY

According to a 2017 report from the Pew Research Center, a Washington, D.C. nonpartisan fact tank, “U.S. students continue to rank around the middle of the pack, and behind many other advanced industrial nations” (Desilver, 2017, para. 1) in both mathematics and science proficiency. For a student who wants to enroll in STEM-based degree programs in a post-secondary institution, prior mathematics preparation is a contributing factor in the level of achievement that one experiences, leading those who struggle to meet academic benchmarks to contemplate changing majors. Additional impact on students, due to their inadequate preparation in pre- and post-secondary education, includes adverse effects on their self-belief and motivation to persevere through the learning experience.

Purpose of the Study

The purpose of case study was to determine, through exploration and qualitative analysis, the impact AITS has on the behaviors, beliefs, and motivations of students to learn mathematics in a local charter middle school from the perspectives of the teachers. Creswell (2013) stated that a case study is an “in-depth exploration of a bounded system” (p. 476). This researcher chose the case study design because the study takes place in a real-world bounded system (i.e., a small charter middle school) within a defined timeframe (eight weeks) and with a select group of participants (mathematics teachers). According to Yin (2018), the case study approach also seeks to explain the “how” or the “why” of contemporary circumstances or phenomena. In the context of this study, the researcher explored what can be learned from the teachers’ perspectives, using the application of AITS in middle school mathematics classrooms, by applying an exploratory case study design using open-ended questions in the form of surveys and a focus group.

Research Questions and Design

The following research questions were constructed to uncover rich data to formulate a story for expanding the current conversation regarding technology-based instructional interventions and their impact on student self-efficacy and motivation toward mathematics. The guiding question in this study was:

- What instructional approaches to mathematics-based interventions do teachers believe impact middle school students' affective domain for learning mathematics?

The supporting questions in this study were:

- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating adaptive intelligent tutorial intervention in a general education setting?
- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting?

Chapter 3 includes the qualitative methodologies chosen to conduct this exploratory case study. Also provided are detailed descriptions of the study site, an overview of teacher participants, and their selection criteria. Subsequent sections outline the data collection instruments, a timeline for the study, the methods chosen for data analysis, participants' rights, and potential limitations that might have existed within the study.

Site Information

The setting for this exploratory case study was a small charter middle school with a total population of 144 students, 12 teachers, 8 support staff, and 1 in-house administrator. The demographics, by race, for the student population show approximately 63% of the students as Caucasian, 17% Hispanic, 10% multi-racial, 7% African American, 2% Asian, and 1% Native American. As an alternative measure of the socioeconomic makeup of the school, 51% of the students are eligible for the free or reduced-price lunch program, out of which, 38% are free-lunch eligible. Neither race nor socioeconomic background have a bearing on this study.

This middle school is part of a two-school LEA, another designation for charter school districts, and is a feeder program for the high school. The middle school class structure is similar at every level, grades 6 through 8, which consist of 3 to 4 classes per grade with average class sizes between 12 to 16 students. As a requirement of their charter, the school maintains an inclusive classroom climate, which refers to a learning environment where all students belong regardless of their identity, learning style, or level of education, and are supported both academically and intellectually ("Inclusive classroom climate," 2018). Combining this climate with the small classroom structure provided an ideal environment for this research study, allowing the participating teachers to evaluate each class individually.

As a feeder for the high school, the middle school fosters a culture of consistency that provides a seamless transition for students going into high school. As a "culture of consistency," the charter middle school has a better handle on the course sequencing and assessment of student needs prior to entering the ninth grade, especially in mathematics.

According to the Rhode Island League of Charter Schools, the value of the entrance lottery is to provide a transparent process "open to all students, including many from low income, diverse communities" (Rhode Island Charter Schools, 2018, para. 2). One restriction to this process is a charter school's inability to request and review students' prior ability or grade status until they are selected. In past years, students' mathematics ability was a problem, with 21% of the school students meeting proficiency. Today, the middle school has shown a decline in scores with only 15-19% of the students attaining the mathematics proficiency standard. With mathematics proficiency serving as one of the key indicators for a healthy and prosperous school, this research is timely. The researcher received support for this investigation from the superintendent, school principal, and the current president of the board of trustees.

Participants/Sample

The participants of the study consisted of state-certified, middle school mathematics teachers (n = 5) who hold a secondary grades mathematics teacher certification to teach middle school mathematics. Aside from the state certification, selection criteria of these teachers include their willingness to participate in the pre-survey, acclimation, and study phases of this research; teaching or supporting mathematics classes in the sixth, seventh, eighth, and ninth grade; and their preparedness to incorporate the AITS in their classroom for the duration of the study. Included in the study is one ninth grade transitional math class totaling 23 students; this brings the total population engaged in the study to 167 students. All prospective participants received an informational letter that outlined the study, the research questions, and the data collection methods with assurances that all information would be kept secure. Invitations to the study (Appendix B) were sent to the appropriate participating individuals via school emails.

Pre-Survey Phase

The pre-survey phase was a one-week period that provided the participating teachers time to access and complete the first online survey (Appendix D) for the study. All surveys were created using Google Forms, and an access link was provided to potential participants via the school email system. Informed Consent (Appendix C) was included on the first page of the survey along with a checkbox that participants needed to select to proceed. The pre-survey consisted of 18 open-ended questions and took approximately 45-60 minutes to complete. The goal of this survey was to gather data regarding teachers' perceptions of students' motivations and self-beliefs concerning learning mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting. This pre-survey phase overlapped the acclimation period by a few days to conserve time.

Acclimation Phase

The acclimation phase was a two-week preparation period for the participating teachers. During this phase, the teachers were introduced to the AITS via access to self-paced professional development videos offered at no cost from the ASSISTments website. These short, self-paced videos cover topics that include basic site navigation, creating classes and organizing assignments, and easy to use tools for the integration and support of the AITS software. The acclimation period also allowed teachers to introduce the AITS to the students through introductory assignments. This acclimation period provided the teachers with a transparent and seamless transition once the study began, and the student population began using the online program for daily problem solving.

Study Phase

The study phase took five weeks. During the first four weeks of this phase, teachers implemented AITS online applications in all of their mathematics classes. The teachers observed the behaviors, attitudes, engagement, and motivations of the students as they worked through the mathematics assignments each day of the study. The fifth week provided the teachers access to the online post-survey (Appendix E), which focused on the observations of the classroom, concerning the motivation and self-belief of middle school students' learning mathematics when incorporating AITS intervention in a general education setting. Similar to the pre-survey, the post-survey, also created in Google Forms, consisted of 17 open-ended questions and took approximately 45-60 minutes to complete. Upon the completion of the post-surveys, willing participants were provided access to the Focus Group Consent and Sign-up form (Appendix F).

Those who filled out the form agreed to participate in the focus group discussions. The voluntary follow-up focus group took place during the week following the in-class study phase period and took 45 minutes to complete. The data gathered in the focus group helped the researcher better understand the teacher's opinions, feelings, and viewpoints of the study and the AITS, which did not surface in any of the other qualitative data collection methods.

Instrumentation and Data Collection

The goal of this exploratory case study was to determine, through data collection methods, the impact of AITS on students' motivation and self-efficacy for learning and achieving in mathematics. The qualitative data sources included teacher pre- and post online surveys focused on their observations and perspectives of students' abilities, engagement, and motivations in their mathematics classes and a follow-up focus group.

The pre-survey (Appendix D) was provided via online through Google Forms and was available to the participants for one week. The goal of this pre-survey was to collect baseline data from the perspective of teachers on current student behavior, ability, and motivation /engagement in mathematics classes with teacher-directed intervention. Also provided via Google Forms and made available to all participants for one week, the post-survey (Appendix E) utilized a similar design of questions to gather data from the teachers' perspectives on students' behavior, ability, and motivation/engagement after the five-week immersion in mathematics classrooms with the AITS. The questions for both surveys were open-ended to provide rich qualitative data. Because self-efficacy is a construct of motivation (Bandura, 1977, 1986, 1997), care was taken to reduce redundancy during question development.

The final data collection method, a follow-up focus group (Appendix G), took place two days after the post-surveys were completed. The focus group consisted of mathematics teachers who volunteered to be part of the final data collection process. The focus group helped to gather additional data on the teachers' perspectives of student learning and the value of the AITS in their understanding of mathematical concepts. The use of focus groups is a valuable tool and has the potential to generate data that may not surface in other qualitative methodologies (Williams & Katz, 2001). According to Krueger and Casey (2015), focus groups are used to gather opinions from participants and to understand better "how people feel or think about an issue, idea, product or service" (p. 2). The focus group design followed an adapted version of a focus group protocol outlined in *Focus Groups: A Practical guide for applied research* (Krueger & Casey, 2015). All focus group questions were open-ended, and the session took place at the middle school at the request of the teachers. The focus group session took 60 minutes to complete, was recorded using an iPad, and uploaded to an online audio transcription service called REV. The participants were informed that all data collected would be secured and handled at the highest levels of confidentiality. Once the transcriptions (both electronic and hardcopies) were completed and returned, they were shared via email with the participating teachers for member checking to validate the accuracy of the findings.

All recorded data are stored digitally on the researcher's partitioned and encrypted flash drive using VeraCrypt. VeraCrypt is a USB drive application that provides secure password-protected storage. Along with the secured flash drive, all hardcopy documents will continue to be stored offsite in a locked file cabinet for one year after the study is completed.

Analysis

Implementing a qualitative case study approach comes with critical decisions in the design and analysis of the study. Based on this supposition, this study's design leaned toward exploratory qualitative data collection and analysis methods grounded in the best practices associated with a qualitative methodology. These methods included the identification of broad themes and patterns through thematic coding of the qualitative surveys and the focus groups. Creswell (2013) stated that coding is a process that categorizes ideas from the transcripts and labels them to create a framework of themes. These themes guided a rich conversation, as this research helped to “generate knowledge grounded in human experience” (Sandelowski, as cited by Nowell, Norris, White, & Moules, 2017, p. 1) as well as capture their perspectives of the classroom, student behavior, and ability.

