2020

Perceptions of Adaptive Technology Usage in Secondary Math Classrooms

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PERCEPTIONS OF ADAPTIVE TECHNOLOGY USAGE

IN SECONDARY MATH CLASSROOMS

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A dissertation submitted to the faculty of Lynn University in partial fulfillment of the requirements for the degree of DOCTOR OF EDUCATION in EDUCATIONAL LEADERSHIP

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Abstract

Adaptive learning is an emerging technology in education that teachers use to instruct, reinforce, and assess student performance (Smith, 2016). Adaptive technology is powerful because it gives teachers an opportunity to differentiate based on individual needs (Bilous, 2019). It is efficient, allows students to get instant feedback, and can improve the learning experience for students (Matherson & Windle, 2017). Like many other technologies, it is constantly evolving; this makes it difficult to research and update curriculum because programs are constantly changing (Parsons, 2014).

With these changes, teachers are also required to update how they manage their classroom and how they deliver instruction. Students are no longer expected to "sit and get", a term used for when teachers lecture to uninterested or disengaged pupils (McLeskey & Waldron, 2002). Lecture-based learning is no longer seen as an effective method for teaching children (McLeskey & Waldron, 2002). Instead, students are given more autonomy and teachers are expected to deliver lessons that are interactive, engaging, and impactful (Matherson & Windle, 2017).

EdTechXGlobal estimated that $252 billion would be spent on education technology by 2020 (EdTechXGlobal, 2016). School leaders believe in investing in technology; however, research suggests that simply investing in software and smart devices is not enough (Zhu, Yu, & Riezebos, 2016). Teachers must also know how to use the tools effectively. Students must buy into the concept of computer-based curriculum. Based on the results of this study, there is plenty of room for growth in this educational technology and adaptive learning.

Prior to this study, there was little empirical research to address adaptive technology, specifically. Without that research, there are simply too many questions that have not been answered about how adaptive technology impacts the classroom. This dissertation sought to provide a current snapshot into adaptive technology, the benefits of using it, and the challenges teachers and students currently face in using it.

Acknowledgments

My journey at Lynn University was incredible. I made lifelong friends, grew as a professional, and had the opportunity to work alongside brilliant educators. That being said, there are a few people I would like to personally acknowledge for the guidance, support, and kindness they have shown toward me over the last three years.

First, I would like to thank my wife, Jennifer Gleason Benjamin. She was the one who encouraged me to enter the doctoral program to pursue my passion in education. She critiqued my presentations, provided an honest opinion, and listened when I needed to talk. Her expertise in research and grammar came in handy, as she was quickly appointed as in-house editor on assorted papers and presentations. We have always said that we are "in this together" and that statement could not do a better job of capturing the essence of our relationship.

Next, I would like to thank Jennifer's parents and my parents. Brenda, David, Colleen, and William, you have provided an unbelievable amount of support throughout my journey. You encouraged me to be a better person and helped me push through the difficult times. Thank you for inspiring me and helping me grow.

I would like to also thank my classmates, professors, and specifically, the members of my dissertation committee. Dr. Jones, Dr. Weigel, Dr. Lesh, you have each made a positive impact on my life and I feel very grateful for that. Lynn University is lucky to have such an amazing group of educators on campus.

Lastly, I would like to thank everyone who participated in my survey on adaptive technology. Your insights were thoughtful and gave me plenty to reflect on. I literally could not have finished this dissertation without your participation.

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Chapter I: Introduction

Statement of Purpose

The purpose of this study was to research adaptive technology to better understand how it is used in secondary mathematics classrooms. Participants for the study worked in large urban school districts in the southeast United States during the 2018-2019 school year. Prior to the study, much of the existing research (Vie, Popineau, Bruillard, & Bourda, 2017; Pearson, 2016) was devoted to assessment, educational gains, and the many types of education technology that are used in today's classrooms. Not as much research was devoted to adaptive technology or how to design and implement adaptive curriculum to improve student learning (Liu et al., 2017).

Adaptive technology refers to "software that learns and alters itself based on the user's inputs, while allowing for interaction with a broad base of learning styles" (Izumi, Fathers, & Clemens, 2013). What this means is that adaptive tools change based on how the user answers questions or inputs information. An example of adaptive versus non-adaptive technology would be a computer-based quiz that has a bank of questions, each question representing a different degree of difficulty. An adaptive quiz would become more and more difficult with each correct answer. A non-adaptive quiz would follow the same sequence of questions regardless of the user's inputs. Both types of assessment use technology and are valuable to educators (Vie, Popineau, Bruillard, & Bourda, 2017). Non-adaptive testing provides a summative measure of learning, while adaptive assessment provides the scorer with unique information that could be used to personalize learning (Bilous, 2019).

This dissertation focused on adaptive technology and how it is used in the high school math setting. The researcher sought to gain information about how adaptive technology is used, when and how often, and the teacher-perceived advantages and disadvantages to using it for math-based curriculum.

Background

Technology has transformed the way students learn and access information (Zhu, Yu, & Riezebos, 2016). It is estimated that 63% of K-12 teachers in the United States use technology with their students on a daily basis (University of Phoenix, 2017). The most commonly used technologies include laptop computers, interactive smartboard displays, and handheld devices like tablets and cell phones (Nagel, 2018). Schools use these tools to supplement learning, increase student engagement, and offer opportunities to students from diverse backgrounds (Godzicki, Godzicki, Krofel, & Michaels, 2013). Technology is also used to differentiate instruction and create learning plans that are specific to individual learning needs (Bilous, 2019). These benefits contribute to a learning environment that is efficient and individualized, both of which are very important to educational success (Zhu, Yu, & Riezebos, 2016).

The hype surrounding technology has led many school districts to prioritize funding to upgrade outdated technologies and offer a "cutting edge" education. The emphasis on technology is generally seen in a positive light (Nagel, 2018). In a recent survey by David Nagel (2018), teachers overwhelmingly endorsed the use of technology in classrooms. The study found that 75% of teachers believe technology has *an extremely positive impact on education* or a *mostly positive impact on education*; only 25% of respondents reported that technology has *a mostly negative impact on education*. The support from teachers can be attributed to a number of educational benefits. The most-commonly cited impacts include higher student engagement, better preparedness for college and careers, and a decrease in the achievement gap (Godzicki, Godzicki, Krofel, & Michaels, 2013; Bill and Melinda Gates Foundation, 2015). Student motivation is another influential argument in favor of technology (Francis, 2017; Forsyth, Kimble, Birch, Deel, & Brauer, 2016). Empirical studies have found that technology has the ability to increase student engagement by offering new and exciting ways of learning, such as educational applications ("apps") and learning games (Gee, 2004; Liu et al., 2017). This is called gamification and it allows students to learn in an entertaining or competitive manner, which compels students to take an active role in their learning (Gee, 2004). Research has proven that higher student engagement leads to deeper learning and higher academic performance (Shute, Ventura, & Kim, 2013; Dillon, 2017).

Still, educators must be very careful and intentional when introducing new learning tools. Having technology, in itself, is not enough to change the learning landscape; educators must also know how to use the technology to create a learning environment that is efficient and standards-based (Zhu, Yu, & Riezebos, 2016). This is a difficult task that warrants further research. It is unclear how *adaptive* technology fits into the bigger picture of *educational technology*. This dissertation aimed to clarify by gaining empirical data on the effectiveness and observations of teachers who use adaptive technology within high school math curriculum.

Theoretical Framework

The theoretical framework used for this study was based on phenomenography (Marton, 1986) and variation learning theory (Miller, 2012). Phenomenography refers to "the qualitatively different ways in which people experience or think about various phenomena" (Marton, 1986). Variation learning theory suggests that "groups of learners have qualitatively varied experiences in learning situations, and that there are a finite number of categories of these experiences" (Miller, 2012). Variation theory, therefore, combines the act of learning with the context in which the student learns.

Travis Miller, from the University of Pennsylvania, outlined two important theories pertaining to this study in a textbook entitled *Educational Technology, Teacher Knowledge, and Classroom Impact* (2012). The first theory Miller presented states that “With appropriate TPACK, teachers can weave technology into the learning process to assist students in discovering and exploring the variation of mathematics content and learning experiences” (Miller, 2012). TPACK refers to *Technological Pedagogical Content Knowledge* and is widely accepted by theorists who have researched educational technology in mathematics. TPACK is based on Lee Shulman’s 1986 theory that asserts that teachers must combine pedagogical knowledge with content knowledge to effectively teach students (Shulman, 1986). In 2005, Koehler and Mishra added technology to the combination, requiring teachers to understand pedagogy, content, and technology to be able to effectively teach math concepts through the use of computers (Koehler & Mishra, 2015).

The second of Miller’s theories argues “technology use can be implemented and researched in a structured yet inclusive fashion” (Miller, 2012). This is the second piece of the theoretical puzzle to researching educational technology in math. It suggests researching technology is valid with solid research design and planning.

This study was based on the TPACK theories and Miller’s suggestion that teachers can effectively teach math with computers under two conditions - if they understand TPACK and if students have the proper context, perceptions, and learning opportunities (Miller, 2012). Learning is a complex task (Karwowski, 2018); the researcher followed the theoretical framework to provide meaningful data that is valid and accurately evaluates adaptive technology in high school math classrooms.

Motivation

The researcher was the primary investigator for the proposed study. He has a master's degree in career and technical education and works as a high school math teacher in a large urban school district. He is part of the Teaching with Technology Trailblazers initiative, which provides teachers with professional development, classroom computers, and interactive flat panel displays (Trailblazers, n.d.).

With this dissertation, the researcher intends to make meaningful contributions to education. He believes technology will continue to dominate how we live, learn, and receive information. He also believes adaptive technology is a powerful tool that educators can use to benefit student learning if it is used properly. This motivated him to research adaptive technology to propose actionable measures for improving existing education technology.

Problem Statement

It is difficult for researchers and schools to keep up with rapidly-evolving technology (Borba et al., 2016). Educational reform takes time and technology advances so rapidly that many innovations are outdated before researchers have studied their effectiveness (Borba et al., 2016). The costs of introducing new technology have historically been cost-preventative to schools (Izumi, Fathers, & Clemens, 2013). With the decreasing costs of purchasing and replacing outdated technology, "high-tech" classrooms are more attainable and less cost-prohibitive as they have been in the past (Izumi, Fathers, & Clemens, 2013).

The problem that was addressed in this study was the degree of up-to-date information regarding adaptive technology. Prior empirical studies researched many new technologies that are not necessarily adaptive - they examined specific tools and programs, as well as, the effects they have on students. Much of the research on *adaptive* technology pertains to test scores and assessment (Pearson, 2016). The researcher believes there is much more to education than assessment. This philosophy is backed by many empirical studies and universities, including Carnegie Mellon University, an institution that cites three components to course planning; learning objectives, assessment, and instructional strategies (Carnegie Mellon University, n.d.). If existing data focuses primarily on testing, there are equally important components of education that have been overlooked in research. This study was designed to provide information on adaptive technology in the contexts of learning, assessment, and instruction.

Conceptual Framework

The literature review suggested a gap in literature exists on adaptive technology, and specifically, when it pertains to instructional strategies (Liu et al., 2017). The researcher argues that learning objectives, curriculum planning, and instruction should also be researched. What are teachers using adaptive technology for? Is it to supplement learning by letting students practice math skills? Is it being used for formative or summative assessment more than it is for instruction? Is adaptive technology mainly being used by teachers to allow students to self-learn or review concepts from class? These are very important questions the researcher sought to answer through research. If adaptive technology is as powerful some school leaders believe, it is essential that it can also be used outside of testing. It is also critical that educators understand how adaptive technology works within each realm so that existing tools can be used to facilitate learning and plan curriculum.

Research Questions

The researcher sought to answer the following research questions:

1. What is the frequency and purpose of adaptive technology being used in secondary math classrooms?

2. What are the teacher-perceived advantages and disadvantages to using adaptive technology in math-based curriculum?

3. How can existing adaptive technology be improved as an educational tool?

Rationale

The methodology for this study was appropriate for two reasons: there was a gap in literature pertaining to adaptive technology and much of the prior research on education technology was obsolete.

1. There was a gap in literature pertaining to adaptive technology. Prior to this study, there was much research (Pearson, 2016) on what types of technology exist and the pros and cons to using different programs. Most of the research omitted adaptive technology entirely (Liu et al., 2017). The studies that included adaptive technology focused mostly on self-learning or assessment rather than teacher-led instruction and planning curriculum (Liu et al., 2017). Researching these realms allowed for greater understanding of how adaptive programs can be improved to benefit student learning.

2. As technology advances, researchers need to update the focus of their studies because previous research becomes less meaningful (Parsons, 2014). Technology evolves quickly and many of the existing studies were already out-of-date by the time this study was conceptualized (Borba et al., 2016). This gave the researcher reasonable cause to study adaptive technology and how it impacts education in today's classroom.

Significance

There is little consensus regarding the best way to utilize technology in the classroom (Selwyn, 2016). There is research into the types of technology that exist (Nagel, 2018). Studies have looked at specific programs to measure whether or not these programs improve student gains or test scores (Pearson, 2016). However, there is not much research on adaptive technology in the context of instructional practice (Liu et al., 2017). Rosen et al. (2018) argued that "Despite the promise of adaptive personalized learning, there is a lack of evidence-based instructional design, transparency in many of the models and algorithms used to provide adaptive technology (Rosen et al., 2018)."

The purpose of this dissertation was to give educators and administrators more knowledge about the adaptive technologies that are already being used in classrooms. There are adaptive programs like Khan Academy and IXL that help students practice math skills and review important topics. Adaptive technology is also becoming a widely-accepted method for assessing student performance (Vie, Popineau, Bruillard, & Bourda, 2017). Students even have the option to take an adaptive version of the ACT college admission exam (ACT, 2016).

The ACT is just one of the many examples of a non-adaptive tests becoming adaptive. Many industries, including, private business, government, and education, have turned to adaptive technology to measure growth and content knowledge (Kingsbury, Freeman, & Nesterak, 2014). For that reason, the researcher believes is imperative that industry leaders understand adaptive technology when creating or changing policy. This dissertation was intended to provide empirical data to suggest how *adaptive education* fits within high school curriculum and instruction.

Assumptions

The researcher made the following assumptions regarding adaptive technology when undertaking this study.

- Teachers who were included in the study use adaptive technology in a meaningful capacity.

- Participants did not confuse *all* technology with *adaptive* technology. To prevent this, the researcher provided a throughout explanation of adaptive technology with examples of adaptive programs in the initial email (Appendix A) and again in the informed consent document (Appendix B).
- Data obtained from teachers who use adaptive technology one time per month will be less meaningful than teachers who use it daily or weekly. To measure this, teachers were asked how often adaptive technology was used and in what capacity.
- There is an imbalance between how adaptive technology is used in math classrooms. Because most of the research that includes adaptive technology is about assessment, it was assumed adaptive programs were being used for assessment more than for it is for instruction.
- Prior to the study, there was a limited amount of literature that pertained to adaptive curriculum and instruction.

Definitions

Adaptive technology refers to "software that learns and alters itself based on the user's inputs, while allowing for interaction with a broad base of learning styles." (Izumi, Fathers, & Clemens, 2013).

