2020

MyMathLab and Nontraditional Students' Attitudes Toward Technology in Mathematics

Lisa Sherry Olsen
Walden University

Walden University

College of Education

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Lisa S. Olsen

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Review Committee
Dr. Amy Adcock, Committee Chairperson, Education Faculty
Dr. Michael Marrapodi, Committee Member, Education Faculty
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Sue Subocz, Ph.D.

Walden University
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Abstract

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MEd, Grand Canyon University, 2007

BS, Rowan University, 1991

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Learning Instruction and Innovation

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Abstract

Nontraditional students, who often do not have a background in computer usage, are a growing population in higher education. These students are often ill prepared for success in mathematics courses due to attitudes toward mathematics and the use of technology in the learning process. Researchers have looked into the needs of nontraditional students in academic settings but have not focused on nontraditional students' use of adaptive learning components, such as Pearson's MyMathLab (MML), in blended classrooms. The purpose of this sequential explanatory mixed-methods study was to explore the difference in nontraditional students' attitudes toward math and the use of technology depending on the frequency of using MML. This study involved 30 participants between the ages of 27 and 54 years who attended blended learning math classes at a Philadelphia, PA area community college. Dienes's theory of learning mathematics was used for the conceptual framework for this study, as it stresses direct interaction through perceptual variability, mathematical variability, and constructivity. Quantitative analysis was used to examine nontraditional students' responses on the Attitudes Toward Technology in Mathematics Learning Questionnaire. No significant differences were found nontraditional students' attitudes toward math and the use of technology depending on the frequency of using MML. Four professors and 8 students were interviewed to gain knowledge on their attitudes toward technology and mathematics. Open coding was used to develop themes and patterns. Identified themes included the use of tools, support outside the classroom, and pace of learning. This study may support positive social change by providing ways to combat stressors and intimidation and thus improve students' success in the classroom.

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Dedication

I dedicate my dissertation to my family and close friends. Thank you to my loving, supportive, and caring parents, Sherry and Warren. Mom, you always wanted a doctor in the family; it may be the wrong kind of doctor, as you jokingly said, but there is finally one in the family. Dad, thank you for all the support and encouragement; I can now be #1 Dr. Daughter. Zach and Elishah, your moral support as well as getting things done at home helped make this possible. Knowing you two understood how important this was to me, and your support, helped more than you know. Tony, Michele, Sharon, and Shelly, thank you for being so supportive and having faith in me, even when mine faltered. Now I have more time to spend with you all!

Acknowledgments

I would like to thank several groups of people that have helped me get through this long and interesting journey. Each group has been a help in their own way, but without all of them together, I'm not sure if I would have gotten through it.

First, I would like to sincerely thank my committee for their continuous support in completing my PhD. Dr. Adcock, thank you for keeping me on track, helping me stay focused, and answering my many, often rapid-fire, emails. Dr. Marripodi, thank you for your patience and immense knowledge.

Thank you to all of my family for their support. Thank you, Zach and Elishah, for understanding when I was hiding in my office completing research or writing. Thank you for picking up the slack around the house, or just keeping the normal craziness of our home to a minimum. Thank you, Mom and Dad, for being so supportive. I appreciate you listening to me complain about the work and sometimes threatening to quit. You allowed me to voice my frustrations but made sure I always remembered that quitting isn't an option, that I can do this. Thank you for having faith in me when I didn't.

To my friends, thank you for putting up with me! I appreciate you understanding when I backed out of things at the last minute in order to get work done. I appreciate you being my cheerleaders when I got annoyed with all of the work on top of the rest of my crazy life. And yes, Sharon, work at the beach is not as bad as work at home! Thank you, your love and support have been immeasurable.

And last but certainly not least, thank you, Tony, for all of your input, support, "encouragement," and love.