According to Saldaña (2016), the number of coding methods can vary from one study to another, and the researcher decides to select the appropriate number of coding techniques to capture the complexities of the phenomena in a study. The specific coding methods chosen must align with the answers one seeks from one’s research question (Saldaña, 2016). For the pre-post survey and focus group response analysis, this researcher applied exploratory methods, which served as the initial assignments of codes or themes as part of the open-ended question investigation (Saldaña, 2016). Creswell (2013) stated that open-ended questions have considerable drawbacks in coding and analysis and require significant time to categorize the responses into appropriate themes. According to Saldaña (2016), “Coding is not a precise science; it is primarily an interpretive act. Also be aware that a code can sometimes summarize, distill, or condense data, not simply reduce them” (p. 5). These preliminary codes/themes provided the foundation for refined second cycle coding methods, such as focused coding to search for the most frequent or significant themes or codes in the data (Saldaña, 2016).

The data collection methods selected for this study included an online pre-post survey and a follow-up voluntary focus group. For the pre-post survey and focus group response analysis, this researcher applied open hand-coding methods to subdivide the data into first level concepts and created a codebook of initial code assignments from the open-ended questions. For second level coding, this researcher used NVivo, a computer software package designed to assist qualitative researchers working with rich text-based information and analysis tools to help generate code assignments into specific themes or categories. In conjunction with NVivo software, this researcher also used a second round of hand coding to verify codes and theme selections. This process helped this researcher to identify and reinforce the essential components for the development of a data table to organize and explain the results.

Participant Rights

This study was strictly voluntary, and the rights of all participants were clearly stated in the informed consent document located on the first page of the pre-survey. The informed consent document included the description of the data collection methods for the study that consisted of a pre-post survey and a voluntary follow-up focus group. All participants maintained the right to withdraw from the study at any time at no risk to the individual(s). The rights of privacy and confidentiality were in place to protect all participants in the study. All information collected that was not held anonymous, such as names or personal identifiers, was meticulously cleaned from the data. Any personal identifiers that remained became classified as a "need to know" standard. Names of teachers who participated in the focus group were kept confidential or coded with an alias where applicable. These coded-alias reference sheets are stored in a locked file cabinet in a location offsite of the study.

Transcripts of the teacher surveys and focus group feedback were shared with the teacher participants as part of the continuous member checking process. After the data collection, data analysis, and member checking processes were completed, and all hardcopy /electronic transcripts, coded aliases, and numbered reference sheets were securely stored in a locked file cabinet following the agreed-upon security protocol. These electronic and hardcopy documents will remain secured for one year after the study concludes and will be destroyed by a secure shredding service immediately after the one-year timeframe. All digital files, including audio, are secured by encrypted passwords and disposed of following the National Institute of Standards and Technology 800-88r1(NIST) guidelines for media sanitization (Kissel, Regenscheid, Scholl, & Stine, 2014).

Limitations of Research Design

Potential limitations did exist within this study. The most obvious was the small teacher sample population of less than or equal to five participants. There may be concern about bias from the administration since this researcher was part of the board of trustees for many years. This researcher did not have direct authority, a supervisory role, or hold a position of evaluation over the participants of the study. The researcher maintained an open and continuous member checking process as a way to minimize any potential effect of personal bias and conflict of interest. Another limitation may be the length of the study, designed for less than a two-month duration, a time constraint that may also have had a negative impact on the level of student and teacher comfort with the AITS, even with an acclimation period included in the process.

Another significant limitation to this study is the lack of assessment of the effectiveness of the AITS on student mathematics proficiency along with the impact on variables such as gender, math anxiety, socioeconomic status, and race. It is the hope of this researcher that the data collected in this study will generate interest from other researchers to link AITS applications to student mathematics ability and all variables that influence students' mathematics proficiency.

Conclusion

As previously stated, this exploratory case study sought to document the impact of adaptive intelligent tutorials on middle school mathematics students and the basis of the discussion focused on the perspectives of their mathematics teachers. The data collection methods employed helped to gather data at different stages of the study to uncover any subtleties in the information that might have appeared over time. The analysis investigated, compared, and interpreted any subtleties to develop clear patterns, codes, and themes in the data. The following chapter presents, in detail, these findings in a logical and organized manner. Chapter Four summarizes the purpose of the study with research questions, the processes used for survey distribution and the follow-up focus group, the description, and roles of the participants, the pre-post survey and focus group data analysis, and the presentation and summary of the findings.

CHAPTER 4

RESULTS

The purpose of this exploratory case study was to determine if an adaptive intelligent tutorial, such as ASSISTments, had a differential impact on middle school student motivation, engagement, and self-beliefs for learning mathematics. The data collected and analyzed were from the perspectives of mathematics teachers to uncover whether differences existed between the use of adaptive intelligent tutorials and teacher-directed approaches in their classes. This chapter presents the analysis and synthesis of data collected, from three data sources, in response to research questions that guided this investigation. The primary question was:

- What instructional approaches to mathematics-based interventions do teachers believe impact middle school students' affective domain for learning mathematics?

The supporting questions were:

- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating an adaptive intelligent tutorial intervention in a general education setting?
- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting?

The three data sources in this study included a pre-survey, a post-survey, and a focus group. Table 1 further outlines the specific sources of data related to the research questions and the areas of interest that were under investigation.

Table 1

Research Questions and Data Sources

Research Questions	Interest areas	Data Source
RQ1: What instructional approaches to mathematics-based interventions do teachers believe impact middle school students' affective domain for learning mathematics?		Focus group questions
	Formative feedback	3, 6
	Motivation and engagement	1, 4, 5
	Self-regulation	1, 4
	Self-efficacy	1, 4
	Instructional approaches	2, 3
RQ2: What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating adaptive intelligent tutorial intervention in a general education setting?		Post-survey questions
	General questions	1-6
	Motivation and engagement	7-11
	Self-efficacy	12-14
	Self-regulation	15-17
RQ3: What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting?		Pre-survey questions
	General questions	1-5
	Motivation and engagement	6-12
	Self-efficacy	13-15
	Self-regulation	16-18

The first data source, the pre-survey, consisted of 18 open-ended questions organized under 4 areas of interest; motivation, engagement, self-efficacy, and self-regulation; to aid in the organization of the analysis. The pre-survey was administered to five participating mathematics teachers. The distribution of the 5 mathematics teachers, as outlined in Table 2, included one for sixth-grade level, one for seventh-grade level, 2 for eighth-grade level, and one for ninth-grade level mathematics covering 10 sections and encompassing 167 students. As described in research question 3, the pre-survey was designed to gather information regarding teachers' perspectives related to teacher-directed approaches to mathematics instruction in the middle school environment.

The second data source, the post-survey, consisted of 17 open-ended questions structured around the same 4 interest areas employed in the pre-survey and same student population. However, as evident in research question 2, the post-survey design focused on gathering information from the teachers' perspectives regarding their use of the adaptive intelligent tutorial in the middle school and ninth grade transitional mathematics classes. The post-survey was accessible to the teachers after a 10-day acclimation phase, where teachers were provided free training videos about the use of the online AITS system and a 4-week application (study) phase in the classrooms.

The final data source, the focus group discussions, consisted of six open-ended questions administered to the participating middle school and transitional mathematics teachers in a semi-structured approach to help probe into the conversation in greater depth. As described in research question one, the purpose of the focus group was to gain a comprehensive understanding of the case study and collect data not revealed in the earlier data collection approaches and to gather information on the broader impact of AITS on the students' affective domain.

Survey Distribution Process and Focus Group Follow-up

The data collection methods included pre-post surveys along with a voluntary follow-up focus group. To maintain consistency in the distribution process for the surveys, Google Forms were used to develop and distribute both surveys. The pre-survey distribution process began with an informational letter (Appendix B) emailed to each participant via the charter middle school email system. The informational letter provided the study outline, research questions, and pertinent details of the study. One week after the participant information letter was sent out, this researcher forwarded the Google Form link that gave all participants individual access to the informed consent and the pre-survey if they opted to participate. Researcher contact information was provided in the informational letter and informed consent in case there were access problems or questions about the process. The pre-survey was open for one week with an additional three days added due to technical problems with Google Forms. During the pre-survey open-access period, two additional reminder emails were sent to the participants. The participation rate for the pre-survey was 100% with teacher perception data collected from 10 of 10 classes.

During the fourth week of the in-class phase of the study, the post-survey was accessible for one week through Google Forms. Access information was provided to all participants through a secure, Internet-based link, accessible only to the participants via their personal school email addresses. This access information directed the participants to the Google Form site and informed them about the follow-up Focus Group Consent and Sign-up form at the end of the post-survey. The response rate for the post-survey was 90%, with 9 of 10 surveys returned. All pre-post survey data collection was through the Google Form site and stored as tabulated data in files formatted as comma-separated values. This researcher downloaded the tabulated data file to his password-protected laptop as a Microsoft Excel file. The Microsoft Excel file format made it easier to upload into NVivo for additional coding purposes.

The focus group discussion of the study took place two days after the close of the post-survey. All participating teachers filled out the consent form (Appendix C) attached to the end of the post-survey. By filling out the consent form, the participating teachers agreed to be part of the focus group discussion. At the end of the consent form, each participating teacher was asked his or her preference of location for the focus group. Three of five participating teachers requested the focus group to be held in a charter middle school classroom for their convenience. The audio data from the discussions were captured using a password-protected iPad and laptop. This researcher utilized the laptop as a contingency back-up device in case any technical problems arose.

Description and Role of Participants

The participants for this study consisted of both female and male teachers with varying levels of teaching experience. Table 2 provides a breakdown of their professional roles, teaching experience, instructional approaches, and the number of mathematics classes they taught during the study. Based on the confidentiality afforded to the teachers by this researcher at the onset of this study, aliases were randomly assigned to the participating teachers. All other data used in Table 2 were collected from the “General Questions” section of the pre-survey (Appendix D).

Table 2

Teacher Demographics and Instructional Approaches

Teacher alias	Gender	Age	Years of teaching	Math grade	Instructional approaches	# Classes
Jane	Female	37	15	sixth	Direct Instruction/individual work	3
Jody	Female	27	3	seventh	Direct instruction/group work	3
Joseph	Male	29	4	eighth	Small groups/think-pair-share	1
Dawn	Female	27	2	eighth	Direct instruction/group work	2
Sharon	Female	45	1	ninth	Direct instruction/modeling/practice	1

Jane taught sixth-grade mathematics. She had 15 years of teaching experience with 4 years at this charter middle school. During the study, the mathematics topics covered in her class included integers and graphing on the coordinate plane. Her preferred instructional approaches included direct instruction with minimal time for students to work alone.