Assistive technology includes "any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities" (Individuals with Disability Education Act, 2004).

Bubble tests is a term used to describe paper-and-pencil tests that students circle answers or fill in multiple-choice forms such as Scantrons (Duncan, 2010). It can also refer to multiple-choice assessments on the computer that do not adapt or change based on how students answer.

Computer adaptive technology (CAT) is a term that has been included in empirical research since the 1970s and 1980s. It refers to computerized programs that adapt to user input. (Kingsbury, Freeman, & Nesterak, 2014)

Chromebooks are laptop computers that are able to access the internet. Most Chromebooks do not have the capacity to store information (i.e. a hard drive) but allow students to access course materials online. Chromebooks are commonly used in schools because they are cost-effective and offer many of the benefits of PCs or MacOS computers, without the added costs associated with hard drives that are capable of storing user data. (Google, n.d.)

Devices refers to any electronic devices that can be used to access, learn, or practice course content, including, but not limited to computers, tablets, e-readers, and cell phones (Zhu, Yu, & Riezebos, 2016). Google Chromebooks also fall under the category of smart devices

E-books, e-learning, e-tivities, and e-resources are adaptations of "traditional" resources. E- is a prefix that stands for electronic (Borgman, 2007). E-learning refers to learning that is completed on computers or other smart devices. E-tivities are activities or applications that are accessed on electronic devices. E-resources are resources that are accessed electronically, with or without access to the internet.

Hardware is defined by Merriam-Webster as "major items of equipment or their components used for a particular purpose" (Hardware, 2019). For the purpose of this dissertation, hardware will include electronic instruments students use to access course materials, including, but not limited to computers, Chromebooks, tablets, and cell phones.

Gamification is "the use of a computer games-based approach to deliver content, support and enhance teaching, or improve learning, assessment, and evaluation" (Chappuis & Chappuis, 2017).

Smart or *smart devices* refers to small, portable electronics that allow students to access class information whenever they have access to the internet (Zhu, Yu, & Riezebos, 2016). "*Devices*" and "*Smart Devices*" refer to the same technologies in this study.

Software is defined by Merriam-Webster as "programs for a computer" (Software, 2019). For the purpose of this dissertation, software will include any computer program, website, application (app), or educational game that students use to learn, review, or practice foundational math skills.

Tablets are handheld devices are capable of many of the same functions as desktop computers. They are larger than cell phones, but portable. Tablets are a popular tool in education technology because of their functionality and relatively low costs. (Major, Haßler, & Hennessy, 2017).

Trailblazers refer to teachers in the SDPBC who are part of the Teaching with Technology initiative. They complete professional development training sessions and are required to take an exam to become Google-certified educators. Once they complete the Trailblazer training, they are provided with a Chromebook computer cart and interactive SMART flat panel display. (Trailblazers, n.d.)

Organization

This study is as a traditional, five-chapter dissertation. Chapter I includes and introduction and a general outline of the study. Chapter II is a review of existing literature. Chapter III outlines the methodology. These chapters were defended during the initial proposal defense at Lynn University. Approval was granted by the dissertation committee and Lynn's Institutional Review Board (IRB), and the researcher submitted a listserv request form to the Florida Department of Education (FLDOE) to obtain email addresses for secondary math teachers in seven large, urban school districts. Finally, participants were contacted to request their participation in the study.

Chapter IV includes the data analysis. Chapter V presents findings from the research and makes recommendations for improvements to adaptive education and future research.

Dissemination

This dissertation was completed in partial fulfillment of the degree of Doctor of Education in Educational Leadership at Lynn University. The final report and summary will be housed in the Eugene M. and Christine E. Lynn Library and on electronic university databases. It is intended to be accessible to all students and will be offered free-of-charge for students and administrators who would like to review and or/or cite the researcher's work.

Additionally, the report will be linked to the researcher's professional website. Readers will have full access to the document, free-of-charge, and the recommended APA citation will be included.

Chapter II: Literature Review

Technology has taken a stronghold in American society and education. It deeply impacts how teachers approach learning in their classrooms. It also affects how school leaders plan for the future (Grady, 2011). It was expected the global educational technology market will grow to $252 billion by the year 2020 (EdTechXGlobal, 2016). This represents an enormous investment in technology; it affirms that school leaders believe in technology and the educational opportunities it provides for students.

The purpose of this study was to gain insights from teachers who use technology within math curriculum. The researcher chose to focus on adaptive technology because it is often left out of empirical research (Liu et al., 2017). Adaptive technology is popular tool that has garnered a lot of attention when it comes to assessing knowledge or learning (Vie, Popineau, Bruillard, & Bourda, 2017). However, there are many things educators still do not understand about adaptive technology. Can it be used in group instruction or is it only useful for self-learning and assessment? Is there empirical data that indicates adaptive technology helps students learn or retain information? Does adaptive technology provide a more authentic way to assess students? There were too many unanswered questions that have already been researched for other types of technology. This research aimed to reduce the knowledge gap on adaptive technology to make recommendations on how it can be used to improve student learning.

The literature review for this study was systematic. It outlined the most meaningful research available and served as the framework used to answer very specific questions about adaptive technology within secondary math classrooms. The review included topics and themes within the existing research, including, specific adaptive tools, the effects of adaptive technology on learning, perceptions on technology, comparisons between old methods of learning ("low-tech") and new methods of learning ("high-tech"), and assessment.

Historical Context

The world's first computers were built in the 1930s (Purdue University, n.d.). They were enormous machines that cost a small fortune to purchase and maintain (Izumi, Fathers, & Clemens, 2013). They were not accessible to the general public and were cost- and logistically-restrictive to schools because of the expense and immense size (Izumi, Fathers, & Clemens, 2013). Since then, computers have become smaller, more efficient, "smart", and cost-effective. From the 1980s and 1990s until now, the expansion of technology has exploded in growth and computers have become a staple in global classrooms (Selwyn, 2016).

The 1990s were also foundational years for the internet (Leiner, Kahn, & Postel, 2009). The world experienced a paradigm shift that prioritized personal computer use, digitization, and internet reliance. Regardless of some of the negative perceptions about the internet, it has created enormous opportunities to access information quickly and with little effort. This means there are more opportunities to become educated than ever before. There has been extensive research on educational technology in the past (Pearson, 2016); it seems every new product that is released is studied and analyzed to "prove" why it is the next-best-thing. This phenomenon repeats itself over and over; every time new products are released, research on obsolete technology becomes less meaningful (Borba et al., 2016).

Computer adaptive testing (CAT) was first introduced in the 1970s (Weiss & Betz, 1973). It refers to assessments that have larger question banks than "traditional" paper-and-pencil tests. This allows the computer to adapt the test based on how the student answers questions. Adaptive testing has been found to accurately represent student knowledge with fewer questions (U.S. Department of Education, n.d.). This provides a more user-friendly testing experience than non-adaptive tests that are much longer and time-restrictive (Kingsbury, Freeman, & Nesterak, 2014). It is preferred by students and educators for providing immediate and accurate feedback (Kingsbury, Freeman, & Nesterak, 2014). It can also be used with tests that are not "academic", in nature. Vocational fields like nursing, business, and information technology use performance assessment to measure competency and award industry certifications (Choice and Career Academy Programs, 2017). In the southeastern United States, public school students have access to over 300 choice and career programs in vocational education (Choice and Career Academy Programs, 2017). Many of these programs use adaptive assessment to measure students' level of proficiency. There are certification tests that are adaptive and range from Microsoft Office and Adobe Photoshop to Carpentry and Phlebotomy (Choice and Career Academy Programs, 2017). The certifications earned can then be used to strengthen the resumes of students who will eventually enter the workforce.

The article entitled *Beyond the Bubble Tests: The Next Generation of Assessments* outlines the U.S. Department of Education's vision for technology back in 2010. Former Secretary of Education, Arne Duncan, discussed many of the nation's goals in a series of "For the first time…" statements.

> For the first time, many teachers will have the state assessments they have longed for-tests of critical thinking skills and complex student learning that are not just fill-in-the-bubble tests of basic skills but support good teaching in the classroom. (Duncan, 2010)

He continues:

> For the first time, state assessments will make widespread use of smart technology. They will provide students with realistic, complex performance tasks, immediate feedback, computer adaptive testing, and incorporate accommodations for a range of students. (Duncan, 2010)

These statements indicate the Department of Education's view on technology use and assessment. It was written in 2010, but it implies that Education in the United States will be meaningful, adaptive, and technology-based. The only problem is that adaptive education has taken much longer to achieve than Arne Duncan anticipated. Testing methods that claim to be adaptive are rarely such; instead, they are "bubble-in" tests that are taken on the computer. Assessments are not adaptive because they are taken on a computer; assessments are adaptive because they *adapt* to user inputs. There is still a lot of work to be done on adaptive technology. The funding and focus are present. Educators just need a better understanding of how to use adaptive technology to benefit their students.

Adaptive Tools and Resources

There is an incredible amount of technological resources available to teachers and students (Pearson, 2016). There are websites, games, and learning "apps" that can be used to learn or reinforce math topics. Students are generally receptive to working on computers and existing research indicates technology improves student engagement (Francis, 2017). Since engagement leads to educational gains, it is not surprising that school leaders are very supportive of using technology in curriculum (Grady, 2011). This leads to educational policies that encourage, even mandate, the use of technology within curriculum.

A good portion of the research on technology deals with specific programs that have already been rolled out and implemented with students. One of the prominent themes within the research pertains to new technology. Researchers have looked at specific software programs and the hardware that runs them in an attempt to find correlations to student learning. The tools examined include interactive response systems, talking books, Kindles, iPads, e-books, online assessments, learning games, learning platforms, and interactive, flat-panel whiteboards.

One noteworthy study is about the eVIVA project (McGuire, 2005). This was an early initiative to increase the use of e-portfolios. It allowed students to create online portfolios to share their work and highlight their skills. The study found that students who maintained an online profile took more pride in their work, felt empowered, and were more fully engaged in course content (McGuire, 2005). E-portfolios have changed since 2005, but further research has been completed through the years. Eynon, Gambino, and Török linked e-portfolios to higher retention rates, pass rates, and grade point averages (Eynon, Gambino, & Török, 2014). Buzzetto-More (2010) found that e-portfolios helped student reflect on their learning. Many other studies have indicated that e-portfolios lead students to career discovery and a greater sense of self (Buyarski & Landis, 2014; Nguyen, 2013).

Another study looked at a very specific feature of e-books; it found that if professors make annotations in the margins of textbook readings, student learning is improved (Dennis, Abaci, Morrone, Plaskoff, & McNamara, 2016). The point to mentioning these studies is that there is research on hundreds of different types of technology that are used in today's classrooms. It makes it very difficult to compare or replicate studies, which makes generalizability difficult to achieve in educational research.

There are two major components to educational technology that must be addressed; software and hardware. Software refers to programs, games, and applications that are used to learn or supplement learning. Hardware refers to the physical device that is used to interact with the software. It is important to differentiate between the two because the relationship is symbiotic, but existing research varies between the two.

Software

Two of the most-commonly used math software programs in secondary education are Khan Academy (https://www.khanacademy.org) and IXL (https://www.ixl.com), both of which are adaptive. The adaptive portions of these programs change the sequencing and difficulty of questions based on student answers. If students answer questions correctly, following questions become more difficult. If they answer incorrectly, the program gives another problem at the same level of difficulty or gets easier. This provides an effective learning environment that is personalized, standards-based, and “meet[s] students where they are at” (Smith, 2018).

Khan Academy. Programs like Khan Academy and IXL typically have the backing of empirical research before they gain widespread support in education. In 2017, Khan Academy and the College Board (maker of the SAT college-entrance exam) found that “20 hours of practice is associated with a 115-point average score increase from the PSAT/NMSQT to the SAT, nearly double the average gain of students who do not practice on Official SAT Practice” (Khan Academy Official SAT Practice, n.d.). An important distinction is that this study was on SAT practice and not math, specifically. The gains may not correlate *exactly* to math, but represent significantly higher scores for students who used the program versus students who did not use the program. These gains can be attributed to a number of factors, including, the scaffolding of the content, written and video explanations, or the effectiveness of the software. It is backed by a powerful quotation from a first-generation college student, saying:

> For all the times I couldn’t turn to my parents for homework help, I had Khan Academy videos to help me. Khan Academy was the private tutor that my family

> could not afford. For all the times I wanted to learn for the sake of learning, I would pick from the hundreds of Khan Academy videos. (Khan Academy, 2015)

IXL. There are several empirical studies listed on the IXL.com website. The most significant statistics listed on the site include:

- more than 7 million registered students use the software
- 1 in 8 students in the United States uses IXL
- Over 350,000 teachers use IXL with their students
- IXL is used in 95 of the top 100 school districts in the United States (IXL Research, n.d.)

Use Caution!. It is important to look at research on a developer's cite with a critical eye. One must ask questions like "Who completed this research?", "Why?", and "Did they get paid to research the program?" Any personal or financially-beneficial relationship between the researcher and developer could be viewed as a conflict of interests, rendering the data from that study to be less meaningful. This was taken into consideration when compiling information in the literature review of adaptive technology in math curriculum.

Hardware

Hardware refers to the electronic devices on which students access adaptive technology. The most-commonly used hardware in secondary classrooms includes laptops and Chromebooks, tablets, and cell phones (Nagel, 2018). Research on hardware suggests each of the technologies have perceived benefits and detriments to using them.

Laptops and Chromebooks. Computer-usage in classrooms has proliferated in recent years. Three million Google Chromebooks were used in American classrooms in 2014, and Chromebooks only make up half of the market (Newman, 2017). With that many computers in use, it is imperative that educators understand how this impacts learning.

A 2016 meta-analysis of one-to-one computer programs found that laptops contribute to improved academic achievement and "significantly positive average effect sizes in English, writing, mathematics, and science" (Zheng, Warschauer, Lin, & Chang, 2016). Another study suggested that computers are so prevalent in elementary math curriculum that removing computers from curriculum would "separate [students'] classroom experiences from their life experiences" (Powers & Blubaugh, 2005). There is ample research that outlines the benefits of computers in classrooms; most of this research is positive, but there is also critical research that disputes educational gains from technology.

Tablets and Cell Phones. Conflicting research is very prevalent when in reference to research on cell phones and tablets. There are studies that suggest mobile devices can enhance learning gains and enrich learning opportunities (Traxler & Wishart, 2011; Kim & Frick, 2011). Another study on mobile devices in math curriculum found that using mobile devices with math applications made a "positive impact on learning outcomes as well as learning atmosphere both in class and outside the classroom" (Supandi et al., 2018). There are many specific learning gains cited in empirical research.

Many studies have also discredited the positive effects to using mobile devices in education. Research has found a number of issues that should cause concern for educators who plan on or are currently using mobile devices with their students. McCoy (2013) found that students use mobile devices an average of 10.93 times per school day for non-class related reasons (McCoy, 2013). More than 80% of the respondents to the study also acknowledged that cell phones cause them to pass less attention to instruction (McCoy, 2013).