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Chapter 1: Introduction to the Study

Background

For nontraditional students, technology in the classroom may not be something that they are used to or have frequently used (Henson, 2014). *Nontraditional students* are defined as students who are older than 25 years of age while attending college for the first time. Many of these students have time constraints due to family and work obligations (National Center for Education Statistics, 2014). Many nontraditional students may not have used computers as tools in their classrooms before and may not have been permitted to use calculators in their math classes (Henson, 2014). However, the use of technology in math classrooms at the college level is beginning to be commonplace (Carter, Greenberg, & Walker, 2017). Technologies used in this environment range from graphing calculators, to computer programs that perform mathematical equations, to entire digital courses that provide all learning tools and applications for a math class (Venkatesh, Croteau, & Rabah, 2014).

MyMathLab (MML) is an online computer package from Pearson Higher Education that engages students through personalized, stimulating, and measurable learning tools such as e-books, adaptive homework, tests, step-by-step guidance, videos/animations, and discussion tools (Pearson, 2015). MML provides students with online tools that allow them to acquire new math skills in a multitude of ways, all supporting the same learning goal. The MML platform has taken another step in using innovative teaching and learning processes and now uses Knewton Adaptive Learning in order to monitor students' progress and make recommendations based on student performance, thereby providing an adaptive and personalized learning environment (Pearson, 2015). Knewton Adaptive Learning works like a personal tutor, using individualized instruction, assessment, feedback, and remediation for students as they work on the topics assigned (Knewton, 2018). Pearson (2015) has presented MML and Knewton Adaptive Learning as offering an easy-to-use format that helps students to improve their understanding of their work while receiving immediate feedback, indicating the system also provides information for instructors.

In a study on transformations that may occur in higher education through computer-based adaptive learning systems, Johnson and Samora (2016) looked at the effectiveness of adaptive learning systems, which have only recently been studied with their increasing use in the educational arena. Knewton Adaptive Learning was one of the systems studied among over 30 software products in the field. According to Johnson and Samora (2016), adaptive learning systems can potentially be effective in offering one-to-one tutoring but must fit into what is considered the "iron triangle" of education: access, quality, and cost. Furthermore, the studies that have been reviewed in this study concern the effectiveness of adaptive learning in relationship to student retention and improved learning (Johnson & Samora, 2014; Murray & Perez, 2015; Newman, Stokes, & Bryant, 2013; Papousek & Pelanek, 2015). Adaptive learning systems have not been specifically examined in regard to nontraditional learners, nontraditional learners' prior attitudes toward technology in math classes, or adaptive learning systems' effects on nontraditional learners' attitudes toward mathematics.

In another study, Jameson and Fusco (2014) compared traditional and nontraditional undergraduate students in regard to math anxiety and self-efficacy. Although they found that nontraditional learners' math self-efficacy was lower than that of their traditional counterparts, the level of anxiety was not different between these groups (Jameson & Fusco, 2014). Jameson and Fusco stated as students get older, their math anxiety increases and their self-efficacy decreases; they attributed this pattern mainly to areas of math that are considered academic as opposed to utilitarian (e.g., trigonometry vs. fractions). Their study, although important in understanding differences between traditional and nontraditional students regarding math anxiety and efficacy, did not address the attitudes that nontraditional students have toward mathematics and the technology that is now implemented in many blended mathematics classrooms (Jameson & Fusco, 2014).

Rodrigues (2012) stated that when students know "very little about the concepts of math or algebra," "the instructor's goal" is "to work with the students to get them from the point of knowing a very limited amount of math to becoming confident in the classroom" (p. 31). Balentyne and Varga (2017) noted that not only students' self-efficacy toward mathematics, but also their attitude toward mathematics is an important factor in learning mathematics. Additionally, Balentyne and Varga stated that students with greater achievement in self-paced blended classes have a positive attitude toward mathematics. Self-paced blended classes consist of both face-to-face instruction and an online component that allows students to move at their own pace while requiring a specific amount of work that needs to be completed for the course (Balentyne & Varga, 2017). Many studies have afforded insight into the attitudes that students have toward mathematics (Benken, Ramirez, Li, & Wetendorf, 2015; Rodrigues, 2012; Sonnert, Sadler, Sadler, & Bressoud, 2015). However, these studies have not addressed the relationship between nontraditional students in a blended classroom format and the use of MML, as well as such students' attitudes toward technology in the classroom (Benken et al., 2015; Lee, Lim, & Kim, 2017; Sonnert et al., 2015). By understanding how nontraditional students' use of the Knewton Adaptive Learning component of MML influences their attitudes toward mathematics, as well as their attitudes toward technology, it may be possible to help students better address negative attitudes while encouraging positive attitudes.