Jody taught seventh-grade mathematics. She had three years of teaching experience, all at the charter middle school. During the study, the mathematics topics covered in her class included ratio/proportional relationships. Her preferred instructional approaches included direct instruction, cooperative learning groups, and modeling approaches.

Joseph taught eighth-grade mathematics. He had four years of teaching experience all at the charter middle school. During the study, the mathematics topics covered in his class included algebra and linear equations. His preferred instructional approaches included group work, individual work, and multi-tiered instruction.

Dawn taught eighth-grade mathematics. She had been teaching for two years at the middle school. During the study, the mathematics topics covered in her class included algebra and solving and graphing linear equations. Her preferred instructional approaches included direct instruction, goal setting, and cooperative learning.

Sharon taught eighth to ninth transitional mathematics. She had one year of teaching experience at the middle/high school. During the study, the mathematics topics covered in her class included understanding functions and system of equations. Her preferred instructional approaches included direct instruction, modeling, student practice, and formative assessment.

Analysis Method

The analysis of the qualitative data collected was framed around the hypothesis that the classroom context (teacher-directed or AITS) that provides definite levels of feedback to encouraging students' self-regulation had a positive influence on student motivation, student engagement, and student self-belief in their ability. The objective of this research was to identify similarities and differences relevant to the three research questions. The following section discusses each data collection method and the coding processes that led to the analysis. Before the analysis began, the participating teachers were asked to validate their responses as part of the member checking process. The collected data from the pre-post surveys and focus group were forwarded to the participating teachers via their personal school email addresses. The member checking process resulted in 90% of the interviewees responding to confirm they had reviewed the text of the transcripts.

Pre-Post Survey

The pre-survey produced teacher perspective data from all 10 classes investigated for a 100% response rate. The post-survey produced teacher perspective data from 9 of 10 classes studied for a response rate of 90%. The pre-post surveys were analyzed separately, and this researcher maintained consistency in the steps of analysis. These steps included reviewing and grouping the survey by individual teacher responses. Because of the small sample size ($n = 5$), this researcher utilized first round exploratory coding analysis by hand. For each group of teacher responses, codes were assigned to pieces of data in a line-by-line analysis to develop a preliminary codebook for each participant.

All codebooks were uploaded into NVivo and the second round of coding helped the researcher identify associated and redundant codes. These codes were categorized and consistent themes began to appear from the analysis of the data. The design of the surveys focused on three areas of interest: student motivation and engagement, student self-efficacy (self-belief), and student self-regulation. In the analysis of all surveys, these areas of interest became prominent, validated themes throughout the study. Participant responses also produced a subcategory of codes that provided additional subthemes based on the participants' interpretations of the questions, their perspectives of the classroom, and their experience.

Focus Group

The final part of this exploratory case study included a single focus group. Based on the data collected from the Focus Group Consent and Sign-up form, the focus group was held in a classroom at the study site. This researcher chose to hand code the transcripts and use open coding as the initial phase of the qualitative data analysis. At the beginning of the hand coding analysis, the questions and associated answers were separated and analyzed line by line to identify coding patterns such as differences in opinions, similarities in responses, or whether connections existed between concepts discussed. The transcription was upload into NVivo with the established codebook and analyzed a second time holistically to identify any interconnections or overlap between all questions and answers that needed further analysis. All codes defined in the analysis of the focus group transcription were grouped into categories that established themes and subthemes.

As a final validation, this researcher triangulated the data by comparing the participants' responses to each collection method to each other one. The triangulation process enabled the researcher to uncover evidence of similar themes across the different data sources (Creswell, 2013). From the analysis of all three collection instruments, pre-post surveys, and the focus group discussion transcriptions, common themes were identified with regard to the areas of interest, student motivation and engagement, student self-belief, and student self-regulation. Each data collection instrument produced variations (subthemes) based on the classroom approaches used by the participating teachers at the specific intervals of the study, teacher-directed and the adapted intelligent tutorial approaches. The following section is the presentation of these results.

Presentation of Findings

For the presentation of the findings, the results were homogeneously grouped by the data collection methods for ease of comparison. The results were extrapolated from each participant's responses. A broader, more holistic explanation of the results follows in this chapter.

Pre-Survey Results

The participants of the study were presented with 18 pre-survey questions, as indicated in Appendix D, "Pre-Survey." The questions asked in the pre-survey addressed RQ3 and the associated areas of interest, student motivation and engagement, student self-belief, and student self-regulation from the perspectives of teacher-directed approaches in a general education setting. The coding process for the pre-survey produced three primary themes, and the findings are summarized with examples from the participating teachers to illustrate the results. Table 3 outlines the areas of interest delineated in RQ3, the related themes and subthemes, along with the frequencies of the subthemes that were identified from the pre-survey coding.

Table 3

Themes and Subthemes—Pre-Survey

Interest Areas	Primary Themes	Subthemes	Frequency
Student motivation and engagement	The importance of instructional approaches and class culture	Teacher encouragement and support	10
		Group work	9
		Incentive program/goal setting	8
Student self-belief	Varying student ability and confidence	Lack of knowledge and ability	10
		Low tolerance for tasks	7
		Peer pressure/class behavior	5
Student self-regulation	Importance of feedback, goal setting, and time	Teacher and student feedback	10
		Time constraints	10
		Goal setting	8

Theme 1 (Pre-Survey): The Importance of Instructional Approaches and Class Culture

The most frequently occurring theme in the responses to the pre-survey was: the importance of instructional approaches and class culture. The findings clearly show that the classroom context, the way teachers manage their classroom daily, establishing the best instructional approaches, and the overall culture of the classroom do influence the engagement and motivation of the students.

Jane

Jane’s teacher-directed approaches, according to her pre-survey response, included direct instruction with the group and individual work. Her students’ motivation was consistently high but she reported that a large part of her classes' positive motivation was driven by real incentives. Jane explained:

> Motivation needs to be encouraged by the teacher, and the teacher needs to build a class culture that has high expectations but celebrates success. However, for her sixth-grade classes, success is motivated by tangible rewards, such as school-wide incentives and raffle prizes.

In response to the questions regarding student engagement, Jane stated that her students became discouraged with mathematics. Their level of engagement varied with the topics covered and how she, as a teacher, approached the topics in the classroom and the amount of support and encouragement she can provide based on available time.

Jody

Jody's responses to the pre-survey questions provided insight into the motivation and engagement of her seventh-grade classes. Jody articulated her belief that, "Positive classroom culture provides a solid foundation for all her students, even if the students are ready to learn or not." She saw motivation and engagement as a balance between what was being taught and the choices she provided students. Jody experienced days when students were not engaged at all, and days when they were engaged 100%. Jody stated:

> Students are more engaged in their work when she utilizes group work approaches but finds it difficult to maintain this instructional approach across different mathematical topics. Each topic presents different challenges that require different approaches and levels of support to the students.

Jody saw value in being flexible in her classroom approaches, especially when students' engagement and motivation started to diminish.

Joseph

Joseph's algebra class provided different challenges. His pre-survey responses showed that more than 50% of his students had a disdain for mathematics, so choosing the right instructional approach and amount of support was essential to providing a balance in the classroom for the varying levels of ability. According to Joseph, school-wide incentives had little impact on his students' motivation and engagement. From his professional experience, providing a classroom culture that enabled students to feel comfortable and supported stimulated greater engagement and motivation.

Dawn

Dawn's pre-survey responses provided evidence that a classroom culture that had a supportive structure and appropriate instructional approaches had a more significant impact on the motivation and engagement of her students. Dawn's students were less motivated by tangible rewards provided by the school's incentive programs. Dawn stressed that her students' motivation and engagement came from their personal goals of wanting to graduate into ninth grade. Dawn had structured her approaches around less direct instruction and more group work, practice, and learning from each other, seeing the social connection as an essential part of her class culture. The group work with peer feedback had a positive impact on students' motivation and engagement over direct and individual approaches.

Sharon

Sharon taught ninth grade transitional mathematics, which included both students who transitioned from the charter middle school and students from other districts transitioning into the charter high school. Sharon stated:

> My classroom approach is essential at this level, especially since my classroom has three distinct pathways of students, those who are highly motivated, students who have varying degrees of engagement and motivation, and those students that have a disdain for mathematics and show low motivation and engagement for learning.

Sharon described her need to maintain a level of consistency in both teacher support and instructional approaches that met the students' needs. The selection of the right instructional strategies, such as; think-share-pair, group work, or one-on-one instruction, had positive results, even with students who were only motivated by grades.

Theme 2 (Pre-Survey): Varying Student Ability and Confidence

The second theme from the pre-survey was: varying student ability and confidence. This theme was defined by the teachers' perceptions of the varying levels of student ability on students' confidence and their behavior in the classroom. What made this theme thought provoking was its link to the foundational understanding of the dynamics of student self-belief; students' need to be confident in their ability to succeed.

Jane

Jane articulated that the level of ability of her students had a direct impact on their confidence, their motivation and engagement and, at times, she identified a lack of fact fluency and number sense in mathematics as the main culprits for many of her students' lack of confidence and lack of focus on current mathematical topics. Jane added that her students with low self-confidence were affected by passive peer pressure. When students who struggled saw other students doing their work, they shied away from drawing attention to themselves by pretending to understand, which negatively influenced the students' confidence and their ability to ask for help. Jane provided insight into the value of identifying this student behavior and being proactive in delivering increased teacher support and feedback.

Jody

Jody's perspectives provided a further understanding of the connections between students' confidence, self-belief, and the level of mathematical ability. Jody shared that students' ability or inability manifested itself when working alone. She stated:

> When students look around and see their classmates working intensely, but they do not know the material very well, they pretend that they understand it. They tend to move their pencil around their paper, so as not to draw attention to themselves. In the end, choosing not to raise their hand for help.

The best approach for students with low confidence and ability was allowing them to work together. Students enjoyed the group work and displayed positive attitudes in group work, helping each other learn.

Joseph

Joseph clearly articulated that his students were driven by their desire to succeed but lost their confidence when faced with challenging tasks. His instructional approach was to provide his students choice in how they would like to do their work. In his discussion of students' level of confidence in relationship to their ability, Joseph noted:

> Students with higher ability are confident to work alone. But those students who lacked an understanding in the concepts struggled to work alone and sat quietly without accomplishing the task at hand, never seeking out help.