With so many conflicting opinions, it can be difficult for educational leaders to decide whether or not mobile devices should be incorporated within curriculum design. One of the tools leaders use to make policy decisions is the SAMR Model, which was introduced by Ruben Puentedura in 2013. It provides a framework for mLearning (learning by mobile device) by focusing on the four themes of substitution, augmentation, modification, and redefinition (Puentedura, 2013). The SAMR Model is used to evaluate programs. Leaders can then use the information to decide whether or not the proposed technology transforms learning and, if so, the appropriate amount of time and energy to devote to integration (Puentedura, 2013). The SAMR Model has also been researched extensively. Romrell, Kidder, and Wood (2014) found that at the lower levels of substitution and augmentation, the effort of implementing the new technology is not worth the learning gains. They also found that "At the levels of modification and redefinition...mobile technologies become integral to the design of the activity and may potentially be worth the problems" (Romrell, Kidder, & Wood, 2014).

Comparisons

Outside of electronic devices and software, studies have focused on a number of thematic strands. One of the major themes is the comparison between old and new technologies. Old technologies may be described as outdated, antiquated, or "low-tech". New technologies embrace the buzzwords people hear about in popular culture - smart, adaptive, innovative, etc. Paper-based learning is perceived as an "old-school" way of learning; this is why schools that brand themselves with technology and innovation are perceived as being more desirable. Traditional education simply does not offer the same excitement or "Wow Factor".

Research pertaining to educational technology compares traditional classroom tools to the newest and most innovative products available. The best place to start the comparison of "old versus new" is textbooks. Lee, Messom, and Yau (2013) suggested that e-texts have the potential to replace printed textbooks in their entirety. The benefits are clear; smartphones and tablets allow students to access their books from almost anywhere in the world. They are convenient, fast, and accessible. They can also be much cheaper than their printed alternatives (Lee, Messom, & Yau, 2013). Still, research suggests that a lot of students prefer printed textbooks over e-books (Millar & Schrier, 2015).

Research has also been devoted to perceptions regarding technology. How students and teachers feel about educational technology greatly influences its impact in the classroom. Researchers suggest that there are correlations between implementing e-books and enhanced learning and engagement (Martinez-Estrada & Conaway, 2012). Others indicate a positive relationship between online formative assessments and higher levels of motivation and confidence (McGuire, 2005). Godzicki, Godzicki, Krofel, & Michaels (2013) found that interactive textbooks lead to higher content retention. Dennis, Abaci, Morrone, Plaskoff, and McNamara (2016) found that e-learners faired the same as regular students on multiple choice questions but exhibited higher levels of competency on open-ended questions. These are all benefits that suggest educational technology can lead to deeper learning.

Misperceptions

There are two misperceptions commonly made regarding adaptive technology. The first is that all the newest tools and programs are *adaptive* just because they are new. Printed books that are converted to a .PDF or similar file are not adaptive. Adaptive e-books are interactive. They might allow users to edit text, change the colors or sizes of font, write notes in the margins, or enable the device to read text aloud. Adaptive tests are also much different than non-adaptive tests. Adaptive tests change the sequence and difficulty of questions (outputs) based on user response (inputs). Fixed-bank “bubble” tests are still bubble tests regardless of if they are completed on the computer or with pencil and paper. Many times, products that are referred to as *adaptive* are nothing more than electronic adaptations of traditional resources.

The second misperception is that adaptive technology and assistive technology are one in the same. Adaptive technology is designed to differentiate instruction or assessment to suit individual needs (Izumi, Fathers, & Clemens, 2013). It is meant for educators to be able to take a more authentic measure of knowledge and progress. It is a great tool for formative assessment and self-learning. Assistive technology is more-commonly used when referring to students with disabilities. The Individuals with Disabilities Education Act (IDEA) defines assistive technology as “any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability” (Individuals with Disability Education Act, 2004). Assistive technology was not addressed in the proposed research because the study did not focus on special needs or exceptional student education. Any data regarding assistive technology was purely incidental and collected within the context of individual learning differences.

Assessment

Another major theme within the research was assessment. Testing is an important part of the educational system for a number of reasons; it is used to measure progress and assess student learning (Croft, Roberts, & Stenhouse, 2015). It is also used to evaluate teachers and instructional effectiveness (Croft, Roberts, & Stenhouse, 2015). Assessment provides accountability and hard data to make comparisons between students, teachers, and educational institutions (Croft, Roberts, & Stenhouse, 2015).

The three main types of assessment are diagnostic, formative, and summative (Formative and Summative Assessment, n.d.). Diagnostic testing is used to “diagnose” (Formative and

Summative Assessment, n.d.); it is used to understand what students know prior to instruction. This is based on previous content knowledge, critical thinking, and lived experience. The results of these tests allow educators to design curriculum to meet the needs of the learners. Diagnostic testing, although important, was not studied in this dissertation.

Formative and summative assessments are more commonly used to assess progress (Formative and Summative Assessment, n.d.). Formative assessment is an ongoing method of monitoring that provides educators and students with regular feedback (Chappuis & Chappuis, 2007). It includes daily assignments, exit tickets, and observation. The data that is collected is used by educators to check progress and understanding and alter curriculum to address specific needs. Formative assessment is commonly known as assessment *for* learning (Chappuis & Chappuis, 2007).

Summative assessment is known as the assessment *of* learning (Chappuis & Chappuis, 2007). This is the result of learning and is taken after instruction has been completed. Common examples of summative assessment include papers and projects, content exams, and standardized assessments.

Formative and summative assessments can both be adaptive (Izumi, Fathers, & Clemens, 2013). Teachers are able to keep formative tabs on their students through programs like IXL and Khan Academy. Adaptive summative assessment is not as prevalent and is perceived as a "new" technology that takes more time to develop, is costly, and requires continuous attention in educational policy (Izumi, Fathers, & Clemens, 2013).

Perceptions of Technology

Another theme in the literature review included perceptions about technology. Many of the studies on adaptive technology are qualitative and pertain to how students and teachers feel about using technology in education. Hilton (2016) outlined a number of statistics regarding open educational resources (or OER), electronic learning tools that are free to access. He found that "83% of students believed the OER supported their work in the course and 78% would recommend OER to classmates" (Hilton, 2016). He also found that "Half of the instructors said OER was of equal quality as traditional texts, with 33% favoring OER and 17% favoring traditional textbooks" (Hilton, 2016). These findings indicate that teachers and students support electronic learning tools and find value in their usage.

An important phenomenon related to favorable perceptions about technology is that having a high self-efficacy does not necessarily translate into higher learning. For example, one study found that students believed they would have a higher final grade after adopting e-text over the traditional textbook. In reality, non-adopters received an average final grade that was five points higher than e-text users (Terpend, Gattiker, & Lowe, 2014). This is an interesting disconnect that warrants further review.

Another part of perception is comfort-levels and how they affect the frequency that electronic tools are used within curriculum. Fishman, Riconscente, Snider, Tsai, and Plass (2014) found that teachers who are more comfortable using technology implement more innovative lessons. While these findings may not be surprising, they are significant because they indicate teachers are willing to integrate technology to benefit student learning. Technology allows teachers to create more engaging lessons that incorporate activities like learning games, enrichment exercises, and adaptive "apps". These are all tools that could allow educators to take formative or summative assessments of student learning.

Support

Training and support directly relate to how comfortable teachers are with using educational technology. Teachers need to have training on new technologies before they can be expected to implement them in their classrooms. The study by Armellini and Aiyegbayo (2010) mentions a new term called "e-moderation" and argues that e-tivities become increasingly difficult to implement if instructors and tutors do not have the training and support they need. This reverts to the idea that technology can be very powerful, but problematic if it is not used properly. The cause-and-effect relationship between support and success should not be taken lightly; strategic plans must be created by leaders who truly understand educational technology and the impacts it has on learning.

Criticism

The literature review documented a lot of the positive impacts of technology on education. There was also research that disputes the positive impacts of technology in curriculum. The most commonly cited downfall to educational technology is distraction (McCoy, 2013). Research has proven that humans are not effective multitaskers (Mayer & Moreno, 2003). Yet students continue to use their cellphones even though they acknowledge cellphones cause them to pay less attention in class (McCoy, 2013). Sana, Weston, and Cepeda (2013) took it a step further by reporting that students in-view of multitaskers experienced reduced comprehension. It seems some students increase engagement with technology and others increase distraction.

There are also studies that suggest there are no (or at least no *significant*) advantages to implementing technology. A 2015 study reported that "Our findings are not stringent enough to encourage such efforts because the differences in examination results and competence gains between online and offline students are not significant (Dennis, Abaci, Morrone, Plaskoff, & McNamara, 2015)." Terpend, Gattiker, and Lowe (2014) found no meaningful difference in grades between students who used e-books and students who used p-books (print). If there is consolation to these studies, it is that research does not indicate that technology negatively impacts students or learning.

Other challenges to educational technology were outlined by Lee, Messom, and Yau (2013). The researchers found eight challenges in their extensive literature review, including, cost, standardization, service reliability, quality and accuracy of content, ownership of content, visual fatigue, readability, and copyright concerns (Lee, Messom, & Yau, 2013). Not all findings from their review were damning; they found that e-resources improve accessibility and can often be cheaper for students (Lee, Messom, & Yau, 2013). The point is that literature indicates some of the perceived challenges do not make a significant impact one way or the other. Electronic resources that are more affordable for students could be costlier to schools. Policies meant to improve accessibility could widen the learning gap for students who cannot afford the technology needed to implement them. Technology impacts students differently than it impacts schools and districts. Perception is individual and based on the lens through which it is seen; this is a major reason for why research on perception yields a wide variety of results.

Agreement

The literature review indicated that there were some topics researchers generally agree on. Ideas that were prevalent in much of the literature include: a) technology can be helpful if it is properly implemented, b) computers and other electronic resources are becoming increasingly important in education, and c) constant research is needed on educational technology.

Opportunities in Research

Daniel Newman, from Forbes Magazine, listed the most cutting-edge trends in educational technology in the article *Top 6 Digital Transformation Trends in Education*. In the list are augmented/virtual reality, classroom sets of computers or tablets, redesigned learning space, artificial intelligence, personalized learning, and gamification (Newman, 2017). This reaffirms many of the suggestions prior researchers have made regarding future research. It is a great starting point to determining where educational technology is heading, and thus, what research opportunities exist.

Most of the items on Newman's list refer to very specific types of technology. Researchers have also made suggestions about the framework for future research. Many have suggested longitudinal studies on educational technology. One consideration for longitudinal research is that technology is constantly changing. It is very difficult to study products and their impacts when those products are always evolving or being updated. Software updates improve usability. If a software update directly improves usable features from a program, existing research framework might not apply to the newest software. For context: A graduate student is researching the math website IXL.com and its effect on student motivation. When IXL adds learning games to their site, the framework used for the research would not apply to the next study. Replicability is very important in empirical research; lack of replicability makes longitudinal research very difficult to plan for and design.

Adaptive Technology

One thing that is often excluded from empirical research is adaptive technology. "Although there is growing global interest in using learning analytics and adaptive learning technologies to improve teaching and learning, there are not many studies detailing concrete outcomes" (Johnson et al., 2016). The literature review outlined many different types of electronic devices and software programs. Adaptive technology includes both hardware and software. It is critically important that these technologies differentiate between users. Many of the prior studies pertaining to educational technology did not address adaptive technology. The grand majority of existing research on adaptive technology was only in reference to assessment. This created an informational gap the researcher was aiming to reduce. Adaptive technology is related to all six of the educational trends outlined by Forbes Magazine. The literature review indicated further examination on adaptive technology, specifically, was warranted.

Summary

Obsolescence is an enormous challenge to technological research (Borba et al., 2016). It is problematic because existing research becomes less meaningful with each advancement in technology. The researcher for this study recognizes that his research could lose meaning over time. He argues that adaptive technology is likely to become increasingly important in upcoming years. Any technology that is used in classrooms impacts students and increases the stakes at which it is implemented.

Much of the literature review pertained to technology and not *adaptive* technology, specifically. The reason for this is that adaptive technology has not be researched extensively. This dissertation was designed to reduce the informational gap. If adaptive technology is used to assess learning, what does it offer as an instructional tool? Self-learning and discovery are important to the cognitive development of students. Adaptive technology seems to be an effective tool for self-learning. It is also used as a progress report (formative) and for summative assessments like the ACT. However, teachers have struggled to differentiate with this technology in whole-group instruction (Bellman, Foshay, & Gremillion, 2014). This study sought to explore adaptive technology in-depth. The researcher hoped to gain insight from the educators who already use adaptive technology within mathematics curriculum. This information is invaluable because it may influence how teachers teach and how leaders create policy.

Chapter III: Methodology

This study utilized case study design to allow the researcher to gain a comprehensive understanding of adaptive technology through the lens of the educators who use it in daily planning, instruction, or assessment.

Data was collected through an online survey that included, multiple choice, select all, and open-ended questioning (outlined in Appendix C). Close-ended responses were used to understand the context through which each participant uses adaptive technology; this includes courses taught and math proficiency of their students (higher-level learners vs. lower-level learners). Open-ended questions were opinion-based and designed to provide perceptions and experiences about adaptive technology in math curriculum. This data provided a depth and breadth that could not have been accomplished with only close-ended responses.

All responses are stored on Google Drive and a password-protected computer that is only accessible to the researcher. The online database requires two-step authentication and identifying characteristics were removed from responses. Participants accessed the survey through Google Forms. The majority of participants work for school districts that use Gmail for electronic communication. The survey was originally only open to users who had a Gmail account. This was done to prevent participants from submitting data more than one time. Because the initial response was lower than anticipated, this constraint was lifted so that participants could complete the survey without logging into a Gmail account. Email addresses were not recorded or accessible to the researcher; participants are guaranteed anonymity. Contact information for the researcher was also provided to all participants upon completion.

Purpose

The purpose of this study was to examine adaptive technology in secondary math education. Many types of educational technology have been evaluated throughout the years. Researchers have often found correlations between technology, engagement, retention, and academic success (Francis, 2017; Liu et al., 2017). There have also been studies that found negative impacts from the introduction of educational technology, such as, costs and distraction (Grover, 2016; McCoy, 2013). Regardless of findings, much of the existing research fails to include adaptive technology (Liu et al., 2017). Of the research that does exist on adaptive technology, the great majority of it pertains to computerized adaptive testing (Kingsbury, Freeman, & Nesterak, 2014).

The importance of assessment in today's classroom is undeniable. Assessment data provides a baseline for school administrators (Croft, Roberts, & Stenhouse, 2015); it is used to measure student performance, as well as, teacher effectiveness (Croft, Roberts, & Stenhouse, 2015). It is estimated that "7,000 school districts representing 30,000 schools are currently using some form of computerized adaptive testing" (Kingsbury, Freeman, & Nesterak, 2014). Research indicates that some educators prefer adaptive assessment because it allows students to receive immediate feedback, is more efficient, and provides a more authentic measure of learning than traditional paper-and-pencil tests (U.S. Department of Education, n.d.).