Problem Statement

Nontraditional students who are older than 25 years of age attending college for the first time are a growing population in all college settings (National Center for Education Statistics, 2014). Radford, Cominole, and Skomsvold (2015) found that 39% of private 4-year college students are between ages of 25 and 34 years, while 31% are over the age of 35 years. In 2-year institutions, 23% are between the ages of 25 and 34 years, and 16% are over 35 years of age (Radford et al., 2015). This is leading to a shift in what nontraditional higher education students need to succeed in college (Tennant, 2014), such that "while adult students are often more motivated and more determined to overcome their unique obstacles than traditional-aged students, mathematics courses prove to be barriers to adult student graduation" (Tennant, 2014, p. 17).

The presentation of material is also changing in the college setting (Oliver & Stallings, 2014). Many classes are now offered in a blended format, where a portion of the time is spent in a traditional classroom setting, often with lectures, while the remaining time is spent in online delivery, with the student controlling the time, place, or pace of the work (Oliver & Stallings, 2014). According to Oliver and Stallings (2014), “blended learning may prove more challenging to nontraditional students than traditional learning for a number of … cognitive and developmental reasons” (p. 63), such as the level of detail within the information presented by the instructor or the amount of inquiry, or collaborative-based learning used in the course. However, blended learning is better for science, technology, engineering, and math (STEM) subjects, according to Vo, Zhu, and Diep (2017), due to the use of more direct teaching methods, direct instruction, and interactions between students and instructors, as opposed to solely online classes, which are often self-taught through information provided within the course.

The problem addressed in this sequential explanatory mixed methods study is that nontraditional students are not prepared to succeed in math courses due to negative attitudes toward mathematics and the technology used in blended learning math classrooms. Despite the increase in the use of blended learning classes and adaptive learning tools, little research has been done regarding their effect on nontraditional students’ attitudes toward the technology being used (Benken et al., 2015). This problem may negatively impact the graduation rates of nontraditional students, in that these students may not be prepared to succeed in mathematics courses. A study investigating nontraditional students’ attitudes toward technology and adaptive learning tools, by a sequential explanatory mixed methods approach, could remedy the situation. There was a gap in existing research regarding whether the use of the Knewton Adaptive Learning component of MML in a blended mathematics classroom influences attitudes toward mathematics and the use of technology in mathematics among nontraditional students.

Purpose of the Study

The purpose of this sequential explanatory mixed-methods study was to explore the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML and their attitudes toward mathematics and the technology used in a blended mathematics classroom at a local community college in the Philadelphia, PA region. The first phase involved the use of a quantitative research approach in collecting data with the Attitudes Toward Technology in Mathematics Learning Questionnaire (ATMLQ; Fogarty, Cretchley, Harman, Ellerton, & Konki, 2001). The independent variable used in this study was the use of the Knewton Adaptive Learning component of MML in a blended mathematics classroom, and the dependent variables included students' attitudes toward the use of technology and students' attitudes toward mathematics, as measured by ATMLQ. The intervening variable for the study was the age of nontraditional students. The second phase was a qualitative exploration of nontraditional students' attitudes toward technology in blended mathematics classes, as well as their use of MML. The instructors' attitudes and views toward their students' use of technology in the math class, specifically Knewton Adaptive Learning tools, were also examined. Themes from these qualitative data were developed into an instrument to compare a student's age with confidence in mathematics, confidence with computers, and confidence with computers and graphing calculators in the Philadelphia, PA area. Student use of the Knewton Adaptive Learning component of MML was examined to determine how nontraditional students' use of the Knewton Adaptive Learning component of MML in a blended mathematics classroom impacts their attitude toward the use of technology and mathematics.