Joseph's responses showed that most students innately struggled with algebra, but those who understood a given task were engaged. Those who did not understand the concepts lacked the motivation to finish the work.

Dawn

Dawn described her students' confidence in their ability as 50/50. Some of her students saw mathematics as critical to their future and had strong self-beliefs in their ability. Others went through the motions because their parents expected passing grades. Lack of mastery of prior middle school mathematics standards complicated the classroom and reduced the amount of time; Dawn had to provide equity in helping those with varying needs. Based on her pre-survey responses, it was evident that Dawn was a firm believer that the best approach to help her students with low confidence and ability levels was daily encouragement.

Sharon

From Sharon's perspective, confidence and ability worked hand in hand. According to her responses, her ninth-grade transitional mathematics class was divided into three tiers. Those with good ability had greater confidence and did well working alone. Those with moderate confidence tended to be unmotivated and needed continual redirection to accomplish their tasks while those students with the lowest level of confidence and ability required continual feedback on her part to maintain their focus on practicing their skills. Both the middle level and lower level worked well in groups but needed continual validation. Sharon shared:

> There are always clarifying questions as they work through the worksheets, asking for direction. Students with higher-needs look for validation on every other problem, while others ask for no help, even though their results show that they could have used some.

According to Sharon's responses, students who were struggling placed more demands on her time, and when validation or support was not available, the students disengaged from the lessons.

Theme 3 (Pre-Survey): The Importance of Feedback and Time

From the teachers' perspectives, drawn from the pre-surveys, the third theme, the importance of feedback and time, outlined the challenges that teachers faced providing equitable feedback to their students. As noted in the responses, the critical variable was lack of time.

Jane

Jane reported that she encouraged her students to make goals. Some students could set goals on their own, but others needed continual support and guidance. Jane shared:

> Students set goals and check on their progress; reflecting on their performance and providing feedback is often something I "run out of time" with. As an alternative, I have the better students grade their homework, a lot of times, and work with their neighbors regarding any questions they may have, as a form of constant feedback, when I am working with struggling students.

According to Jane's pre-survey responses, group work provided more time for her to do other things, but some of her students preferred always working alone. Those who did tended to need a lot of support and one-on-one attention.

Jody

According to Jody's responses to the pre-survey, she liked to structure her classes around choices in the classroom. Most students tended to choose to work together in groups of two. The sharing of ideas was essential to the students. Moreover, group work enabled Jody to conserve time in the class by providing feedback to 8 pairs of students instead of 16 individual students.

Joseph

Joseph reported that feedback, from himself or student peers in work groups, was vital to the students in his algebra class. He shared:

> When students do not understand a concept or lack the motivation to complete the work. I encourage them to feel free to seek out help (from a group member or me) or work on something else if they need a break from a current task.

In a synopsis of his responses, Joseph's classroom culture enabled students to feel comfortable in class and gather feedback in various ways to help them self-regulate to accomplish their goals. This approach of having choices for feedback saved him time to focus on other students.

Dawn

Dawn's pre-survey responses showed that any feedback she gave her students helped regulate their learning, but providing consistent feedback took time. She stated:

> The curriculum is fast paced and demanding. Fifty minutes is not enough time to cover the material and provide feedback to the students. Students are not as committed to work outside the classroom, such as homework, because they get easily frustrated when they cannot get the answer on their own and become anxious waiting until they return to school.

Group work was a staple in Dawn's classes, and peer feedback had been helpful, but some students preferred to work alone and, at times, required additional guidance and feedback to stay focused.

Sharon

The responses that Sharon shared in her pre-survey showed that her time was split between three levels of student ability. Finding time to provide equity in support and feedback was a challenge. She encouraged her students to develop goals and stay focused on the tasks. Sharon added:

> Learning can be different every day. I begin new skills with a direct instruction approach, and I model the skills the students need. After working through examples and strategies, I provide time for practicing the skills. I urge them to check the answer key, and then we can work through issues as they arise, and I can offer them some feedback, time permitting. It is at this point that students either take ownership or not.

Sharon's survey responses also provided this researcher with additional evidence that reinforced the fact that formative feedback, practice, and students' ownership were the building blocks to students' self-regulation.

Post-Survey Results

After the 4-week classroom study came to completion, the participating teachers were presented with 17 post-survey questions, as indicated in Appendix E, "Post-Survey." The questions asked in the post-survey addressed RQ2 and the associated areas of interest: student motivation and engagement, student self-belief, and student self-regulation from the perspectives of the teachers implementing the AITS, in this study, ASSISTments was used in the general education setting. Only four teachers responded to the post-survey across nine classes. The coding process for the post-survey produced four primary themes, and the findings are summarized with examples from the participating teachers to illustrate the results. Table 4 outlines the areas of interest delineated in RQ2, the related themes and subthemes, along with the frequencies of the subthemes that were identified from the post-survey coding.

Table 4

Themes and Subthemes—Post-Survey

Interest Areas	Primary Themes	Subtheme	Frequency
Student motivation and engagement	Augmentation to learning	Acclimation/confusion	9
		Blended approaches	9
		Excitement	8
Student self-belief	Varying student ability and confidence	Lack of knowledge and ability	9
		Self-paced	7
		Instant practice	5
Student self-regulation	Importance of feedback and time	Instant formative feedback	9
		Time relief	6
		Owning their work	5
	Difficulties with the tool	Level of comfort	8
		Inconsistent support	7

Theme 1(Post-Survey): Augmentation to Teaching and Learning

From the analysis of the post-survey, theme 1, augmentation to teaching and learning, touches on the choices made to implement ASSISTments (AITS) by the participating mathematics teachers in their classrooms that had a more significant impact on their student engagement and motivation.

Jane

Jane's post-survey perspectives revealed that the ASSISTments provided a consistent context, but required some adjustment of resources, posted for the sixth grade, in alignment to the district standards. Her sixth-grade students' motivation waned a bit at the beginning of the ASSISTments implementation, and it took additional time to engage them fully. According to Jane, their motivation was triggered by the excitement of trying something new, especially using technology. She voiced concerns about the amount of time needed with different instructional approaches, citing:

> Students enjoy using technology but often showed less work when completing tasks online, impacting overall accuracy. Modeling of how to complete online work and

> transfer skills is required more frequently than paper/pencil work but can be supported by other instructional approaches.

Jane's overall responses to her classroom approaches to teaching and how her students learned, showed that her sixth graders were very eager and motivated to work with anything on the computer, even before the in-class portion of the study began.

Jody

Jody's post-survey responses shed light on specific adaptations that she needed to make to help students stay focused and engaged with the new software. Books that Jody preferred to use in the classroom were not adequately represented by ASSISTments, and additional preparation was required to meet the students' needs with the topics she was covering. Jody noted that her students' motivation and engagement experienced positive change, notably when, as she put it:

> Students can do their work at their own pace, which can relieve a lot of pressure because everybody is working on different tasks. In addition, when students own their work and are working at their own pace, they tend to do better and are remaining engaged and motivated.

Furthermore, Jody's post-survey responses outlined the need for blending instructional approaches, such as providing paper assignments alongside online tasks and allowing her students to work in small groups for peer support.

Dawn

The responses to the post-survey that Dawn provided highlighted the ease of implementation of the AITS and the available resources. She stated that her eighth graders were more motivated to learn online because her students were willing to try new things and were comfortable using technology. According to Dawn's responses, ASSISTments worked well when she augmented the online tutorial with pencil and paper assignments combined with group work. Dawn's views on how to use ASSISTments effectively coincided with the responses of Jody. Both saw value in the use of blended or differentiated approaches to meet the needs of their students.

Sharon

Sharon's post-survey responses described how the motivation of her students varied with the use of ASSISTments. She wrote:

> The group of high achievers with high levels of motivation remained high throughout the study. The second group, the bare minimum group, continued to be motivated to do just enough, and sometimes not even that. The third group, the group hovering around the passing mark, is the group I believe whose motivation did increase somewhat over the study as they now had the means to know they were getting immediate feedback, and the demand for my attention was less from other students.

Sharon also maintained consistency in her instructional approaches that worked well for each level, but slowly expanded the role of ASSISTments throughout the study. Her responses indicated, that overall, there was slightly more engagement using the online tools, even for those students who tended to be, according to Sharon, the "just enough" group.

Theme 2 (Post-Survey): Varying Student Ability and Confidence

Theme 2, varying student ability and confidence, was a consistent theme between the pre- and post-surveys. ASSISTments did shift the confidence level for many of the students, but those with greater need lacked the confidence in working with the online tool.

Jane

Jane shared in her post-survey responses that ASSISTments provided an opportunity for the students of all ability levels to work at their own pace and practice repeatedly. Jane mentioned:

> Their level of confidence was higher when the students got the right answer and received a green checkmark but were easily frustrated when they received a red “x” for an incorrect answer. Hints are available, but the response times were slow, either a product of the online tool or the school’s network. These issues made it a bit challenging for the students, influencing their level of confidence.

Jane articulated that when issued occurred, she made a shift in the instructional approach by allowing them to master the problem with paper and pencil. They were then excited and confident to try it on the computer again.

Jody

Jody’s post-survey responses to student confidence and ability using ASSISTments provided a different perspective. She revealed:

> I had many students having many questions at the very beginning; they were curious, wondering about the tool. So, I could say, they lacked confidence because they were unaccustomed to using the online tool at the very beginning. But as we continued to use it, they were getting light bulb moments, oh okay that makes a little bit more sense. When they realized, okay, this is what happens if I get a question wrong, they became a little bit more comfortable and confident using the tool.

Some of Jody's responses identified minor defects with some of the learning modules in ASSISTments. The defects interrupted the flow of the lesson and caused frustration among her students.

Dawn

Dawn's post-survey responses showed the confidence level of her students correlated to their familiarity with the topics she was teaching at the start of the study. She indicated:

> The eighth-grade materials provided by ASSISTments were easier to implement because they aligned with the district materials, so students immediately became engaged with the assignment. Many of my students were excited about trying new things and felt comfortable about using this technology.

Dawn's responses included concerns about the layout of some of the lessons being too dull and lacking the flare to maintain students' attention during long lesson times.