Less is known about the instructional potential of adaptive technology (Johnson et al., 2016). It seems testing has taken priority when it comes to funding and focus in adaptive technology in education. This presented an opportunity to research adaptive technology through a different lens. The study was holistic; it compiled insights from teachers to understand how adaptive testing has a multi-faceted effect on education. Education is not just about assessment;

it is important to research adaptive tools without sacrificing emphasis on course planning, learning objectives, instructional practice.

Research Questions

The study was guided by the following questions:

1. What is the frequency and purpose of adaptive technology being used in secondary math classrooms?

2. What are the teacher-perceived advantages and disadvantages to using adaptive technology in math-based curriculum?

3. How can existing adaptive technology be improved as an educational tool?

Setting

The survey was completed using Google Forms. Respondents were asked to fill out an online survey representing their feelings and experiences with adaptive technology in the classroom. To add a level of authenticity, the researcher designed an adaptive survey that changed the sequence and questioning based on participants' responses. It is believed that adaptive technology can provide the same depth of information with fewer questions (U.S. Department of Education, n.d.). The researcher hoped to capitalize on the improved user-experience to collect more responses and reduce survey attrition.

Historical Context

Adaptive technology is not a new idea (Kingsbury, Freeman, & Nesterak, 2014). Computerized adaptive testing (CAT) has been researched since the 1970s (Weiss & Betz, 1973; Kingsbury, Freeman, & Nesterak, 2014). Still, adaptive technology is perceived as one of the newest and most innovative educational tools (Pearson, 2016). This is likely due to the advances in the hardware (electronic devices) that is used with adaptive technology. New products lead to new features and heightened attention, thus, creating the perception that adaptive software is new or innovative. More often than not, investment in "new" technology refers to hardware; it includes computers, tablets, and other smart devices, rather than the adaptive programs or assessments schools use in combination with hardware and electrical devices. This is likely due to the fact that many of today's adaptive resources for math, like Khan Academy, IXL, and Algebra Nation are license- or subscription-based and can be difficult to purchase with increasing budgetary constraints (Izumi, Fathers, & Clemens, 2013).

Market Growth

The global market for educational technology has exploded in growth over the last several years (Schaffhauser, 2015). School districts across the United States were expected to spend $4.7 billion on educational technology in 2015 (Schaffhauser, 2015). While this figure seems to inflate with each policy reform, it does not include *all* spending in educational technology. Corporations and venture capital firms have also joined the effort. In 2017, investment in educational technology had reached $9.56 billion globally (Adkins, 2018). This emphasis on technology foreshadows a strong presence of technology in future classrooms.

The U.S. Department of Education affirmed support of adaptive technology in 2010. Statements by the then-Secretary of Education Arne Duncan made it clear that America would become a leader in adaptive assessment. In 2019, adaptive testing had still not gained the traction that was predicted. Adaptive assessment was less widespread than it was anticipated in 2010. This could be because of budgetary and policy constraints that make real policy change slow to come to fruition (Johnson et al., 2016). It could also be because assessment had overshadowed other areas of education (Croft, Roberts, & Stenhouse, 2015); adaptive learning tools and curriculum are even slower to catch up than assessment. This study was designed to research adaptive technology as an educational tool for assessment *and* instruction.

Research Design

This dissertation was a case study analysis that utilized purposeful sampling of secondary math teachers. The rationale for utilizing case study design was that it allowed for the greatest depth and breadth of information to be gained from research data (Yin, 2017). The study was nonexperimental and allowed the researcher to study how a very specific type of technology, adaptive technology, was used in math classrooms. It expanded the research base by examining adaptive technology through the context of leaning, curriculum design, instructional strategy, and assessment. There was little research to indicate concrete learning gains from adaptive technology (Johnson et al., 2016). There was even less information on how adaptive technology is used outside of testing (Liu et al., 2016); a case study was designed to provide specific insights that could be valuable to teachers and educational technology developers.

An extensive literature review was conducted to explore existing research and correlations between adaptive technology and learning and assessment. The review outlined many of the positive benefits to using technology in the classroom (Gee, 2004; Liu et al., 2017; Martinez-Estrada & Conaway, 2012; Godzicki, Godzicki, Krofel, & Michaels, 2013). It also suggested that adaptive technology is an underrepresented field of educational technology (Liu et al., 2017; Johnson et al., 2016). More research on curriculum side of adaptive technology was warranted, and the researcher hoped to reduce this gap in understanding.

The study was designed to further educational knowledge on adaptive technology by compiling the data from the educators who use it in secondary math curriculum. Insights from teachers captured a current snapshot into adaptive educational technology, its usage, and perceptions regarding its benefits. The goal of the study was to further the knowledge base on adaptive technology to make recommendations for improvements and future research. It was theorized that improving the knowledge base on adaptive technology would create positive impacts in the classroom and ultimately lead to an improvement in student learning and curriculum development.

Participants

Sampling for the study was purposeful. Participants included all secondary math teachers in several large, urban school districts. To obtain email addresses, the researcher submitted a listserv information request to the Florida Department of Education (FLDOE). A total of seven districts were included in the information request from the FLDOE.

The total count of high school math teachers in the included districts for the 2018-2019 schoolyear was 2,738. Of that, there were 154 teachers who did not have an email address listed and another 107 email accounts rejected the initial email as undeliverable. Because of the sample size and the fact that many of these teachers could have left their respective district since 2018-2019, the researcher did not attempt to find the corresponding emails or inquire as to if the teachers are still employed; instead, they were removed from the sample. This brought the total sample size to 2,477.

There was a total of 97 responses to the survey, a return rate of 3.92%. Researchers agree there is no mandated minimum response rate that must exist in research (Fowler Jr., 2013). Because of the large sample size, the researcher hoped to get a response rate of at least 5%. Although 5% was not achieved, the large sample size and meaningful feedback from teachers suggests the data provides a good representation of the target sample. This was confirmed by reliability and validity testing in the data analysis.

There were several factors that could have contributed to a lower response. The survey was longer than other electronic survey instruments. It required participants to dedicate 10-15 minutes to complete, depending on the level of detail provided in their responses. Secondly, the researcher confirmed that some of the emails went to spam folders. There is no way to verify how many emails went to spam and how many non-participants simply chose not to take the survey.

The researcher sent a total of three emails to each participant. The initial email (Appendix A) introduced the study and provided a link for participants to access the survey. Follow-up emails were sent to encourage teachers to complete the survey. Because the response rate was lower than the target of 5%, the form settings were reconfigured to allow participants to respond without logging in to a Gmail account. This led to a total of 97 completed surveys.

Instrumentation

An electronic survey was the primary instrument used for data collection. The questions and sequencing of the survey are outlined in Appendix C. Teachers who use adaptive technology were asked to provide information, including, how often they use adaptive technology, the context (instruction, assessment, supplementation/enrichment, etc.), and their perceptions of adaptive technology. They were also asked to provide recommendations for how adaptive technology could be improved to benefit learning, assessment, or curriculum development.

Questions for the survey were close- and open-ended. Including both required a more extensive analysis but was deemed the more appropriate way to gain a depth and breadth of understanding that could not have been accomplished with only close-end responses (Reja, Manfreda, Hlebec, & Vehovar, 2003). Furthermore, Singer and Couper (2017) reported specific advantages to open-ended questioning on electronic surveys; they found open-ended responses provide a wider range of possible responses, while digitized surveys simplify the process of transcribing data (Singer and Couper, 2017). The researcher believes this led to a more efficient study, while also allowing the researcher to capture the essence of participants' responses.

Data Sources and Collection

The study consisted of an electronic survey that was sent to all secondary math teachers in seven large, urban school districts. An introductory email detailed the purpose of the study, researcher's contact information, and importance of participation. Participants needed to electronically "sign" the statement of informed consent that was provided in Appendix B before continuing to the survey. If it was not signed, it was assumed consent was not granted and the respondent was not permitted to continue. Participants were informed that participation is optional. There was no punitive action for participants who did not complete the survey, opted out, or requested that their contributions be removed from the final report. The researcher's contact information was provided in the invitation email and when they submitted their online form in the case that any participants had questions or decided they would like to have their responses excluded from the study.

Because the survey was adaptive, some of the questions indicated that a participant is not a good fit for the survey; in this case, the form submitted, and data was recorded. Participants did not have the option to revise or re-submit with different responses. The adaptive nature of the survey reduced the average completion time, which was intended to lead to a higher response rate.

Response.

Previous researchers have suggested varying response rates for internet-based surveys (Fowler Jr., 2013). Content, sample size, timeframe, and other factors impacted how many respondents participated. Because the sample for this study was so large (n=2477), the researcher was aiming for 5%, or at least 100 participants.

The researcher sent out an initial email requesting participation from all math teachers in the large urban school districts (Appendix A). This was followed by two follow-up emails to remind participants to complete the survey. The survey was originally designed to require participants to sign into a Gmail account to prevent teachers from submitting more than one form. These settings were reconfigured after the initial set of emails to allow respondents to participate from any device with an internet connection, thus, removing the requirement that participants login to their Google account.

Appendix C details the survey questions and sequencing.

Procedures

The procedures for the study are outlined below in chronological order:

1. An invitation email was sent via email and will included a link to the Google Form. It asked educators how often they use adaptive technology, its purpose (assessment, learning, supplementation, etc.), and their perceptions. Emailing participants directly was ideal because the researcher was able to send reminders for participants to complete the survey. The invitation is provided in Appendix A of this study.
2. Two follow-up emails were sent to remind teachers to participate in the study.
3. Surveys were completed online via Google Forms.

4. Results of the survey are stored in Google Drive. This is password protected to guarantee confidentiality and anonymity. Email addresses were not collected, but some teachers had to sign into a Google account to participate.
5. The data was analyzed.

Data Analysis

The researcher took an inductive approach to analyzing data. Forced-choice questions asked for informed consent, if the participant is a secondary math teacher, and if they use adaptive technology with their students. It was possible for participants to skip other questions on the survey. Prior to the study, it was determined that respondents who did not answer at least 75% of the questions they saw would not be included. This policy did not lead to the disqualification of any responses. There was one instance where the respondent did not give an exact number for years of experience or age. Instead, the respondent stated “over 30” for experience and “over 40” for age. These responses were recorded as 30 and 40, respectively. Any responses that included half-years (i.e. “6.5 years of experience”) were rounded up to the next whole number. This data was altered to lessen the possibility of skewing the data.

Open- and close-ended questions were used to explain teacher perceptions, and the case study design allowed for depth and breadth of understanding that could not have been achieved using other research designs. Close-ended questions helped the researcher compile demographic information. This portion included questions like “What classes do you teach?” and “How many years have you been a classroom teacher?” The questions were meant to ease participants into the study and provide the researcher with information on the lens through which each teacher had experienced adaptive technology in their classroom. The researcher used descriptive statistics in the data analysis to summarize responses and inferential testing (ANOVA, chi-square, post-hoc, etc.) was completed to indicate correlational trends and tendencies. The series of ANOVA testing can be found in Chapter IV of this dissertation.

The p-value for the ANOVA testing was set at $P<0.05$. Depending on statistical significance, post-hoc testing was also used to identify differences between test groups and control experiment-wise error. A number of chi-square goodness of fit tests were completed to determine if research data was significantly different from expected values. Lastly, a Cronbach's alpha test was completed to measure the reliability of the survey. Calculations were completed on Stata statistical software.

Open-ended responses were classified and coded. Concept mapping was utilized to establish thematic strands and organize the analysis. Open-ended questions for this study were designed to provide information that previous studies on adaptive technology did not expand upon. Are there ways in which adaptive curriculum could be used within a group setting? Could adaptive technology be used to plan curriculum? These are the types of insights that teachers were able to provide that were not emphasized in prior research. The analysis was detailed and systematic. It provided valuable information regarding teacher perceptions and indicated specific recommendations for how to improve adaptive technology.

Ethical Considerations

Participation in this study was completely voluntary. Participants were not penalized for opting out or requesting to have their contributions omitted from the final report. Identifying characteristics were excluded from documentation and email addresses were not collected.

Prior to completing the survey, respondents provided informed consent via electronic signature (see Appendix B). Responses did not include identifying information but are stored in password-protected databases regardless. Encryption offers an extra layer of security. After a period of 5 years, the data will be deleted and completely removed from record.

Validity

The biggest threat to validity for this study was survey bias. Sampling was purposeful because it only included high school math teachers in the seven districts. Bias could have been introduced when specific teachers/groups did not participate. For example, the majority of respondents who participated could have been the teachers who love using adaptive technology with their students. If the group of teachers who are disinclined to use adaptive technology did not participate in the survey, survey bias would exist, and the external validity of the study would suffer.

To mitigate survey bias, the researcher sent reminder emails to urge participants to complete the survey. The sequencing of electronic communication included three emails: one introductory email with survey link (Appendix A), followed by two reminder emails.

Reliability

Non-participation could have negatively impacted reliability. Reliability refers to the consistency of the survey. The researcher reduced the likelihood of non-participation by sending reminder emails to each of the teachers selected in the samples. He also designed an adaptive survey to require the fewest questions needed to provide meaningful feedback. The survey was designed to be completed in 15 minutes or less to reduce the survey attrition. Cronbach's alpha was also calculated to measure reliability.

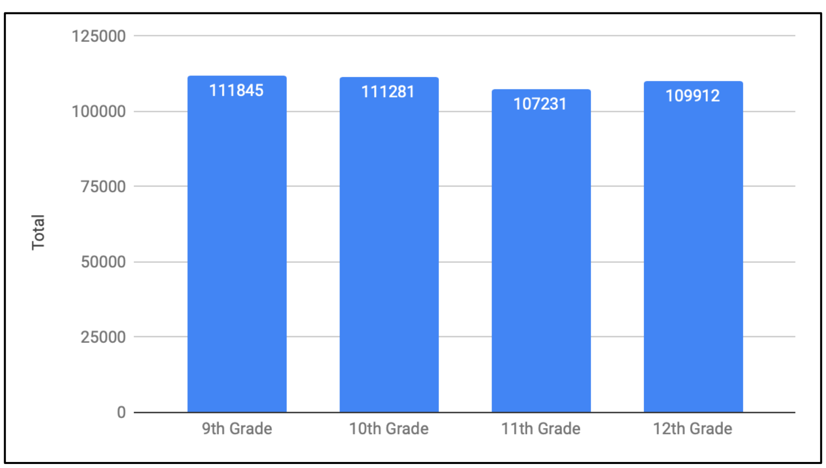
Limitations

This study researched adaptive technology and how it is used in secondary math classrooms in seven large, urban school districts in the southeast United States. The researcher found it appropriate to focus on mathematics for two reasons; it is the researcher's teaching content area, and math curriculum works well with adaptive programming. Answers are very precise. Most questions have right and wrong answers, which allows computer programs to easily differentiate between correct and incorrect answers. For this reason, math is one of the content areas that utilizes adaptive technology on a much higher scale than curriculum that is subjective.

The purpose of including seven districts is to improve the generalizability of the data. With that, it is important to note the findings from this particular study may not represent how adaptive technology is used in *all* classrooms. The instrumentation used in this study could produce different results if the exact same survey were to be completed in a rural setting in the Midwest or other side of the world.

To limit the likelihood that generalizability will negatively impact the study's replicability, student and teacher demographics have been compiled and presented in Figures 1-5. Figure 1 exhibits the number of high school students by grade in the urban districts that were included in the research. The districts included in the study service over 440,000 students.