Research Questions

The following quantitative questions and hypotheses framed the study:

RQ1. What was the difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology?

$H1_0$. There was no significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology.

$H1_1$. There was a significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology.

RQ2. What was the difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward mathematics?

$H2_0$. There was no significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitude toward mathematics.

$H2_1$. There was a significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitude toward mathematics.

The following qualitative questions will frame the study:

RQ3. How did students perceive the influence of the Knewton Adaptive Learning component of MyMathLab on their attitudes toward the use of technology?

RQ4. How did instructors perceive the influence of the Knewton Adaptive Learning component of MyMathLab on students' attitudes toward mathematics?

Conceptual Framework

The conceptual framework for this study was Zoltan Dienes's theory of learning mathematics (Dienes, 1959). This theory addresses six stages of learning mathematics:

1. *Free play* involves interaction with a situation or problem.
2. *Playing by the rules* occurs when one finds the rules that fit the situation or problem.

3. The *comparison stage* involves looking at how the new rules fit with other problems or situations.
4. The *representation stage* shows how the rules can be represented.
5. The *symbolization stage* occurs when the properties of the system can be described.
6. The *formalization stage* involves the setup of a formal system to describe the problem.

Dienes stressed the importance of learning mathematics by direct interaction with the subject, by being very active both physically and mentally with it (Dienes, 2000; Post, 1981; Sriraman & Lesh, 2007). His theory includes three separate principles: perceptual variability, mathematical variability, and constructivity.

The *perceptual variability principle* (Dienes, 1959) involves acknowledgment that conceptual learning is maximized when concepts are exposed in a variety of physical and contextual formats. The *mathematical variability principle* suggests that generalizing of mathematical concepts is enhanced when the concept is shown under variable conditions that use varied irrelevant and relevant variables (Post, 1981). The *constructivity principle* used by Dienes (1959) involves acknowledgment of the need to construct mathematical concepts before analysis of the concepts can occur. Dienes's framework is popular with mathematics educators due to its constructive nature, as it includes the building of concepts in order to learn the basics and then progress in mathematical learning; Dienes's contribution to mathematics education, the six stages of mathematical learning, is ranked with the contributions of Piaget and Bruner (Gningue, 2016).

MML provides students with the basics of a problem, what information is given and what is being looked for, and then continues with students following through with the remaining steps. For instance, two points on a coordinate plane may be given, and the slope may be asked about (Pearson, 2015). The students must determine what rules are being used to fit the situation, and then how the information is similar to or different from previous learning. For example, students may ask themselves, “If a line is drawn, what does the line represent?” Students must then decide if the slope is related to something that they have done before. They may consider questions such as the following: “What rules can be written to form the problem, if we are talking rise over run, how can that be indicated? If we can show rise over run on the graph, how can we now write it as a problem that can be solved?” Where Dienes’s (1959) theory initially worked with the hands-on manipulative nature of mathematics, MML provides the technological version of the six stages of mathematical learning. MML takes students through the process of discovery such that they begin with the basics and build from that point (Pearson, 2015).

Nature of the Study

Using a sequential explanatory mixed methods approach, I examined how nontraditional students’ use of the Knewton Adaptive Learning component of MML influenced their attitudes toward the use of technology and mathematics in a blended mathematics classroom. The mixed methods approach was selected because it provided a more robust look at the data and what influences nontraditional students’ attitudes toward technology in the mathematics classroom. Johnson and Onwuegbuzie (2014) stated that mixed methods provide both qualitative and quantitative formats, which, when combined, produce an approach that is not restrictive or constraining, allowing the researcher to be eclectic in thinking about and conducting the study. The quantitative analysis of students' attitudes toward mathematics gave insight into the components that influence nontraditional students' success when using the Knewton Adaptive Learning component of MML by analyzing the components that were used the most by the students. Interviews with nontraditional students gave additional insight into the components of MML that they felt improved their attitudes toward mathematics that were not considered with the scales used. Additionally, interviews with professors of nontraditional students addressed any effect that MML use had on nontraditional learners in regard to technology in the classroom and how professors saw students using the technology to learn mathematical concepts.