Sharon

According to Sharon's responses, she saw a correlation between ASSISTments and the students' level of ability. She explained:

> Her class is a mixed bag and likely depends on the different student personalities and ability. The students who worked hard before tended to be the ones who continued to work hard and benefited the most from using the platform. Those that needed validation continued to raise their hand. Students complained a great deal at the beginning, but as the study progressed and all students adapted to ASSISTments, there were fewer complaints about doing online assignments

Sharon's responses enlightened this researcher on the difficulties she faced with managing the varying levels of ability and engagement of her students. The high achievers maintained their motivation and did well. The group that put in minimum effort became frustrated, and those will low ability continued to need her attention.

Theme 3 (Post-Survey): The Importance of Feedback and Time

Theme 3, the importance of feedback and time, resonated across both the pre- and post-survey. The difference in the post-survey showed how the tool, ASSISTments, provided not just formative feedback to the student, but also gave teachers valuable time to provide students with different abilities more one-on-one help.

Jane

The sentiments of Jane's responses regarding the feedback provided by the ASSISTments tool were mostly positive. She described the value of the feedback as the best part of the tutorial program, especially when blending it with traditional instructional approaches. She revealed:

> The balance between conventional instructional/traditional instructional approaches and then having that Internet-based program is important. It gives those students some satisfaction when they are doing some of their online work to have that instant gratification, that instant feedback, that reflection, and reassuring piece.

Jane's response also outlined how her time was refocused on smaller groups of students when the class utilized ASSISTments.

Jody

Jody's responses echoed similar sentiments about the feedback portion of the ASSISTments tool. She saw value in this element, but when the students hit a snag, it would frustrate them. Allowing them to work it through with a partner on paper first reinforced their confidence and ability. When the students were engaged in the assignments online, she found it easier to move from students or groups to provide advice or support.

Dawn

According to Dawn's responses, her eighth-grade classes liked the instant feedback when they gave the correct answer but got frustrated when an answer was wrong. ASSISTments provided the students the opportunity to redo the question repeatedly, but they would become disengaged if they did not get the answers after two or three tries, requiring her to be very observant of the students' progress.

Sharon

The sentiment of Sharon's responses regarding the ASSISTments tool was a bit more negative than other teachers in the study. She regarded the feedback element of the tool valuable since it did provide her more time to work with her low-ability students. Sharon saw the need to maintain current instructional approaches of demonstrating the skill, working the problem together, and practicing. She believed that the tool had more benefit with her two top levels of students. She shared:

> There was an increase in student engagement when using a strategy that empowered them to use immediate feedback to improve their understanding and make corrections in the first two groups of students (those who are workers and very conscientious and those who struggle but try hard even though they are on the cusp). Even the third group of "doing the bare minimum" students put in perhaps a little more effort than usual for a couple of the assignments, but their efforts were not consistent enough to generalize the strategy or the novelty of using Chromebooks and ASSISTments regularly.

Sharon preferred a differentiated approach in her instruction to provide students with the learning method that enabled them to be comfortable and confident in doing their assignments. She saw value in any feedback but maintaining consistency in the process took time. Timely feedback, according to one of Sharon's responses, "helps students embrace the productive struggle and grow in their approach to difficulties."

Theme 4 (Post-Survey): Difficulties with the Tool

From the post-survey, theme 4, difficulties with the tool, outlined difficulties that the teachers faced with the implementation of the ASSISTments tool. The combined sentiments of the teachers from the responses were primarily positive. Issues did arise causing teachers to reassess their approaches to ASSISTments. The following is a summary of these concerns.

Jane's biggest concern was the lack of alignment of the course material and books she used with her sixth-grade classes and the ASSISTments tutorial. During the acclimation period, she needed to identify the best methods that would maintain a seamless transition from her current instructional approaches to the use of ASSISTments in the classroom.

Jody and Dawn's students found the ASSISTments tutorial a bit boring in comparison with other gaming/learning tools they used in the classroom before the study. Sharon thought that the ASSISTments tutorial took longer than the acclimation period to implement.

Jane, Jody, Dawn, and Sharon all experienced latency issues with the online tutorial but did not know if it was directly related to the online tutorial or the school's network. The latency issues caused students to become frustrated at times. All teachers believed that the study was too short and would have liked to implement the tool from the beginning of the year.

Focus Group Results

Four of five study participants agreed to be part of the voluntary focus group discussion. These participants were asked six predetermined questions, as indicated in Appendix G, "Focus Group Questions." Because of the semi-structured approach used for the focus group, three additional probing questions were asked. The questions asked in the focus group addressed RQ1 regarding mathematics instructional interventions and the impact on the students' affective domain. A learning domain deals with students' motivation, attitudes, values, and emotions and what teachers can do to help the student learn. The coding process for the focus group produced three primary themes and eight subthemes. The findings are summarized with examples from the participating teachers to illustrate the results. Table 5 presents the themes and subthemes from the coding analysis of the focus group discussion.

Table 5

Themes and Subthemes—Focus Group

Primary Themes	Subtheme
Blended instructional approaches has greatest impact	Practice and group work are important
	Meeting the students' needs
	The power of pencil and paper
Lack of ability is a barrier	From challenges to comfort level
	The honest effort
Instant formative feedback brings overall satisfaction	Increase confidence and self-regulation
	Minimization of teacher time

Theme 1 (Focus Group): The Right Approaches

In the group-depth conversation of the focus group, the four participating teachers strongly agreed that understanding how to reach all levels of students in the classroom was important, but at times, challenging. Finding the best middle of the road approach produced the best results most of the time. The use of AITS brought value to the classroom, but not as a stand-alone tool. Early challenges caused frustrations, as Jane added:

> At first, it was a little challenging for them, so a few of them became frustrated because of the way the assignment was presented in ASSISTments, for the sixth-grade stuff. At times it didn't show any images on the screen so that I would give them an actual copy of the worksheet. A couple of my student would get stuck in the weeds; they would go to the worksheet, then the computer.

The charter middle school was a Chromebook school, so technology was part of their learning. The focus group discussion also revealed that the students could be creatures of habit, and the best way to introduce changes in teaching was slowly. Jody shared:

> As a seventh-grade teacher, you see their progression over time where it's a lot of paper and pencil, and then we slowly integrate the technology. In my opinion, it's a totally different skillset. So, they need to know how to master the math skill and then they are able to kind of translate that into the technology work.

The focus group discussion uncovered patterns from this researcher's interpretation. Being in a small school environment, all the teachers shared their best practices. Because of their interactions, one consistent theme came to the surface, the power of group work, even with the tutorial. Group work was that middle of the road approach that engaged and supported the varying levels of student ability. Jody articulated the sentiments of the teachers regarding the power of group work best:

> I noticed many of the students working well together. You'd think on a computer, that it's so isolated to do it themselves, but I'm noticing when I give them an assignment, they are willing to work with each other, especially when they weren't really sure about a lot of things. And so they formed a bond through learning this new platform, working through the challenges together.

In a final analysis of this theme, there is clear evidence that the choices teachers made in the structure of their learning environments did affect students' attitudes and motivation to learn.

Theme 2 (Focus Group): Lack of Ability is a Barrier

A second theme to come out of the focus group discussion was the levels of student ability across all classes, a theme that resonated across all data collection methods used in this study. For all the teachers participating in this study, it was about providing the appropriate support structures to meet the needs of these students. Their only expectation of the students was for them to give it their best effort. Sharon stated:

> In my ninth-grade class, the high achievers demand less of my time. The middle group, with a little assistance along the way, did work more productively. The feedback element kept their motivation level up. The kids with the lowest ability struggled the most and got frustrated after the first attempt. I instructed them to try it at least three times and give it a reasonable, honest effort. By encouraging them to try this approach, I noticed them not calling me over every time; I took that as a self-confidence boost on their part.

Stephen took a different perspective on the student ability discussion and thought that the tool had value, but as he put it:

> I think tools like this are useful, but the students have to all be at a certain point with their knowledge of a topic before the program is effective for instructional intervention. Yes, the students can work at their own pace, and instant feedback is helpful, but after 50 minutes, the level of productivity is very different. This ties back to the need for mixed approaches to support the knowledge levels of the students.

In the discussion, it was evident that each class observed in the study had groups of students that struggled with various instructional approaches. However, for the most part, the participating teachers saw an increase in the students' confidence by the end of the study.

Theme 3 (Focus Group): Instant Formative Feedback Brings Overall Satisfaction

When discussing the value of students' self-regulating their learning, all of the participating teachers stated that there were two important factors to keep in mind: time and feedback. As discussed in the focus group, the time element was truly a commodity for them. In the planning of a 50-minute class, the teachers' best intentions were to carve out a segment of class time for working one-on-one with their students, but in reality, time was fleeting. In many cases, students needed validation that they were doing well. Sharon provided this perspective:

> When students are struggling, there are more demands on me—far more questions from all the students seek out that feedback on a constant, almost monopolizing basis, sometimes looking for validation on every other problem. Their constant need takes me away from others in the classroom.

During the focus group discussion, the participating teachers collectively agreed that the instant feedback element of the ASSISTments tool provided benefits to both the students and themselves. Aside from providing formative feedback to the students, it reduced their need for continual attention, freeing up valuable time for the teachers to help others. Jane mentioned:

> The students in my classes enjoyed instant feedback, and it did help motivate them more. They were able to self-monitor their progress and become more engaged in their work. I was able to notice that those that monitored their progress were feeling happier, and had positive attitudes, especially when they were getting stuff right.

What was interesting about the focus group discussion was the participating teachers' perspectives on peer feedback as an augmentation to the online tutorial. Jody stated:

> The instant feedback part was beneficial. It did allow them to self-regulate throughout their progression with ASSISTments. I also noticed many of the students, when somebody got a question wrong, working in groups, to help others understand the problems. Together self-regulating and taking the feedback for what it was.

Collectively, the focus group believed that the tutorial provided additional time for one-on-one support sessions. From their perspectives, all of these feedback approaches; teacher, peer, and tutorial; provided value to the student by making them feel more confident with their assignments and helping them self-regulate their learning.

Summary of the Findings

The purpose of this qualitative case study was to describe teachers' perceptions regarding the impact and differences of teacher-directed learning and AITS on students' motivation and student self-belief for learning mathematics in the general education setting. This chapter provided the data analysis approaches, tables revealing the themes and subthemes, with the themes supported by quotes from the participating teachers. All of these components helped to organize the data to support the perspectives of middle school mathematics teachers, which showed that students' motivation and self-belief were positively impacted by providing the best instructional approaches to meet the students' needs and ability level and providing levels of feedback that could help students self-regulate their learning.