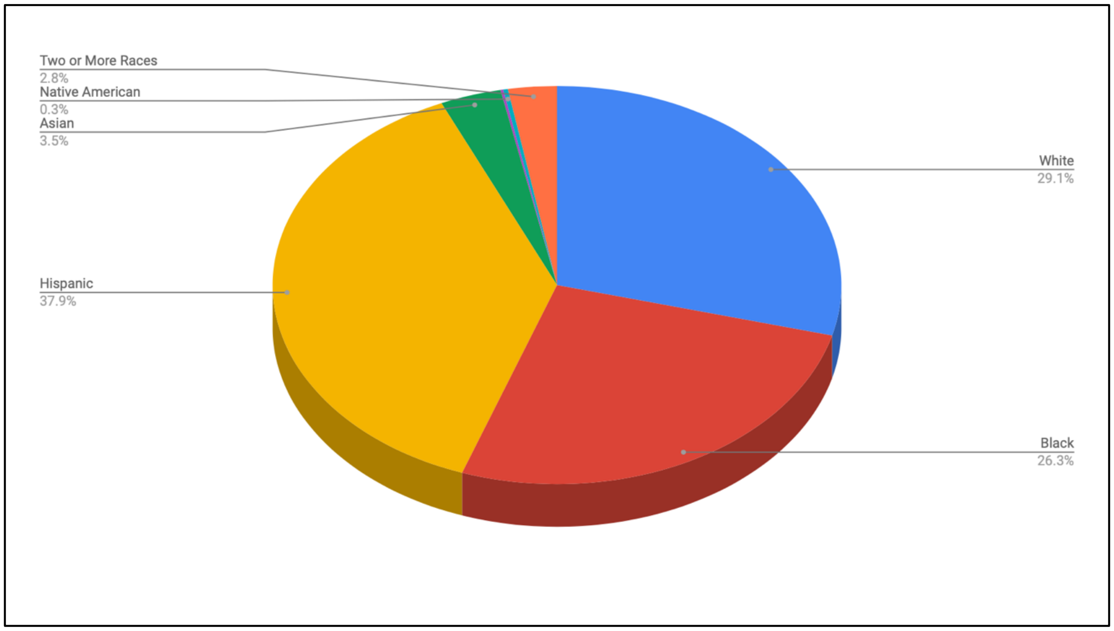
Figure 1: Number of Students by Grade (2018-2019)



(PK-12 Public School Data Publications & Reports, 2019)

Figure 2 displays student demographics for all high school students in the included districts. It is sorted by race/ethnicity and categorized by Hispanic (37.9%), White (29.1%), Black (26.3%), Asian (3.5%), two or more races (2.8%), and Native American (0.3%).

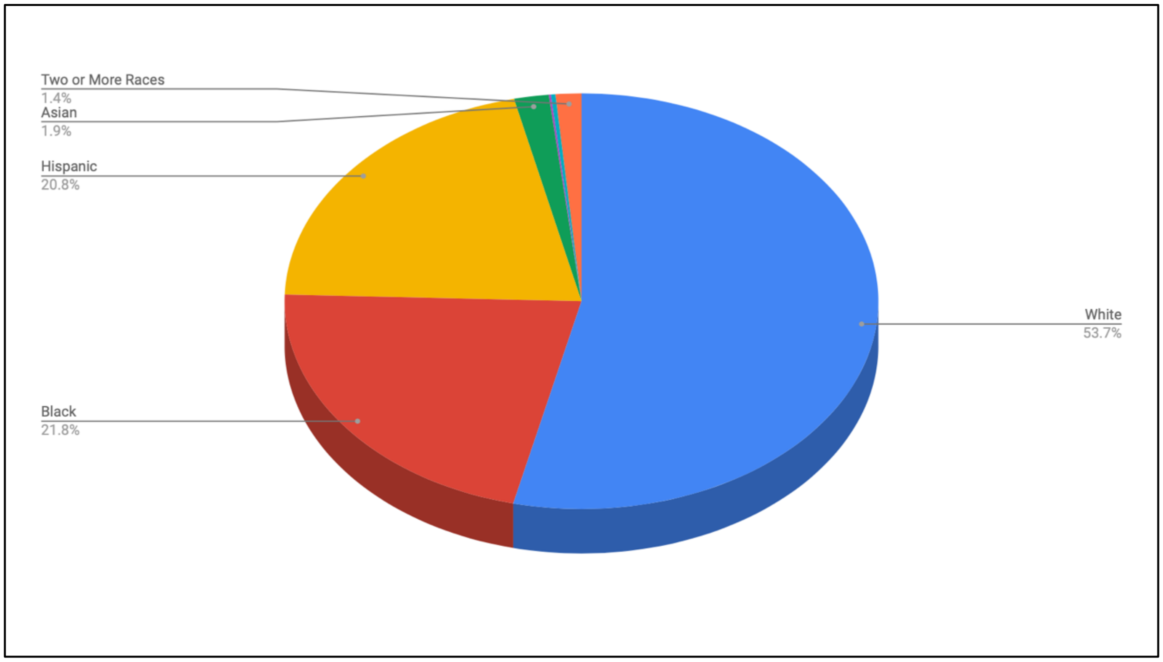
Figure 2: Student Demographics (2018-2019)



(PK-12 Public School Data Publications & Reports, 2019)

Figure 3 depicts secondary classroom teacher demographics by race/ethnicity. Information on teacher demographics by content area is not publicly available, so Figure 3 includes *all* secondary classroom teachers in the included districts. It is not limited to math teachers only.

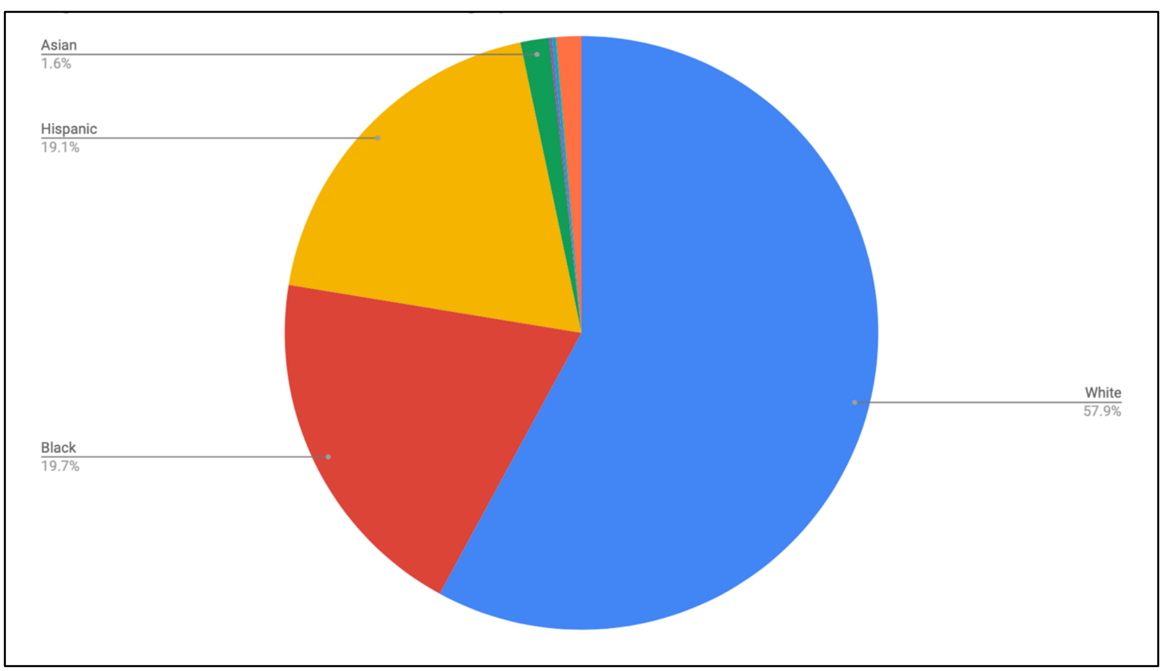
Figure 3: Teacher Demographics (2018-2019)



(PK-12 Public School Data Publications & Reports, 2019)

Figure 4 represents the demographic statistics for male secondary teachers. Again, this is not broken down by content area. It includes all male teachers in the respective districts.

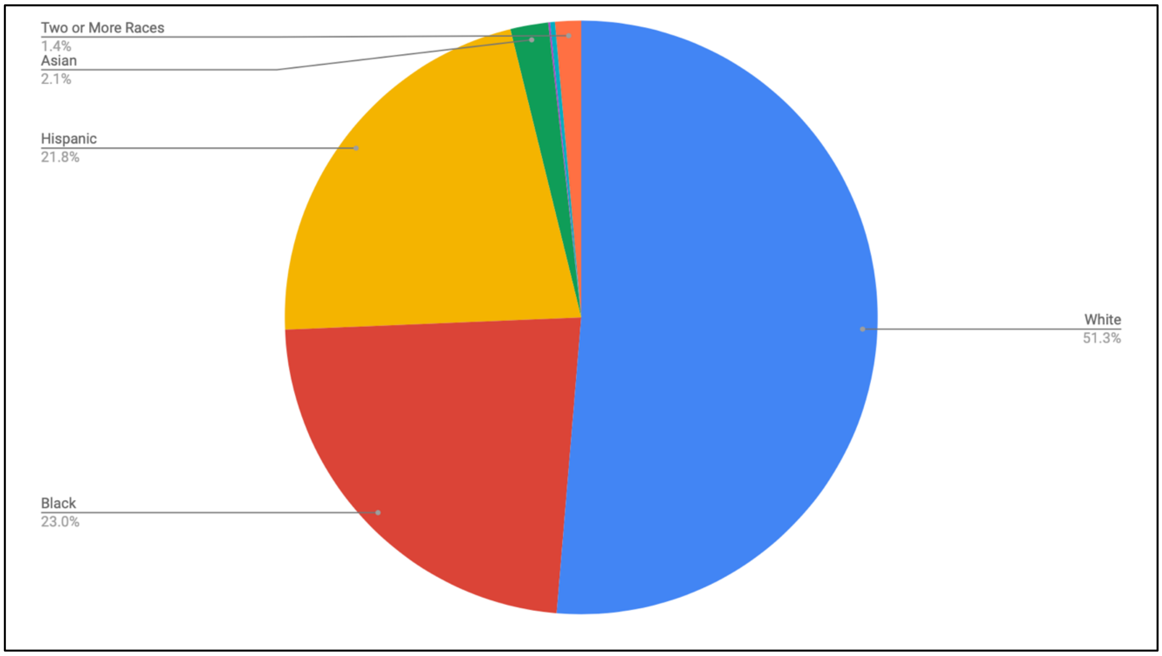
Figure 4: Male Teacher Demographics (2018-2019)



(PK-12 Public School Data Publications & Reports, 2019)

Figure 5 represents the demographic statistics for female secondary teachers. This includes all female teachers in the included districts. It is not limited to math teachers only.

Figure 5: Female Teacher Demographics (2018-2019)



(PK-12 Public School Data Publications & Reports, 2019)

Delimitations

Delimitations existed for the proposed study because all the fields of education were not included in sample. Adaptive technology is utilized the most in the core content fields of math and English. Many of the elective options students have use technology, but that technology is not necessarily adaptive. There is a lack of adaptive resources available to non-core subjects because they do not require the same level of monitoring or standardized testing. This would make it more difficult to find teachers of elective courses who regularly use adaptive programs. The study was, therefore, only focused on math in high school education.

Another delimitation was not using including elementary teachers or professors from colleges and universities. It is significant because the findings of this study would not replicate the findings of the same study if it were conducted outside the high school setting. Teachers in high school education work with adolescents who are at a much different phase of cognitive development than with younger or older students. Their experiences will, therefore, be very different than elementary educators who teach children and university professors who teach adults.

Summary

The study utilized case study design. Participants completed an online survey that indicated how often they use adaptive technology, the curricular purpose of it in their classroom, and their perceptions. Data was carefully collected and analyzed. Chapter IV summarizes each of these factors to provide a "snapshot" of adaptive technology in secondary math curriculum. The researcher aimed to provide empirical data and recommendations to improve learning and instruction. The body of knowledge surrounding adaptive technology was limited in scope and sequence. Adaptive technology was often omitted from empirical studies (Liu et al., 2017). When it was included, it was mostly in the context of testing. This warranted more research into adaptive technology in the contexts of learning, instruction, and assessment. The goal of the study was to improve instructional practice so that students learn more efficiently and teachers can develop cutting-edge curriculum. Chapter V outlines recommendations for future research and curriculum design.

CHAPTER IV

Introduction

The purpose of this study was to research adaptive technology and how it is used in high school math classrooms. This was accomplished by surveying high school teachers (n=2477) who use adaptive technology to teach or assess student progress. Teachers were asked to provide demographic information, including, their age, years of teaching experience, and the classes they teach. They were also asked to share their perceptions regarding adaptive technology and its impacts on student performance. The goal for gathering this data was to analyze trends and identify how prevalent adaptive technology is in high school math, the purpose for which it is used, and the teacher-perceived advantages and disadvantages to using adaptive tools.

An extensive literature review was completed prior to developing the survey instrument. The researcher studied the types of technology math teachers use, what empirical research has found in regard to the positive and negative impacts of technology, and the trends within the research. The survey was then designed to focus on adaptive technology, specifically. The study was aimed to identify if teachers are using adaptive technology, how often, and for what purpose. The survey achieved these goals and, therefore, can be considered to have a high level of content and construct validity.

The study was outlined, rationalized, and presented to Lynn University's Institutional Review Board (IRB). Once the study was approved by the IRB, a listserv request was submitted to the Florida Department of Education (FLDOE). The data that was requested included the names and email addresses for all high school math teachers in seven urban school districts during the 2018-2019 school year. The FLDOE responded with a list of 2,738 teachers and their contact information. Of that sample, there was no email address listed for 154 teachers. Another 107 email accounts came back as undeliverable. The resulting sample was 2,477 teachers.

The survey that participants completed was open for a total of three weeks. An introductory email (Appendix A) presented the study and encouraged teachers to participate. The researcher waited seven days to send the first follow-up email and another seven days for the final request. After 21 days, the survey was closed, and the data was prepared for analysis.

The survey was adaptive. There were questions built into the survey that would not apply to certain participants, based on their answers. Because of this, they skipped unnecessary questions and were routed directly to questions that applied. This design was intentional and was used to shorten the amount of time needed to complete the survey, thus reducing survey attrition.

Reliability and Validity

The researcher calculated a Cronbach's alpha coefficient (Table 1) on the data for all numerical and Likert scale questions. The test resulted in a coefficient of 0.888. Because this is considered a "good" rating (George & Mallery, 2003), the test suggests the survey instrument was reliable.

Table 1: Reliability Statistics for Electronic Survey on Adaptive Technology

Cronbach's Alpha	N of Items
0.888	9

The reliability and validity measures for this study suggest the survey is sound. However, there are threats to the external validity that must be mentioned. For one, the study was conducted in one state in the southeastern United States. That means that the results of the study may not represent the views of all teachers in the United States or the rest of the world. To mitigate this risk and improve generalizability, seven school districts and over 2,000 teachers were included in the sample.

Another threat to external validity is the result of purposeful sampling. Only high school math teachers were included in the sample. That means that elementary teachers and college professors were not included. Teachers who do not teach math were also excluded. This hurts the generalizability of the study because the populations that were not included in the sample could have different experiences and perceptions regarding adaptive technology.

As a result of the aforementioned threats, the researcher would consider this study to have low external validity.

Summary of Results

Descriptive Statistics

The researcher used descriptive statistics to identify trends within the data. A total of 97 teachers responded to the survey request. Four of the participants did not consent and were, therefore, not able to access or complete the survey. Of the 93 teachers who provided informed consent, 91 participants taught math during the 2018-2019 school year. 69.23% of the respondents reported that they use adaptive technology within their math curriculum. The average age of participants who use adaptive technology was 44.21 years and the average years of teaching experience was 13.72. Teachers who do not use adaptive technology were slightly older and more experienced with 44.96 years and 15.23 years, respectively.

Of the teachers who used adaptive technology, 30.16% of users reported using it within curriculum daily, 50.79% reported using it 1-3 times per week, and 19.05% reported using it 1-3 times per month or less. Teachers who did not use adaptive technology did not answer the remaining questions.

When asked what teachers use adaptive technology for, there were a variety of answers. 90.48% of the teachers who use adaptive technology reported that they use it for practice. This was followed by review (77.78%), formative assessment (58.73%), summative assessment (47.62%), and self-learning (46.03%). 28.57% of teachers reported using adaptive technology for group instruction, while one participant (1.59%) used the "explain" option to respond with "flipped classroom".

Teachers were also asked about learning gains and if using adaptive technology has positive or negative effects on students. When asked whether or not teachers observed learning gains when they used adaptive technology with students, 90.48% of teachers said "yes", they observed learning gains. 80.95% of teachers agree that adaptive technology has a positive impact on learning, and 76.19% reported that adaptive technology makes their jobs easier.

To counter, 9.52% of teachers claimed they have not observed learning gains from using adaptive technology. 7.94% of teachers report that adaptive technology does not have a positive impact on learning and 6.35% of teachers believe adaptive technology makes their jobs harder. 11.11% of teachers said adaptive technology does not have a positive or negative effect on student performance, while 17.46% of teachers said it does not make their job easier or harder.

Lastly, teachers were asked about which programs they use. The data suggests most teachers only use between 1-2 adaptive programs. The most popular programs include Khan Academy (66.67%) and IXL (42.86%), followed by Desmos (36.51%), Geogebra (22.22%), and SMART Learning Suite (15.87%).

Inferential Statistics

To find data regarding the first research question, *What is the frequency and purpose of adaptive technology being used in secondary math classrooms?*, the researcher used inferential statistics to identify correlations between data sets. A series of one-way ANOVA ($p<0.05$) and chi-square tests were used to measure relationships between variables. The researcher also completed a Tukey post-hoc analysis in regard to teaching experience and frequency of using adaptive technology within curriculum.

Whether or Not Teachers Use Adaptive Technology.

ANOVA testing was completed to measure relationships between dependent variables and independent variables. Table 2 shows an analysis of variance between age and whether or not teachers use adaptive technology. The results revealed no statistically significant difference among the two variables. This suggests there is no significant correlation between how old a teacher is and whether or not they use adaptive technology in high school math curriculum.

Table 2: ANOVA Test – Age and If Teachers Use Adaptive Technology.

```
                        Analysis of Variance
    Source              SS         df       MS             F     Prob > F
------------------------------------------------------------------------
Between groups      9.91641712      1    9.91641712      0.07      0.7869
 Within groups      10379.6785     77     134.80102
------------------------------------------------------------------------
    Total           10389.5949     78    133.199935

Bartlett's test for equal variances:  chi2(1) =   0.2295  Prob>chi2 = 0.632
```

Table 3 exhibits an ANOVA test regarding experience and whether or not teachers use adaptive technology. Again, the data revealed there is no statistically significant difference among the factors. This suggests there is no significant correlation between a teachers' years of experience and whether or not they use adaptive technology in high school math.

Table 3: ANOVA Test – Experience and If Teachers Use Adaptive Technology.

Source	SS	df	MS	F	Prob > F
Between groups	43.8056223	1	43.8056223	0.48	0.4882
Within groups	7864.00337	87	90.3908433		
Total	7907.80899	88	89.8614658		

Analysis of Variance

Bartlett's test for equal variances: chi2(1) = 1.0295 Prob>chi2 = 0.310

How Often Teachers Use Adaptive Technology Within Curriculum.

The researcher also sought to determine if age impacts how often teachers use adaptive technology within curriculum. Table 4 exhibits an ANOVA test regarding age and how often teachers use adaptive technology. The test revealed there was no statistically significant difference among these factors.

Table 4: ANOVA Test – Age and Frequency of Using Adaptive Technology.

Source	SS	df	MS	F	Prob > F
Between groups	660.169778	2	330.084889	2.77	0.0725
Within groups	5964.5472	50	119.290944		
Total	6624.71698	52	127.398403		

Analysis of Variance

Bartlett's test for equal variances: chi2(2) = 0.0581 Prob>chi2 = 0.971

ANOVA testing was also completed in regard to years of teaching experience and how often teachers use adaptive technology within curriculum (Table 5). The results of this ANOVA test revealed there was a statistically significant difference ($p<0.05$) among the factors.

Table 5: ANOVA Test – Experience and Frequency of Using Adaptive Technology.

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	782.424033	2	391.212017	4.38	0.0169
Within groups	5177.83826	58	89.2730735		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(2) = 7.0064 Prob>chi2 = 0.030

To confirm the results of the ANOVA test, the researcher used post-hoc testing (Table 6). A Tukey honestly significant difference test (HSD) was used because the number of comparisons being made. The test confirmed a pairwise statistical difference ($p<0.05$) among experience and frequency of adaptive technology use. The results of ANOVA and post-hoc testing suggested teachers with more experience are more likely to use adaptive technology daily, as opposed to 1-3 times per week.

Table 6: Post-Hoc Test – Frequency of Use.

	Number of Comparisons
Freq_num	3

Experience	Contrast	Std. Err.	Tukey [95% Conf.	Interval]
Freq_num				
1-3 week vs Daily	-7.730287	2.799891	-14.4649	-.9956707
1-3 month vs Daily	-1.638889	3.521227	-10.10854	6.830765
1-3 month vs 1-3 week	6.091398	3.212351	-1.635313	13.81811

Learning Gains.

Chi-square testing was completed to find data regarding the second research question, *What are the teacher-perceived advantages and disadvantages to using adaptive technology in* *math-based curriculum?* Teachers were asked if they observe learning gains after using adaptive technology. Table 7 exhibits the chi-square test between perceived learning gains and how often adaptive technology is used. The results suggested there is no statistically significant difference among these factors. It is important to note that there was a small number of participants who reported no learning gains. The low sample size of teachers who did not observe learning gains could have impacted the overall results of the test.

Table 7: Chi-Square Test – Learning Gains.

Notice_gain	Freq_num Daily	1-3 week	1-3 month	Total
0	2	1	3	6
1	17	31	9	57
Total	19	32	12	63

Pearson chi2(2) = 4.8782 Pr = 0.087

Impact on Teachers (Does adaptive technology make things easier or harder?).

A Likert scale question was used to ask teachers whether adaptive technology makes their job easier or harder. Table 8 shows the results of a chi-square test regarding how adaptive technology impacts teachers' jobs and how often they use adaptive technology. The test revealed no statistically significant difference among these factors, however, a small sample size for teachers who reported "neither", "harder", or "much harder" could have impacted the results of this test.

Table 8: Chi-Square Test – Impact on Teachers.

Easier	Daily	Freq_num 1-3 week	1-3 month	Total
A little harder	2	1	1	4
Easier	6	13	5	24
Much easier	9	14	1	24
Neither	2	4	5	11
Total	19	32	12	63

Pearson chi2(6) = 9.9151 Pr = 0.128

Positive Impact on Learning.

A Likert scale question was also used to ask teachers whether they believe adaptive technology has a positive or negative impact on student learning. Table 9 show the results of a chi-square test regarding how often teachers use adaptive technology and whether or not they think adaptive tools have a positive impact on learning. The test suggested there was no statistically significant difference among these factors, however, a small sample size of teachers who reported “neutral”, “disagree”, or “strongly disagree” could have impacted the results of this test.

Table 9: Chi-Square Test – Positive Impact on Learning.

Positive_lab	Daily	Freq_num 1-3 week	1-3 month	Total
Agree	17	26	8	51
Disagree	0	4	1	5
Neutral	2	2	3	7
Total	19	32	12	63

Pearson chi2(4) = 5.5930 Pr = 0.232

Adaptive Technology as an Effective Tool.

Teachers were asked whether they believe adaptive technology is an effective tool for learning. Chi-square testing regarding frequency of use and whether or not teachers believe adaptive technology is effective revealed no statistically significant difference among the factors, however, a small sample size of participants who reported “neutral”, “disagree”, or “strongly disagree” could have impacted the results of this test.

Table 10: Chi-Square Test – Effective Tool.

	Freq_num			
Effective	Daily	1-3 week	1-3 month	Total
Agree	16	25	10	51
Disagree	1	6	1	8
Neutral	2	1	1	4
Total	19	32	12	63

Pearson chi2(4) = 3.1155 Pr = 0.539

Purpose for Using Adaptive Technology.

The researcher also used a series of ANOVA tests ($p<0.05$) to find data regarding the purpose for which teachers use adaptive technology (Research Question #1). These were based on a survey question that allowed participants to select all the boxes that applied their classroom. Table 11 shows the results of an ANOVA test that included teaching experience and if teachers use adaptive technology as a tool for summative assessment. It revealed there was no statistically significant difference among the factors, which suggests the number of years of teaching experience a teacher has does not determine whether or not they use adaptive technology for summative assessment.

Table 11: ANOVA Test – Experience and Adaptive for Summative Assessment.

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	41.3528123	1	41.3528123	0.41	0.5233
Within groups	5918.90948	59	100.3205		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 0.0035 Prob>chi2 = 0.953

Table 12 exhibits the results of an ANOVA that included teaching experience and if teachers use adaptive technology as a tool for formative assessment. The test revealed there was no statistically significant difference among years of teaching experience and using adaptive technology for formative assessment.

Table 12: ANOVA Test – Experience and Adaptive for Formative Assessment.

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	251.930073	1	251.930073	2.60	0.1119
Within groups	5708.33222	59	96.7513936		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 1.3796 Prob>chi2 = 0.240

Table 13 shows the results of an ANOVA that included teaching experience and if teachers use adaptive technology as a tool for having students practice their skills. The test revealed there was no statistically significant among these factors.

Table 13: ANOVA Test – Experience and Adaptive for Practice.

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	13.901689	1	13.901689	0.14	0.7117
Within groups	5946.36061	59	100.785773		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 0.0407 Prob>chi2 = 0.840

Table 14 exhibits the results of an ANOVA that included teaching experience and if teachers use adaptive technology as a tool for teaching within group instruction. The results revealed there was no statistically significant difference among these factors.

Table 14: ANOVA Test – Experience and Adaptive for Group Instruction.

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.044380643	1	.044380643	0.00	0.9833
Within groups	5960.21791	59	101.020643		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 1.1043 Prob>chi2 = 0.293

Table 15 shows the results of an ANOVA that included teaching experience and if teachers use adaptive technology as a tool to help students learn on their own. The results revealed there was no statistically significant difference among these factors.

Table 15: ANOVA Test – Experience and Adaptive for Self-Learning.

Analysis of Variance					
Source	SS	df	MS	F	Prob > F
Between groups	65.563211	1	65.563211	0.66	0.4212
Within groups	5894.69908	59	99.910154		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 0.3155 Prob>chi2 = 0.574

Table 16 exhibits the results of an ANOVA that included teaching experience and if teachers use adaptive technology as a tool for reviewing content. In this case, the ANOVA revealed there was a statistically significant difference ($p<0.05$) among these factors.

Table 16: ANOVA Test – Experience and Adaptive for Review.

Analysis of Variance					
Source	SS	df	MS	F	Prob > F
Between groups	15.9051522	1	15.9051522	0.16	0.6926
Within groups	5944.35714	59	100.751816		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 4.0615 Prob>chi2 = 0.044

The researcher also compiled a table that outlined participant responses in relation to their experience. Table 17 shows the statistically significant difference among using adaptive technology for review and years of teaching experience is that teachers who were more experienced were more likely to use adaptive technology for review than teachers who had fewer years of teaching experience. Standard deviations for these fields are in parentheses.

Table 17: Purpose and Years of Teaching Experience

Purpose	Yes	No
Summative assessment	14.59 (9.95)	12.94 (10.07)
Formative assessment	12.03 (8.89)	16.16 (11.07)
Practice	13.56 (10.10)	15.17 (9.41)

Group instruction	13.76 (8.43)	13.70 (10.59)
Self-instruction	14.81 (10.53)	12.73 (9.49)
Review	14.00 (10.82)	12.79 (6.56)

After completing the ANOVA testing in regard to why teachers use adaptive tools within math curriculum, the researcher also completed chi-square testing regarding how often teachers use adaptive technology and for what purpose. Table 18 shows the results of a chi-square test that included frequency of use and summative assessment. The test revealed there was no statistically significant difference among how often teachers use adaptive technology and how many teachers reported using it for summative assessment.

Table 18: Chi-Square Test – Summative Assessment.

Purpose_summative	Daily	1-3 week	1-3 month	Total
0	10	14	9	33
1	9	18	3	30
Total	19	32	12	63

Pearson chi2(2) = 3.4175 Pr = 0.181

Table 19 exhibits the results of a chi-square test regarding frequency of use and using adaptive technology as a tool for formative assessment. The test revealed there was no statistically significant difference between these factors.

Table 19: Chi-Square Test – Formative Assessment.

Purpose_formative	Daily	1-3 week	1-3 month	Total
0	9	10	7	26
1	10	22	5	37
Total	19	32	12	63

Pearson chi2(2) = 3.0586 Pr = 0.217

Table 20 shows the results of a chi-square test regarding frequency of use and using adaptive technology as a tool for practicing skills. The test revealed there was no statistically significant difference between these factors.

Table 20: Chi-Square Test – Practice.

Purpose_practice	Freq_num Daily	1-3 week	1-3 month	Total
0	1	3	2	6
1	18	29	10	57
Total	19	32	12	63

Pearson chi2(2) = 1.1116 Pr = 0.574

Table 21 exhibits the results of a chi-square test regarding frequency of use and using adaptive technology as a tool for facilitating group instruction. The test revealed there was no statistically significant difference between these factors.

Table 21: Chi-Square Test – Group Instruction.

Purpose_groupinst	Freq_num Daily	1-3 week	1-3 month	Total
0	12	23	10	45
1	7	9	2	18
Total	19	32	12	63

Pearson chi2(2) = 1.4733 Pr = 0.479

Table 22 shows the results of a chi-square test regarding frequency of use and using adaptive technology as a tool for self-learning. The test revealed there was no statistically significant difference between these factors.