From the perspectives of the teachers, the results of the pre-survey showed some minor differences in how students stayed motivated and engaged in their work. For the sixth graders, school-wide incentives and raffles had the most significant impact on their motivation. For grades 7 through 9, these tangible incentives had little bearing on the students' motivation, but goal setting was more prominent. For all participating teachers, there was an overall consensus that class culture, the context of their classroom, and providing a supportive structure had positive influences on students' motivation and engagement. It was clear that understanding the ability of all the students and providing the appropriate instructional approaches was paramount to students' success. Differentiating the instructional approaches took time and needed additional levels of support. However, maintaining consistency in these approaches was hampered by lack of time to provide equitable feedback to all students.

The post-survey results varied a bit with the introduction of the AITS tool. After the participating teachers overcame the minor flaws in the product, they produced a classroom environment that allowed high and medium achievers to learn mathematics at their own pace. Blending different instructional approaches; such as one-on-one, group work, and pencil and paper with the tutorial, did increase students' motivation and engagement. A significant benefit of the AITS approach over the teacher-directed approach was the instant feedback function of the AITS tool. There was a consensus between all participating teachers that the feedback function freed up valuable time for them to work with students who struggled with assignments or mathematics in general.

The focus group results did substantiate various concepts that the participating teachers saw as best practices from teacher-directed and AITS approaches. The participating teachers were comfortable identifying instructional approaches that met the students' needs. These approaches varied across the grade levels and classrooms but focused on meeting the students' needs and motivating them to learn mathematics. In the investigation of teacher-directed approaches, students were more comfortable with the selected approaches because they were exposed to these ways of learning longer. While the AITS produced positive results in terms of engagement, self-regulation, and increased confidence in the students' learning of mathematics, in the short timeframe of the study, it did not directly impact all student learners. The students of greater need still required the teachers' time for one-on-one teacher support reducing their time working with the AITS tool.

Chapter 5 provides a review of the research questions and a summary of the responses. It also presents the interpretation of the findings in alignment with the literature, along with the implications, and recommendations for actions and future studies.

CHAPTER 5

CONCLUSION

The study revealed insights into the use of an AITS, but also the importance of knowing what ancillary instructional approaches best met the needs of the students. Though the sampling population was small ($n \leq 5$), the observed population of 167 students influenced the teachers' responses to the pre-post survey and focus group discussion. These responses provided evidence of connections to the conceptual framework (Appendix A). Additionally, theoretical confirmation of these connections was indicated in the review of the literature in Chapter 2. For example, one of these connections was instructional approaches used by the teachers that provide consistent feedback, and the link to students' self-regulation of their learning, and the strengthening of their confidence, motivation, and engagement in the learning process. The data from the participants' perspectives supported the value of formative feedback, but many variables such as student ability, maintaining alignment with district standards, and most importantly, teachers' time, can create barriers to this process. A key element of the adaptive intelligent tutorial instructional approach was the instant feedback feature, which did provide relief to teachers by gaining additional time for them to work with students of greater need. Due to the short duration of the study, under two months, it was inconclusive whether an extensive study across the full school year would have produced more in-depth results across all ability levels.

This chapter discusses the findings and interpretations of the study, alignment to the literature and research questions, recommendation for action, and how these recommendations could stimulate broader conversations and future studies on the use of AITSs as an augmentation to students' learning mathematics. This section wraps up with final thoughts.

Interpretation of the Findings

The three research questions that guided this study are presented, along with the summaries of the responses from the perspectives of the teachers, collected, and analyzed in Chapter 4. For consistency, the research questions are presented in order of the data collection method linked to the research questions, as included in Table 1.

RQ3: What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting?

Two positive factors emerged from the findings of the participant responses to the pre-survey, which are linked to RQ3. These factors include instructional approaches, student ability, teacher time constraints, and feedback. Based on a consensus across the respondents, one of these factors showed that providing a positive classroom culture, along with the appropriate instructional strategies that met the needs of the students, had a positive impact on student learning. The responses by the participating teachers on the importance of the classroom environment and instructional strategies to engage students in the learning process were consistent with the literature provided by Chang and Chang (2010), Donnely (2010), Kohn (2010), and Dhanda (2015), which showed that different students prefer different instructional approaches, especially if they increase students' level of comfort, which in turn, has a positive effect on their motivation and engagement.

The analysis uncovered a factor that was not a focus of the study but a concern to all participants—student ability. It was evident from the in-depth analysis of participant responses that student ability had a direct influence on what instructional approaches teachers used in the classroom to keep a student engaged and motivated. The results of this study reinforce Hattie's (2012) comprehensive research related to the change agent mindsets that teachers need to grasp by having the confidence to facilitate positive change in student learning by understanding the needs of their students. Hattie (2012) concurred with the work of Dweck (2010), which shows that the role of a teacher is to support and inspire students, along with using strategic teaching goals to provide deliberate interventions to assist with the students' cognitive change.

Providing feedback to students became a concern for the participating teachers in the teacher-directed approaches during the study. The varying levels of student ability created time constraints for the teachers in the classroom. The findings, from the perspectives of the participating teachers, show that equitable feedback is necessary to maintain student engagement and confidence in their ability. Furthermore, these findings align with those of Glaus (2014) and Hattie (2012), who revealed that teachers are the activators and evaluators of student learning. In addition, teacher voices are the feedback vehicles that share the observation of changes as they occur, helping to identify the failures and successes to move students effectively to their learning goals and help stimulate their engagement and motivation. However, Hattie and Timperley (2007) also stressed that the right type of feedback is critical to students' learning process. It needs to be the right information to fill the gaps in one's understanding, not just the task at hand and stimulates self-regulatory process (Hattie & Timperley, 2007).

RQ2: What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating adaptive intelligent tutorial intervention in a general education setting?

One of the key factors that appeared in the analysis of the post-survey data, which was tied to RQ2, was the value the AITS tool brought to the classroom, especially when combined with other instructional strategies, such as group work, one-on-one, and pencil and paper. The teachers in this study indicated the need to leverage the use of blended instructional strategies when implementing AITS with students in their classroom. It is worthy of noting that blending of instructional strategies is not a new concept; according to Marsh (2012), effective teaching and learning has evolved from the selection and use of different methods and strategies to maximize students' learning. Furthermore, Dhanda (2015) and Lalima and Dangwal (2017) supported the notion that the role of the teachers in the classroom is changing, as they transition from a teacher-centered information provider to a learner-centered approach that supports peer group interactions, face-to-face teaching, and individualized computer-based learning.

A second factor, having consensus among the teachers who participated in the study, was the effectiveness of the instant feedback feature of the AITS tool. The feedback feature is an automatic response function built into the AITS that provides students immediate results upon pressing the enter key allowing students to learn at their own pace, but also giving teachers additional time to provide equitable feedback to students of varying levels of ability. According to a consensus from the participating teachers, providing equitable feedback is an important factor in their students' learning process, a position that is supported by the research of Hattie and Timperley (2007), along with Hattie and Gan (2011) that has shown that feedback is an essential dynamic in motivating learning in various instructional environments, including technology-supported learning applications.

The teacher responses have shown that consistent feedback when combined with blended instructional strategies, such as group work and pencil and paper, can help students stay engaged in their work. The respondents of the post-survey detailed how the AITS provided additional time for feedback in various forms, peer (group work), teacher (one-on-one), or as an integral part of the technology application (AITS), creating opportunities in the classroom for both the students and the teachers. The post-survey findings were in contrast to the findings in the pre-survey where feedback was difficult to accomplish due to time constraints. In addition, the post-survey showed that this level of feedback provided by the AITS had a positive impact on the high- and mid-range achievers with a moderate effect on the lower level learners, who needed additional teacher support.

Supporting these findings, the conversations found in the literature showed that the use of computer-assisted intelligent and adaptive tutorial/learning systems had an encouraging influence on students' academic accomplishments and attitudes toward mathematics (Arroyo et al., 2013). Furthermore, the feedback feature of an AITS provides formative assessment and feedback beyond just a correct answer to stimulate the learning process and help students master learning tasks (Narciss, 2013).

The teachers who participated in this study indicated that the time relief provided by the AITS enabled them to work one-on-one with students of greater need, but also allowed the teachers to have a greater role in providing support across all levels of learners. While Dhanda (2015) saw the role of technology as the catalyst for classroom change, moving teachers away from the central role of information provider to a supporting role working with students one-on-one or in groups, provided them the needed feedback and support to be successful in their learning. Brasiel et al. (2016) suggested that the roles are also influenced by AITS, as the students' instruction is personalized and tailored to students' pace, student ability, and the learning environment.

RQ1: What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating Adaptive Intelligent Tutorial Intervention in a general education setting?

According to the findings from the focus group discussions, which were tied to RQ1, blended instructional strategies and instant formative feedback had the most significant impact on students' attitudes, motivation, and increased engagement to learn. These findings emerged across both teacher-directed and AITS instructional interventions. From the teachers' perspectives, the use of blended instructional strategies (classroom context) with instant formative feedback, either provided by the technology or from the teachers, enabled students to become more motivated and engaged in their learning. These findings are supported by the research works of Brophy (2004) and Schunk, Pintrich, and Meece (2008), which stated that student motivation to learn is the epicenter of shaping students' behaviors and helping them appreciate their learning opportunities, especially when provided with the appropriate tools, adaptations, and interventions for successful learning in the classroom.

The research findings from this study also provided evidence that students who self-monitor and self-regulate their learning are more engaged and have greater confidence in their attainment of knowledge. The teachers' responses aligned with Zimmerman's 1989 social cognitive theory regarding self-regulated academic learning (SRL), which recognizes the value of SRL as a vehicle for increasing engagement and improving student learning. This theory was also supported by John Hattie (2012), who wrote that self-regulation allows students to control emotions, monitor their situations and behaviors, and become experts in their learning processes, all elements of students' affective domain.

Many variables impact students' ability to learn mathematics, but when a student is in control of the learning process, it provides many positive experiences that have a lasting effect on students' confidence, attitude, and level of anxiety, which directly influences students' engagement and motivation to learn (Al-Mutawah, 2015). In the end, the instructional approaches that best served the middle school population were a blend of group work, paper, and pencil, along with the self-paced nature of the AITS. Together, these approaches and the instant feedback component of the AITS enabled students to self-regulate, and in turn, be self-confident in their ability and motivated to learn.