Table 22: Chi-Square Test – Self-Learning.

Purpose_self	Daily	1-3 week	1-3 month	Total
0	9	17	8	34
1	10	15	4	29
Total	19	32	12	63

Freq_num

Pearson chi2(2) = 1.1212 Pr = 0.571

Table 23 exhibits the results of a chi-square test regarding frequency of use and using adaptive technology as a tool for reviewing content. The test revealed there was no statistically significant difference between these factors.

Table 23: Chi-Square Test – Review.

Purpose_review	Daily	1-3 week	1-3 month	Total
0	2	8	4	14
1	17	24	8	49
Total	19	32	12	63

Freq_num

Pearson chi2(2) = 2.5038 Pr = 0.286

Different Adaptive Programs.

The remaining tests were conducted to gain data on which adaptive programs high school math teachers used in the 2018-2019 schoolyear, and whether there were correlations between experience or frequency of use and the programs teachers used. There were five programs that more than one teacher reported using, including, Khan Academy, IXL, Desmos, GeoGebra, and Smart Learning Suite.

ANOVA testing was completed to find data regarding years of teaching experience and the programs that teachers used. Table 24 outlines the results of an ANOVA test that included experience and teachers who reported using Khan Academy. The results of the test indicated there was no statistically significant difference between these factors. This suggests there is no significant correlation between experience and which program as teacher chooses to use.

Table 24: ANOVA Test – Experience and Khan Academy.

Source	SS	df	MS	F	Prob > F
Between groups	82.2161641	1	82.2161641	0.83	0.3674
Within groups	5878.04613	59	99.6279005		
Total	5960.2623	60	99.3377049		

Analysis of Variance. Bartlett's test for equal variances: chi2(1) = 0.7194 Prob>chi2 = 0.396

Table 25 exhibits the results of an ANOVA that included teaching experience and teachers who reported using IXL. The results indicated there was a statistically significant difference ($p<0.05$) among these factors.

Table 25: ANOVA Test – Experience and IXL.

Source	SS	df	MS	F	Prob > F
Between groups	219.736196	1	219.736196	2.26	0.1382
Within groups	5740.5261	59	97.2970525		
Total	5960.2623	60	99.3377049		

Analysis of Variance. Bartlett's test for equal variances: chi2(1) = 5.4296 Prob>chi2 = 0.020

Because there was a statistically significant difference, the researcher compiled a table to exhibit the adaptive programs teachers used in relation to their experience. Table 26 shows the statistically significant difference among program used and years of teaching experience is that teachers who used IXL had less teaching experience. Standard deviations for these fields are in parentheses.

Table 27: Program and Years of Teaching Experience

Program	Yes	No
SMART	17.6 (11.34)	12.96 (9.62)
Khan	14.56 (10.51)	12.12 (8.87)
IXL	11.52 (7.24)	15.36 (11.41)
Desmos	12.95 (10.06)	14.15 (10.02)
GeoGebra	13.89 (10.40)	13.67 (9.95)

Table 27 exhibits the results of an ANOVA that included teaching experience and teachers who reported using Desmos. The results indicated there was no statistically significant difference among these factors.

Table 27: ANOVA Test – Experience and Desmos.

```
                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      20.2308266      1   20.2308266      0.20     0.6556
 Within groups      5940.03147     59   100.678499
------------------------------------------------------------------------
    Total            5960.2623     60   99.3377049

Bartlett's test for equal variances:  chi2(1) =   0.0004  Prob>chi2 = 0.984
```

Table 28 exhibits the results of an ANOVA that included teaching experience and teachers who reported using GeoGebra. The results revealed there was no statistically significant difference among these factors.

Table 28: ANOVA Test – Experience and GeoGebra.

```
                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      .534711495      1   .534711495      0.01     0.9422
 Within groups      5959.72758     59   101.012332
------------------------------------------------------------------------
    Total            5960.2623     60   99.3377049

Bartlett's test for equal variances:  chi2(1) =   0.0393  Prob>chi2 = 0.843
```

Table 29 exhibits the results of an ANOVA that included teaching experience and teachers who reported using SMART Learning Suite. The results revealed there was no statistically significant difference among these factors.

Table 29: ANOVA Test – Experience and SMART Suite.

Analysis of Variance					
Source	SS	df	MS	F	Prob > F
Between groups	179.940726	1	179.940726	1.84	0.1805
Within groups	5780.32157	59	97.971552		
Total	5960.2623	60	99.3377049		

Bartlett's test for equal variances: chi2(1) = 0.4283 Prob>chi2 = 0.513

After the ANOVA testing regarding the adaptive programs teachers used, the researcher conducted chi-square testing in regard to frequency of use and which adaptive programs teachers used during the 2018-2019 schoolyear. Table 30 shows the chi-square test that included frequency of use and Khan Academy. The test indicates there is no statistically significant difference between these factors.

Table 30: Chi-Square Test – Khan Academy.

Program_Khan	Freq_num Daily	1-3 week	1-3 month	Total
0	7	10	4	21
1	12	22	8	42
Total	19	32	12	63

Pearson chi2(2) = 0.1678 Pr = 0.920

Table 31 exhibits the results of a chi-square test regarding frequency of use and IXL. The test revealed there was no statistically significant difference between these factors.

Table 31: Chi-Square Test – IXL.

Program_IXL	Freq_num Daily	1-3 week	1-3 month	Total
0	14	16	6	36
1	5	16	6	27
Total	19	32	12	63

Pearson chi2(2) = 3.0395 Pr = 0.219

Table 32 exhibits the results of a chi-square test regarding frequency of use and Desmos. The test revealed there was no statistically significant difference between these factors.

Table 32: Chi-Square Test – Desmos.

Program_Desmos	Freq_num Daily	1-3 week	1-3 month	Total
0	14	18	8	40
1	5	14	4	23
Total	19	32	12	63

Pearson chi2(2) = 1.6277 Pr = 0.443

Table 33 exhibits the results of a chi-square test regarding frequency of use and GeoGebra. The test revealed there was no statistically significant difference between these factors.

Table 33: Chi-Square Test – GeoGebra.

Program_GeoGebra	Freq_num Daily	1-3 week	1-3 month	Total
0	16	24	9	49
1	3	8	3	14
Total	19	32	12	63

Pearson chi2(2) = 0.6513 Pr = 0.722

Table 34 exhibits the results of a chi-square test regarding frequency of use and SMART Suite. The test revealed there was no statistically significant difference between these factors.

Table 34: Chi-Square Test – SMART Suite.

Program_SMART	Freq_num Daily	1-3 week	1-3 month	Total
0	16	27	10	53
1	3	5	2	10
Total	19	32	12	63

Pearson chi2(2) = 0.0072 Pr = 0.996

Qualitative Analysis

Inferential statistics provided data on the first two research questions. The researcher also requested that teachers answer qualitative questions to add to this data and provide insight into Research Question #3, *How can existing adaptive technology be improved as an educational tool?* They were asked about their concerns and criticisms about adaptive technology, the advantages of adaptive programs, and how they think adaptive tools could be improved. Answers to these questions were classified and coded, and themes emerged within the responses.

The most commonly referenced concerns were in regard to the content (30.77% of responses) included within adaptive tools. Teachers expressed the need for tools to align with state standards. They also said that many of the programs need more questions, better explanations, and more options to review content. Of the participants who cited criticisms, 23.08% referenced specific limitations to technology, such as problems with logging in, having difficulty monitoring students in real-time, and not being able to control if students cheat. 23.08% also referenced costs and access, including the need to have computers in class, the cost of programs like IXL that are subscription-based, and lack of internet access outside of school.

Others (15.38%) said adaptive tools make grading more difficult because it is time consuming and the tools do not sync with learning management software. A small portion of teachers (7.69%) said adaptive technology is distracting and leads to worsened student engagement.

Despite the challenges, many of the participants also expressed excitement about adaptive technology. The most commonly cited advantage was the adaptive questioning on these programs (30.43% of responses). Teachers said they prefer adaptive programs because they have large question banks, scaffold the content, and provide real-time feedback. 15.22% of teachers cited explanation videos as effective remediation tools. 13.04% of respondents used the corresponding question to mention specific tools on the program of their choice. Less mentioned advantages included having more instructional options (13.04%), usability (8.70%), and content alignment (6.52%).

The last question of the survey asked teachers to provide specific recommendations for how existing tools could be improved. Most suggestions (26.98%) were in regard to ease of use. They included things like making programs more user-friendly or making easier to link to learning management software. The participants also requested that these programs make collaboration easier and improve accessibility for students when they are not on campus.

The next biggest recommendation was to add more tools to adaptive programs. Teachers requested more videos, more games, interactive activities, and the ability to create better reviews and assessments. One teacher recommended more teacher interaction in whole-group and small-group instruction. This participant said existing technology is “too much ‘you do’ material and curriculum resources” and added that there is “not enough relevant training that is usable or easy to use in classroom”.

Other recommendations included improving the actual content/questions (17.19%), better content alignment (11.11%), improve progress tracking (11.11%), more buy in from teachers and students (7.94%), and better security (1.59%).

CHAPTER V

Introduction

The purpose of this study was to research adaptive technology and its use in high school mathematics. Teachers were asked to provide information about the classes they teach, how often they use adaptive technology, and their perceptions regarding adaptive curriculum. They were also asked to explain the impacts of adaptive technology on students and learning. Their insights provided a great deal of information regarding the positive and negative implications for using adaptive technology to plan and deliver content.

The researcher completed and extensive literature review. In it, there were a number of themes that became apparent. The first theme that emerged was that much of the existing research was based on product or program reviews. For example, there were studies that evaluated the effectiveness of one-to-one computer policies (Steiner, 2017). There were studies on tablet computers and how they improve students' ability to access materials from outside of school (Huda et al., 2019). There were also studies on specific software programs (Pearson, 2016). All too often, these studies omitted adaptive technology and focused on technology as a whole. The bulk of any literature on adaptive programs like Khan Academy and IXL were non-empirical or commissioned by the companies who own/sell the products. This type of research must be taken at face value. The researcher does not doubt the findings of these studies; however, the goal was to research this topic without the bias or financial incentives involved in prior research.

The next theme in the literature review was comparisons between old technology and new technology. There were many studies (Grover, 2016) that compared books to e-books. Studies highlighted how existing/printed materials that were digitized led to different outcome (i.e. textbooks becoming electronic can be more cost-effective for schools and students, etc.). These studies are important because they explain how technology has evolved and changed the landscape of education. However, they do not address adaptive technology because it is perceived as 'new' and 'cutting edge' even though it has been around since the 1970s (Kingsbury, Freeman, & Nesterak, 2014).

One of the most prominent themes in the literature review was assessment. This is not surprising because education is a field in which accountability and data is critical (Ozga, 2016). This dissertation was designed to explore what adaptive technology means outside of just testing. Testing is important because it allows teachers to measure student gains. Curriculum planning and instruction are also very important. It seems that prior research had focused much more attention on testing than the other components of education.

Lastly, much research has been devoted to teacher and student perceptions of technology. This dissertation also asked teachers to share their opinions and experiences with adaptive technology. This allowed the researcher to develop a deeper understanding of adaptive technology and its usefulness to teachers and students.

In Regard to Adaptive Technology

The literature review revealed that it is clear that adaptive technology is an under-researched field of education technology. This created an opportunity for the researcher to study the topic in-depth to provide information and recommendations for how it can improve. If technology is the 'way of the future', it is crucial that teachers and administrators understand it. The researcher believes this goal has been accomplished through the thoughtful responses of teachers who use adaptive technology in their classrooms. These participants provided a great deal of insight and their contributions are meaningful.

Summary of Findings

Data collection provided sufficient information regarding adaptive technology and how math teachers use it in the classroom. Teachers expressed an overwhelming amount of support for adaptive technology as a whole. 69.23% of teachers reported using adaptive technology. Of that population, 30.16% of users reported using it daily, 50.79% reported using it 1-3 times per week, and just 19.05% reported 1-3 times per month or less. 66.40% of teachers found that it makes their job ‘much easier’ or ‘easier’. More importantly, 80.95% of teachers found that adaptive technology has a positive impact on learning. Commonly-cited benefits included real-time feedback, higher participation, and improved student engagement. Teachers reported using adaptive technology for practice (90.48%), followed by review (77.78%), summative assessment (47.62%), and formative assessment (58.73%). The most-commonly used programs included Khan Academy (66.67%), IXL (42.86%), and Desmos (36.51%).

Reliability and Validity

The results of the data analysis are considered both reliable (responses were consistent) and valid (the electronic survey provided and accurate measure of what it was supposed to). These were verified using a number of statistical analyses, including, one-way ANOVA testing, chi-square goodness of fit tests, and Cronbach’s alpha. Most of the ANOVA testing ($p<0.05$) revealed no statistical significance between variables. The exceptions to this were that teachers with more experience were more inclined to use adaptive technology daily and for review but less inclined to use IXL.com as their program of choice. Chi-square testing revealed no statistical differences. Cronbach’s alpha (0.888) was found to be well-within a ‘good’ rating (George & Mallery, 2003).

Implications

Many of the recommendations from teachers were based on improving the adaptive programs that are already being used in classrooms. Teachers recommended adding tools, such as, easier ways to differentiate instruction, ability to create study guides, and more activities that are fun and engaging. With these improvements, it seems integrating adaptive technology will become smoother and more seamless. Teachers already use adaptive programs but have expressed a desire for more 'buy in' to technology as a whole. Participants said administrators and students must also understand the importance of using computers and adaptive technology for it to truly change how students learn. Many teachers also said that placing more of a focus on aligning content to state standards is needed.

It is important to note that even with explanation, there is still some confusion regarding what adaptive technology is or is not. There were a few teachers who mentioned using specific computer programs, like Algebra Nation, that are not adaptive. Adaptive programs are not adaptive because they are on the computer; they are adaptive because they differentiate based on student input. It is important to differentiate between all technology and adaptive technology.

Conclusions

Research Question #1

The first research question was "What is the frequency and purpose of adaptive technology being used in high school math classrooms?". This question was answered through a series of multiple choice, Likert-scale, and select all questions. Of the teachers who use adaptive technology in curriculum, 90.48% of teachers reported using it to help students practice the skills they learned in class. Another 77.78% of teachers use it for review, while 47.62% of teachers use it for summative assessment and 58.73% use it for formative assessment.

Of the teachers who responded that they use adaptive technology, 30.16% of users reported using it daily and another 50.79% reported using it 1-3 times per week. Only 19.05% reported 1-3 times per month or less. These statistics indicate adaptive technology is commonly-used in high school math curriculum. This agrees with past research, including David Nagel's report (2018) that suggested teachers are in support of technology and frequently use smart devices as a tool for learning.

The data suggests that adaptive technology is mostly being used for assessment, review, and practice. It is occasionally used for self-learning or collaboration, but seldomly used for whole- or small-group instruction. Only 28.57% teacher reported using adaptive instruction for group instruction. This coincided with existing research that found a "lack of evidence-based instructional design, transparency in many of the models and algorithms used to provide adaptive technology" (Rosen et al., 2018). This creates an opportunity for educators to reevaluate curriculum design and potentially place more focus on adaptive instruction.

Research Question #2

The second research question was "What are the teacher-perceived advantages and disadvantages to using adaptive technology in math-based curriculum?". This question was addressed in open-ended and select all questions. 63.16% of the teachers who reported learning gains claimed that adaptive technology helped address student differences and learning disabilities. Another 61.40% of teachers said adaptive technology improves the learning experience and 59.65% of teachers said students who use adaptive technology exhibit higher content retention. Teachers also cited improvement in motivation, engagement, and access to materials outside of class. These statistics agree with previous research that suggested there are positive impacts from using technology (Francis, 2017; Forsyth, Kimble, Birch, Deel, & Brauer,

2016) and dispute research that has branded technology as a distraction (McCoy, 2013; Sana, Weston, and Cepeda, 2013).

There were not a lot of teachers (7.94%) who said adaptive technology does not have a positive impact on learning. The biggest concerns from these teachers included giving students an excuse (i.e. “I could not log in.” or “I do not have a computer at home.”, etc.) and cheating. These concerns are valid, however, it seems both would exist regardless of whether technology is involved or not.

Research Question #3

The final research question was “How can adaptive technology be improved as an educational tool?”. This question was answered through an open-ended response question that concluded the survey. Participants provided meaningful feedback that fell into a number of categories, including, improving current programs, adding content and tools, doing a better job of aligning to state standards, and making adaptive technology easier to track individual students. Surprisingly, 7.9% of teachers also commented on ‘buy in’. They claimed that school culture plays a major part in whether technology implementation is successful or not. If school administration does not ‘sell’ adaptive technology, neither will the math department. In turn, teachers do not buy in and neither do students. Therefore, it seems that school administration needs to be forward-thinking for adaptive technology to be effective.

Recommendations

The researcher offers several suggestions for future research and improvements to current programs. These are based on the data from the survey and the recommendations are meant to improve how educators integrate adaptive technology into math curriculum. The recommendations are intended to create a seamless transition that improves classroom efficiency and improves student learning. The suggestions are proposed in an effort to improve best practices to improved student learning.

Future Research

As outlined in Chapters I and II, it is difficult to replicate studies that pertain to computers because of the evolutionary nature of technology. It would not be sufficient to advise future researchers to replicate this study or complete longitudinal research using the methodology from this dissertation. Rather, the researcher challenges future researchers to take a holistic approach to studying technology. Look at the implications of adaptive (and other) technology from the angles that have not been addressed in formal research. There is more to education than assessment. It is important to plan research to also encompasses curriculum developments and instruction. This will assure that data gleaned from the research is meaningful and valid.

For this specific study, the researcher would recommend expanding the sample to include teachers from other disciplines, educational settings, and geographic locations. For example, teachers in the Midwest or West Coat of the Unites States may offer different ideas than teachers in the Southeastern United States. English teachers may have different experiences than math teachers; certainly, elective teachers would have different uses for adaptive technology than core-content-area educators. College professors would have different input than middle and high school teachers. Expanding the scope of the study would only improve its generalizability and leading information-rich data.

Improvements to Technology

Participants made several recommendations for improvements to technology. Most of these recommendations pertained to improving the framework that currently exists. Some teachers recommended adding tools, including, the option to create study guides, adding more games, and improving videos/explanations of the content. Others recommended programs take more of a focus on aligning to state content standards. A lot of teachers would like to be able to link the grades in adaptive programs to their grading platform. All of these improvements would make the connection between technology and the classroom more seamless, which would benefit teachers and students.

One participant eluded to the researcher's biggest recommendation to improve current technology. The participant said adaptive technology needs to increase the amount of teacher interaction with students, as opposed to having only "you do" exercises. The participant also said there is "not enough relevant training that is usable or easy to use with students". The researcher would take this a step further by saying that adaptive technology is simply not being used in group instruction enough. Only 28.57% of the respondents reported using adaptive technology within group instruction. If 58.73% of teachers are using adaptive technology for formative assessment and 47.62% of teachers are using it for summative assessment, why are only 28.57% using it for group instruction (teaching lessons in class)? The answer to that question is that there are not a whole lot of adaptive tools that are designed to be used within instruction. The researcher recommends that developers keep this in mind when designing new adaptive programs.

Final Thoughts

The majority of participants from this study agree that educational technology can be useful within high school mathematics. They outlined the inherent benefits and challenges to using new tools and adaptive technology. They also explained how often they use adaptive technology and for what purpose. Nearly 80% of teachers reported using adaptive technology at least one time per week for various functions, including, adaptive and summative assessment, reinforcing class concepts, reviewing material, and explaining difficult concepts.

Given the frequency and use of adaptive technology, the researcher argues that adaptive technology requires further consideration when it comes to research, planning, and instruction. Students should learn in the same manner in which they are tested. More than half of the participants who said they use adaptive technology reported using it for testing but only 28.57% of them use it for teaching. This suggests there is a gap between curriculum and assessment in adaptive education. Future research is needed to address this gap and improve curriculum that incorporates educational technology.

The data suggests it is a group effort; administrators, teachers, and students all must “buy in” to adaptive technology for it to become a standard in education. There is still much work to be done. The researcher hopes that with these recommendations, adaptive technology will become a more effective and widely used tool for educators. The purpose of the study was to improve learning. Participants expressed conviction that adaptive technology is valuable and offered specific recommendations for how to improve existing tools. The foundation has been set to use adaptive technology to improve the learning landscape. Educators must continue to evaluate how technology impacts their students. Adaptive technology must continue improving and serve its purpose as a tool for learning, assessment, and instruction.

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Appendix A: Explanatory Email and Invitation to Participate

Good afternoon,

My name is Ryan Benjamin. I am a secondary math teacher and doctoral candidate in Lynn University's College of Education. You are receiving this email because I believe you can help further my research into adaptive technology in secondary education.

Adaptive technology refers to computer programs and smart device applications ("apps") that change based on user inputs. The outputs for these programs change based on how students answer questions, and when teachers manipulate inputs to demonstrate how changes to mathematical formulas/variables impact the final answer. Commonly used adaptive programs include the SMART Technologies Learning Suite, Khan Academy, IXL, and Aleks, among others.

The title of my dissertation is "Perceptions of Adaptive Technology Usage in Secondary Math Classrooms". My goal is to learn more about how teachers use adaptive technology to plan, instruct, and assess student learning. The purpose of this study is to improve student learning and make it easier for teachers to use adaptive technology for planning and instruction. I believe the insights and experiences from my fellow teachers is invaluable, and I would be extremely grateful to have your participation in the survey.

The survey is adaptive; it was designed to be efficient and meaningful (I do not want to waste your time with questions that do not pertain to you). The survey will take roughly 15 minutes to complete and participation is voluntary. Please feel free to contact me with any questions regarding the survey. I can be reached through my university email at rbenjamin@email.lynn.edu. I look forward to reading your replies and appreciate any insight you can offer. Please click the link below to continue to the survey.

Best regards,

Ryan Benjamin

Appendix B: Google Forms Online Informed Consent

Informed Consent

INTRODUCTION:

You are invited to participate in a web-based survey on adaptive technology. Adaptive technology refers to computer software and applications that adapt based on the user's inputs. An example of this is math programs that get easier or harder based on students' answers. This is a research project being conducted by Ryan Benjamin, a secondary math teacher and doctoral candidate at Lynn University. The survey should take approximately 15 minutes to complete and will provide the researcher with valuable insight into how adaptive technology is being used in math classrooms.

PARTICIPATION:

Participation in this survey is completely voluntary. If you feel uncomfortable by any of the questions or wish to discontinue the survey, please click the "X" at the top of the page to close the survey. Non-participation will not have any sort of negative consequences to you, personally. Your insights are valued and will be used only for the purpose of furthering research into educational technology.

BENEFITS:

You will not receive monetary or tangible gifts for participating in this research study. However, your responses will be used to help educators learn more about adaptive technology in math curriculum. Your insights will help the researcher pinpoint the strengths and weaknesses that exist within adaptive technology to improve instructional practice and benefit student learning.

RISKS:

There is no personal risk to participating in the study other than the time it takes to complete. All responses are confidential and identifying characteristics (such as school, classes taught, etc.) will not be linked to individual responses. The survey should take approximately 15 minutes to complete and submit; it must be completed in one sitting. Please return at a later date if you are unable to dedicate roughly 15 minutes to complete the survey. If you feel uncomfortable by any of the questions, please discontinue the survey by using the "X" button at the top of the browser.

CONFIDENTIALITY:

Answers will be submitted through Google Forms and stored on Google Drive. The survey is anonymous; identifying characteristics will not be linked to individual input, and email addresses will only be used to ensure the survey is not submitted more than once for each participant. Survey responses will be store on for a period of 5 years, after which point, they will be deleted from electronic record.

*Please note that data may be reviewed by Lynn University's Institutional Review Board (IRB) for regulatory and research oversight purposes.

CONTACT:

If you have any questions about the research project, please contact Ryan Benjamin at rbenjamin@email.lynn.edu. He would be happy to answer any questions about the study or direct you to the Lynn University personnel responsible for overseeing the study.

ELECTRONIC CONSENT:

I have read the introduction and understand that participation in the study is voluntary. I have been provided with the researcher's contact email and understand that I can contact him with any questions regarding the study. By clicking "Yes", I consent to participating and will answer questions to the best of my ability. By clicking "No", I acknowledge that I will not participate in the study.

Appendix C: Google Forms Online Survey Questions

The following questions will be accessed via Google Forms. Some of the answers will alter the sequence or questions that follow. These adaptations and important notes will be outlined in *italics* font.

TEACHER INFORMATION

1. **Are you a high school math teacher in your school district?** *(Required question)*
   Yes *(Survey will proceed to Question 2)*

   No *(Survey will submit if the user submits a response of "No")*

2. **Which of the following math classes do you teach? Please select all.**

	Regular	Honors	Intensive/Block Period	AICE or AP
Liberal Arts Math I				
Algebra I				
Liberal Arts Math II (All sections)				
Geometry				
College Readiness Math				
Algebra II				
Advanced Math Topics				
Trigonometry				
Pre-Calculus				
Statistics				
AICE Math				
Calculus (AB or BC)				

3. **How many years of experience do you have as a classroom teacher?**

4. **What is your age?**

ADAPTIVE TECHNOLOGY IN YOUR CLASSROOM

Please read the description below

Adaptive technology refers to any computer program or application ("app") that changes based on how the user interacts with the program. This could mean that questions get easier or harder based on students' answers. It could also refer to software you use to demonstrate how changes in inputs affect the outputs (think charts and graphs). Commonly-used adaptive programs include Khan Academy, IXL, the SMART Learning Suite, and Aleks, among others.

5. Do you use adaptive technology for your math classes (planning curriculum, teaching, reinforcing learning, etc.)?

Yes *(Survey proceeds to Question 6)*

No *(Survey will submit if the user submits a response of "No".)*

6. How often would you say you use adaptive software with your math students?

Every day

2-3 times per week

Once per week

2-3 times per month

Once per month

Less than one time per month

7. What do you use adaptive technology for? Please select all and explain if you choose "other".

Formative assessment (checking progress - can be during class or daily)

Summative assessment (to see how much students learned - tests and assignments)

For students to practice what they learned in class

Within group instruction

For students to learn topics on their own

As a tool for students to review class topics

Other:

8. Please select all the adaptive programs you use with students.

SMART Learning Suite or SMART Notebook

Khan Academy

IXL

Desmos

GeoGebra

Aleks

Other:

If you chose "Other" for the previous question, please list the adaptive program(s) you use that are not on the list. Otherwise, please type "NA" (not applicable) or leave this box blank.

PERCEPTIONS OF ADAPTIVE TECHNOLOGY

9. Do you agree or disagree that adaptive technology is an effective teaching or learning tool?

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

10. Do you agree or disagree that your students enjoy using adaptive programs for math?

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

11. Have you noticed any specific learning gains from your students when they use adaptive programs? Academic gains include benefits like increased motivation, better understanding of concepts, or higher completion of assignments.

Yes *(Survey proceeds to "LEARNING GAINS")*

No *(Survey skips to Question 12)*

LEARNING GAINS

Which of the following academic gains have you observed when students use adaptive technology? Please select all and explain if you choose "other".

Increase in motivation

Higher engagement and participation

Improved knowledge retention

A better learning experience for students

Better access to materials inside or outside of class

Higher classroom morale

Easier for students with disabilities or language differences

Other:

PERCEPTIONS OF ADAPTIVE TECHNOLOGY

12. Do you agree or disagree that adaptive technology makes a positive impact on student learning?

Strongly disagree

Disagree

Neutral

Agree

Strongly agree

13. Do you think adaptive technology makes your job easier or harder? Please consider planning, grading, and instruction.

Much harder *(Survey proceeds to "ADAPTIVE TECHNOLOGY IS MORE DIFFICULT")*

A little harder *(Survey proceeds to "ADAPTIVE TECHNOLOGY IS MORE DIFFICULT")*

Neither *(Survey skips to Question 14)*

Easier *(Survey skips to "ADAPTIVE TECHNOLOGY IS EASIER")*

Much easier *(Survey skips to "ADAPTIVE TECHNOLOGY IS EASIER")*

ADAPTIVE TECHNOLOGY IS MORE DIFFICULT

Please select all of the following reasons that adaptive technology makes your job more difficult. Please explain if you choose "Other".

It is too difficult to use

I do not have access to computers often/every day

It takes too long to plan lessons

It is distracting and wastes instructional time

It takes too long for students to log in and work in class

It does not allow me to control the content or sequence of questions/assignments

I have not noticed any learning gains from using adaptive technology

It makes grading more difficult

Computer and internet problems prohibit students from achieving class goals

It is difficult to get approval or funding from administration

The benefits of using adaptive technology are not worth the effort it takes to implement

Other:

(Survey skips to Question 14)

ADAPTIVE TECHNOLOGY IS EASIER

Please select all of the following reasons that adaptive technology makes your job easier. Please explain if you choose "Other".

It is efficient

It is easy for students to access from home

It is more fun for students and they take an active role in their learning

I can enter grades and check progress easier

It reduces the amount of time I need to plan lessons

I do not have to make as many copies

Students are more engaged in class

Adaptive technology makes it easier to teach difficult concepts

Other:

(Survey proceeds to Question 14)

PERCEPTIONS AND OPEN-ENDED QUESTIONS

For this section, please feel free to write as much or as little as you would like. Summarization and bullet points are acceptable ways to answer these questions; full sentences are not mandatory. Please leave blank or type "NA" (not applicable) if any of these questions do not apply.

14. Do you have any major criticisms of adaptive technology? If so, what are they?

15. Are there specific components of adaptive technology that you love or cannot imagine not having? If so, what are they?

16. Do you think adaptive technology is used more for assessment (testing) than planning lessons or teaching concepts?

Yes

No

17. Do you think adaptive technology could be improved to offer more instructional resources for planning and delivering content?

Yes

No

YOUR INPUT

Please feel free to write as much or as little as you would like.

18. How do you think adaptive technology could be improved to help students learn or teachers plan, instruct, or assess students? Please feel free to write as much or as little as you would like.