Implications and Recommendations for Practice

There is an agreement among many researchers that the sharing of research findings has the most significant impact for change in current practice and policy when research is conducted in concert with practitioners (Block, Engel, Naureckes, & Riordan, 1999; Mouradian, Mechanic, & Williams, 2001). The dissemination of the research message, to a targeted audience, needs to be framed in a way to evoke emotion and interest while demonstrating usefulness (Milkman & Berger, 2014). The goal of this researcher was to be an advocate of change by providing these research findings and recommendations for practice to a broader audience of other middle school mathematics teachers, school principals, technology directors and the district leadership via publications, such as the *Mathematics Teaching in Middle School* and conference presentations organized and approved by the National Council of Teachers of Mathematics. *Mathematics Teaching in Middle School* is a peer-reviewed journal and a product of the National Council of Teachers of Mathematics and is a resource for all middle school teachers, their students, and teacher educators (National Council of Teachers of Mathematics, n. d.). The

National Council of Teachers of Mathematics was founded in 1920 and is the largest organization for mathematics education throughout North America.

Even though 167 students were observed using the AITS tool, limitations, such as the small participant population ($n \leq 5$), the restricted length of the study, and the narrow focus of student motivation and self-belief for learning mathematics, the findings cannot be generalized across all middle schools. For a more in-depth exploration into the impact of AITS for the selected variables of student motivation and self-belief, this researcher recommends that the school employ an appropriate AITS for a full school year cycle and for consistency in the learning process, also making the AITS application available for homework usage. As a second recommendation for practice, district leadership needs to ensure that all supporting materials, such as books and worksheets, are available for each grade level before the intervention with AITS tools begins. Providing appropriate resources would ensure reliability at each grade level and reduce any barriers that may exist or interfere with the study's progress. Another recommendation for practice concerns leadership support and time to share best practices and provide professional development. School leadership, as well as IT support staff, must be fully engaged in the AITS process to create a positive and supportive learning environment, a recommendation that is supported by the research of Inan and Lowther (2010) and Willen (2014), which showed lack of professional development, administrative and technical support were the most significant barriers to successful integration of technology in the classroom. Furthermore, Hattie (2009) provided evidence from a meta-analysis conducted by Timperley, Wilson, Barrar, and Fung (2007) that professional development was more effective when school leadership supported the process, providing access to the relevant expertise and the sharing of new information in a timely manner.

One final recommendation for practice is to work with the developers of ASSISTments, the AITS tool, to review the barriers and flaws of the online tool that were revealed in the teachers' responses, such as deficient materials to support certain grade levels, an interface that lacked appeal for middle-school-aged students, and latency issues with the online platform. These issues were consistent problems that the teachers faced while implementing the online tool across the different school grade levels engaged in the study. The ASSISTment development team, in partnership with Worcester Polytechnic Institute and Lesley University's Center for Mathematics Achievement, provided the conduit for teachers to offer opinions and recommendations about their use of the online tutorial tool and the student feedback system ("Working with us," 2019).

Recommendations for Further Study

One factor that became most evident from the research results was the level of student ability. For this study, student ability was not a study variable, but became an influencing parameter when the teachers decided on the appropriate instructional approaches to use. One recommendation for future research would be to investigate the causes and variables surrounding the student ability phenomenon, and how AITS could impact the diversity of learners in the classroom. This researcher would also recommend expanding the knowledge base regarding AITS by investigating the impact of the tool on student achievement and proficiency in mathematics. As a focal point of standardized testing and as one of the critical measurements of students' performance in the districts, students' proficiency in mathematics continues to be the center of discussion across the nation as STEM degrees and careers become more prominent (Enderson & Ritz, 2016).

A final recommendation is for additional studies to explore and document more completely the key tenets of the shifting roles of teachers from sole provider of information to coach and facilitator in a technology learning environment that specifically engages AITS as a self-paced learning and homework support platform. Three of the five participating teachers saw value in expanding the use of the AITS tool in the classroom and for homework use, but were uncomfortable about fully utilizing the tool in the classroom, expanding the conversation around the role of technology in the classroom and how teachers can adapt to incorporate technology in their classrooms (Bryant, 2016).

Conclusion

As technology is becoming more predominant in the classroom, providing students with the skillsets to meet the needs of the 21st century, it is also having a positive impact on student learning (Costley, 2014; Cox, n.d.). Teachers see the benefit of teaching with the new technologies that are beginning to populate the classroom. Educational technology companies are heeding the call to help close the achievement gap phenomenon, such as in mathematics, that plagues American school districts (Lynch, 2017). As school districts struggle to meet the needs of the teachers and students, budget cuts dominate the conversation. By providing low- or no-cost alternatives for the districts and the teachers, their goal of individualizing student learning through the self-paced tutorial and online applications can become a reality. For middle school students, grades six through eight are also formative years, as they begin to shape emotional and social connections. It is also a time when middle school students start to form a conclusion about their motivation and ability to do mathematics (Protheroe, 2007). Providing the best learning environment to support students' learning and meeting their students' needs is paramount to the teachers.

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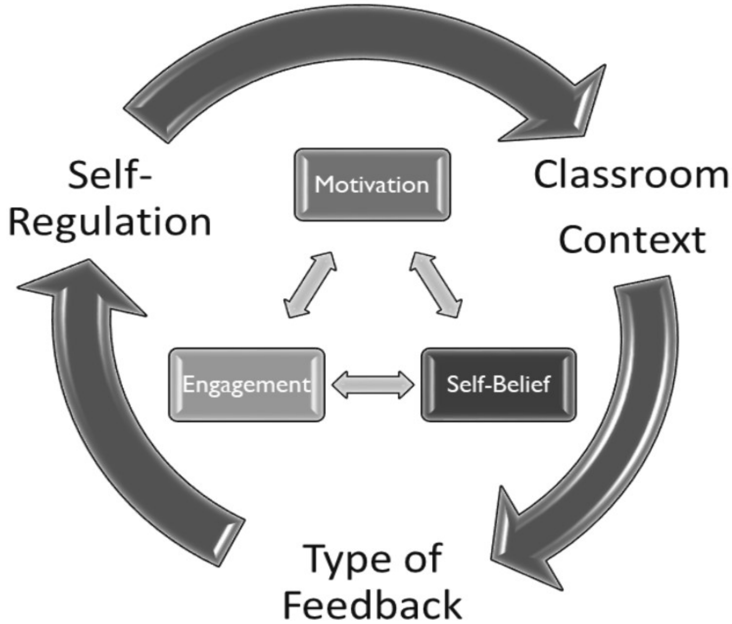
Appendix A: Conceptual Framework Model



Appendix B: Participant Information Letter

INVITATION LETTER TO POTENTIAL PARTICIPANTS

Dear Teachers,

In addition to my professional responsibilities as Dean of the College of Engineering & Design at Johnson & Wales University, I am also a doctoral student at the University of New England's Transformative Leadership program. I am conducting a research project titled: *Teachers Respond to Impact of Intelligent Mathematics Tutorial on Students' Motivation and Engagement.*

I want to invite you to participate in this research study which will be conducted with a sample of middle school mathematics teachers. The purpose of this qualitative exploratory case study is to explore the impact of an Adaptive Intelligent Tutorial System (AITS) when applied as an instructional intervention tool to middle school mathematics. This study will further evaluate this technology as a tool to enhance middle school mathematics proficiency leading to change in a student's self-efficacy and motivation. Research in this area is limited; and, to begin my investigation, I intend to pose the following questions:

Leading question

- What instructional approaches to mathematics-based interventions do teachers believe impact middle school students' affective domain for learning mathematics?

Supporting questions

- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating Adaptive Intelligent Tutorial Intervention in a general education setting?

- What factors do mathematics teachers perceive affect middle school students' motivation and self-belief to learn mathematics when incorporating teacher-directed approaches to mathematics-based intervention in a general education setting?

As mathematics teachers, you can provide your perspective for how student perform with Adaptive Intelligent Tutorial systems, such as ASSISTments, a product of a collaboration between Worcester Polytechnic Institute and Carnegie Mellon University. This online tutorial provides formative assessment and generates data that allows you the freedom to adjust assignments to the needs of the students. The study timeframe is approximately two months; the first month will focus on the acclimation of the instructional intervention tool. Online professional development video will be provided to assist you with the acclimation, implementation, and integration of the online platform. The second month will be the actual study, which includes the anonymous online pre- post-surveys and a voluntary focus group.

I am inviting you to be a part of this research study based on your experience as mathematics teachers in the middle school environment. If you agree to participate, you will be asked to complete online pre- post-surveys and have the opportunity to participate in the follow-up focus group, which includes questions related to the following:

- Student motivation to learn mathematics
- Student self-belief (self-efficacy)
- Student engagement and achievement
- Impact of self-regulated learning

All information provided will be kept secure. All transcripts will be shared with you for your review to maintain the accuracy of the data collected. At the end of the study, a report will be generated to communicate the findings of the research.

Your involvement in this study is voluntary. The information gathered from this study will be published as group results and cannot be traced back to one professional. The online pre-post-surveys that will take approximately 15-20 minutes (each occurrence) to complete and there is no penalty if you choose not to participate. There will also be a follow-up focus group that will take about 45- 60 minutes of your time. You have the option to stop participation at any time, or not to participate at all. If you decide not to participate, your decision will not affect the benefits or services to which you are otherwise entitled in any way. Your participation will be kept anonymous. Pseudonym(s) of your choice will be used during the focus group process. No names of students, faculty or the school will be included in the online surveys and interview transcripts or the final research report.

In the next few weeks, you will be provided an online link to the informed consent agreement via Google Forms. If you have any questions about participating in this research study, do not hesitate to ask. You can reach me at ftweedie@une.edu. Thank you for your consideration.

Sincerely yours,

Frank Tweedie
Doctoral Candidate
University of New England

Appendix C: Informed Consent

Dear Teachers,

You are invited to participate in a research study that will attempt to understand the impact of Adaptive Intelligent Tutorial Systems on the motivation, engagement, and self-belief of your mathematics students, from your perspective. The following information is provided to assist you in making an informed decision whether or not you will participate in this study. If you have any question, please do not hesitate to ask. You have been selected for this study because you are a certified mathematics teacher in this middle school.

Study Title: *Teachers Respond to Impact of Intelligent Mathematics Tutorial on Students' Motivation and Engagement.*

Purpose of this Study: The purpose of this qualitative exploratory case study is to explore the impact of an Adaptive Intelligent Tutorial System (AITS) when applied as an instructional intervention tool to middle school mathematics.

Procedures: You will be asked to participate in a two-month study that is divided into three phases. The pre-survey stage will require you to complete a 30- 45-minute pre-survey that will be available to all participants for one week.

The second phase is a four-week acclimation phase. During this phase, participants will be introduced to the Adaptive Intelligent Tutorial System (AITS) via access to self-paced professional development videos, offered at no cost from the ASSISTments website. These short self-paced videos cover topics that include basic site navigation, creating classes and organizing assignments, and easy to use tools for the integration and support of the AITS software. This acclimation period will provide for a transparent and seamless transition once the study starts and the student population begins using the online program for their daily problem solving.

The final phase or the study phase is projected to take six weeks. During the first four weeks of this phase, teachers will be implementing AITS online application in all of their mathematics classes. The teachers will be observing the behaviors, attitudes, engagement, and motivation of the students as they work through the mathematics assignments each day of the study. During the fifth week of this study, participating teachers will have access to the online post-survey, which will focus on the observations of the classroom, concerning the motivation and self-belief of middle school students' learning mathematics when incorporating AITS intervention in a general education setting. Similar to the pre-survey, this post-survey will take approximately 30-45 minutes to complete.

After the study and post-surveys have been completed, a voluntary follow-up focus group will be held at a location suitable for all participants. The focus group session will take between 45 minutes to one hour and recorded with the use of a mobile transcription application. The focus group questions are designed to understand teachers' opinions, feelings, and viewpoints that did not surface in the other qualitative data collection methods.

Risks: Besides the inconvenience associated with the time needed for the completion of the surveys and participation in the focus groups, the risks are limited. Due to the small scope of the study, a reader may discern who the participants are.

Benefits: There are no immediate or direct benefits to the participants of this study. However, the results or findings of the study may provide opportunities for the school, and its teachers may use them or to expanding the conversation regarding mathematics instructional interventions as part of school's continuous improvement process.

Confidentiality: The rights of privacy and confidentiality will be in place to protect all participants in the study. If data collection is not anonymous, any personal identifiers, such as names, will be meticulously cleaned from the data, and identifiers that cannot be removed will be classified as "need to know" standard. Names of teachers that participate in the focus group will be kept confidential or coded with an alias. These coded/encrypted aliases or number reference sheets along with all digital transcripts will be stored up to one year after the study, in a lock file cabinet in a location offsite. After one year, all hardcopy and digital files will be destroyed using the appropriate and secured methods.

Compensation: Participants will not receive any compensation for participating in this study.

Opportunities to Ask Questions: The researcher is available to answer any questions you may have before agreeing to participate or at any time during the study. Please contact Frank Tweedie via email ftweedie@jwu.edu or call any time at 401-497-5016. Your questions are important, and this researcher will make it his priority to return your calls and emails promptly.

Freedom of Withdrawal: All participants will maintain the right to withdraw from the study at any time at no risk to the individual(s).

Consent: By checking the "proceed" box below, you agree to participate in this study. No signatures are required. You then can proceed to the pre-survey that is available on the next pages. Thank you for your consideration.

Thank you
Frank Tweedie

University of New England
Doctoral Candidate

To opt into the study and move to pre-survey, please check the box provided:

☐ Accept and proceed

Appendix D: Pre- Survey

Pre- Survey Questions

Please answer the following question as pertaining to your current teacher-directed approaches to teaching mathematics.

General Questions:

1) Grade level: 6^{th} 7^{th} 8^{th} (Circle one)

2) What topics in mathematics are you currently teaching?

3) Please explain your level of confidence with using technology as an instructional tool in the classroom.

4) What experience do you have with technology-based tutorials?

5) What teacher-based instructional approaches are you currently using in your mathematics classes? If you have multiple class sections, please answer for each class section of mathematics you are teaching. Please identify your sections with the letters A, B, or C.

Motivation and Engagement:

1) How do you believe your students respond to the current instructional approaches used in the classroom?
2) Please describe the dynamics of your students working well alone.

3) Do you believe motivation can be taught? Please explain your answer.

4) What are your first impressions of the of the current student motivation in your classrooms?

5) Describe the level of engagement your students have with their mathematics work.

6) Describe when your students are in the "look busy but accomplishing nothing" mode.

7) From your perspective what triggers the "look busy but accomplishing nothing" mode?

Self-Efficacy:

1) What are the indicators, from your perspective, that is evident when students in your mathematics class struggle?

2) From your perspective, what is the level of confidence of your students, when faced with challenging mathematics tasks or problems?

3) From your perspective, do your students believe in their ability to achieve mathematics goals that they have set?

Self-Regulation:

1) Do you believe that the current instructional approach provides opportunities for student self-regulation in the classroom? Please explain.

2) Within your current instructional approach, do your students' effectively gather and use feedback to improve their motivation and self-belief toward mathematics. Please explain.

3) From your perspective, do you see an increase in student engagement when employing self-regulation strategies? Please explain.

Appendix E: Post-Survey

Post-Survey Questions

Please answer the following question as pertained to the instructional intervention using the adaptive intelligent tutorial, ASSISTments.

General Questions:

1) Grade level: 6th 7th 8th 9th (Circle one)

2) What topics in mathematics are you currently teaching?

3) Please explain your level of confidence with using technology as an instructional tool in the classroom.

4) What experience do you have with technology-based tutorials?

5) How are you using the ASSISTments tutorial in your classrooms?

6) From your observations, explain how your students are adapting to the technology-based application in the classroom.

Motivation and Engagement:

1) How do you believe your students respond to the technology-based instructional approaches used in the classroom?

2) Please describe the dynamics of your students working alone with ASSISTments.

3) What are your first impressions of the current student motivation in your classrooms with ASSISTments?

4) Describe the level of engagement your students have with their mathematics work using this tool.

5) From your perspective, describe the difficulties your students may have with this online tool.

Self-Efficacy:

1) From your perspective, does ASSISTments promote a higher level of confidence in your students' ability? Please explain.

2) From your perspective, what is the level of confidence of your students, when faced with challenging mathematics tasks or problem sets when using this tool?

3) From your perspective, do you feel that ASSISTments has a positive impact on your students' ability to achieve mathematics goals that they have set? Please explain.

Self –Regulation:

1) Do you believe that the current instructional approach provides opportunities for student self-regulation in the classroom? Please explain.

2) Within your current instructional approach, do your students' effectively gather and use feedback to improve their motivation and self-belief in their ability to learn mathematics. Please explain.

3) From your perspective, do you see an increase in student engagement when employing self-regulation strategies, such as formative feedback and managing their behavior? Please explain.

Teachers,

Thank you for your participation in the survey portion of this study. You now have the opportunity to participate in a follow-up focus group.

The focus group is voluntary, but this researcher highly values your participation.

If you are interested in participating in the follow-up focus group, please check the box below, which will take you to the contact information page. Please fill out the form provided, and the researcher will contact you. By filling out his form, your answers will no longer be anonymous, but all personal identifiable information will be kept at the highest level of confidentiality.

☐ Proceed to focus group consent & sign-up

Appendix F: Focus Group Consent and Sign-up

Purpose: Thank you for deciding to participate in this voluntary focus group, as a follow-up to the study regarding "The Impact of Adaptive Intelligent Tutorial Intervention on Middle School Students Mathematics Learning." The focus group questions are designed to understand teachers' opinions, feelings, and viewpoints that did not surface in the other qualitative data collection methods. All information gathered in this focus group format will be used to augment the data collected from the pre- post-surveys.

Procedure: As part of this study, you will be placed in a group of 4-5 individuals. A moderator (researcher) will ask you several open-ended questions while facilitating the discussion. The focus group will require between 45-60 minutes of your time and will be held at a location preferred by all participants. As approved through the University of New England's Institutional Review Board, the focus group is being recorded with the use of a mobile device and uploaded to an online audio transcription service.

The focus group is an open and honest interaction of opinions, feelings, and perspectives, and there are no right or wrong answers to these questions. Please refrain from interrupting those speaking; everyone will have an opportunity to provide input to the questions. You also have the right to opting out of answering any or all questions.

Benefits and Risks: Your participation may have benefit to you, your students, and your school by providing perspectives that may be implemented a part of the school's continuous improvement process. Due to the small scope of the study, a reader may discern who the participants are. Risk pertaining to focus groups: beyond the normal conversation, there may a risk of sharing confidential or personal information by chance, or engaged in topics that make you feel uncomfortable.

Confidentiality: The rights of privacy and confidentiality will be in place to protect all participants of the study. If data collection is not anonymous, any personal identifiers, such as names, will be meticulously cleaned from the data, and identifiers that cannot be removed will be classified as "need to know" standard. Names of teachers that participate in the focus group will be kept confidential or coded with an alias. These coded/encrypted aliases or number reference sheets along with all digital transcripts will be stored up to one year after the study, in a lock file cabinet in a location offsite. After one year, all hardcopy and digital files will be destroyed using appropriate and secured methods.

Contact: Please forward all questions to Frank Tweedie (principal investigator) at ftweedie@jwu.edu or 401-497-5017.

Please fill out the following form with your contact information:

Name: ____________________________ Phone (mobile or home): (__) ___________
Email: ____________________________ Preferred location: (circle one) Offsite - On campus Contact preference: (circle one) email phone

Appendix G: Focus Group Questions

Focus Group Questions

1. What changes have you observed in your students learning behaviors from the beginning the study to now?

2 In your opinion, what did the Adaptive Intelligent Tutorial System (AITS) bring to the classroom in comparison to the traditional instructional approach?

3. From your perspective, what values to the learning process standout most with this form of instructional intervention in the classroom? Please explain.

4. During the course of the study, was there any noticeable changes in student motivation, engagement, and confidence? Please explain

5. AITS provides instant formative feedback, from your perspective, did this component of this tool help students to self-monitor their progress and heighten their motivation, engagement, and self-belief in their ability. Please explain.

6. What are your opinions of the AITS as an instructional intervention in the mathematics classes? What values to the learning process stand out most with this form of instructional intervention in the classroom? Please explain.