The ATMLQ was used when surveying the nontraditional students participating in the study. This public domain tool measures the attitudes that students have not only toward math, such as "It takes me longer to understand mathematics than the average person," but also toward the use of technology (both mathematics technology and computer confidence), such as "When I have difficulties using a computer, I know I can handle them" and "I like the idea of exploring mathematical methods and ideas using technology." All three scales were used in the study because they provided different outlooks on each component of the study. Students' attitudes toward mathematics, as well as their use of technology in the blended mathematics classroom, may indicate confidence in using computers, as well as student attitudes toward technology.

The ATMLQ measures attitudes toward situations where technology is used to learn mathematics with a 34-item, 5-point scale, composed of brief descriptions of various situations that reflect the use of mathematics with and without technology. This inventory, developed by Fogarty et al. (2001), is for respondents ages 18 years and older and has been in use since 2001. Additionally, follow-up interviews were conducted that allowed participants an opportunity to discuss how they perceived the influence of the Knewton Adaptive Learning component of MML on their attitudes toward the use of technology. Interviews were conducted with the professors who chose to participate in the study, to discuss how the instructors perceived the influence of the Knewton Adaptive Learning component of MML on students' attitudes toward mathematics.

Definitions

Adaptive learning: A method of learning and teaching that addresses the specific concerns of the learner while detecting patterns of successes and failures in order to choose appropriate content (Henson, 2014; Johnson & Samora, 2016).

Attitude: The affective domain of noncognitive thought regarding emotions, attitudes, beliefs, and values (DeBellis & Goldin, 2006).

Knewton Adaptive Learning: A personal tutor that uses individualized instruction, assessment, feedback, and remediation for students while they work on the topics assigned (Knewton, 2018).

MyMathLab (MML): Pearson's online learning platform that utilizes Knewton Adaptive Learning for mathematics classes that use Pearson's mathematics books.

Nontraditional students: Students who are older than 25 years of age attending college for the first time. These students also have time constraints due to family and work obligations (National Center for Education Statistics, 2014).

Self-paced blended classroom: A classroom that uses both instructor-based learning as well as online learning components. The work completed in the class is done at the pace required by each student, with a set learning/work outcome required (Balentyne & Varga, 2017).

Assumptions

Assumptions are facts that are considered true but not verified, as stated by Marshall and Rossman (2014). Assumptions support a study using a clear and logical rationale (Marshall & Rossman, 2014). Two assumptions were made for this study. First, nontraditional students were honest in their completion of the survey tool. Second, in interviews, nontraditional students were open and honest regarding their feelings, intentions, and outlook toward the questions. The need for open and honest dialogue was shown through the synergistic relationship between technology and learning, where technology provides the means to new teaching strategies that could not otherwise be implemented (Schmid, Bernard, Borokhovski, Tamim, Abrami, Surkes, & Woods, 2014).

Scope and Delimitations

The scope of the study involved understanding the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML in a blended mathematics classroom and their attitudes toward the use of technology and mathematics gathered through analysis of the data collected from the ATMLQ survey. Additionally, information gathered through interviews focused on students' perceptions of the influence of the Knewton Adaptive Learning component of MML on their attitudes toward the use of technology as well as their professors' perception of the influence of the Knewton Adaptive Learning component of MML on students' attitudes toward mathematics.

The boundaries of the study fell within three aspects: The focus was on college developmental math classes and beginning-college-level mathematics classes; the population focused on nontraditional students over the age of 25; and the classes needed to require the use of the MML program. Additionally, the classes selected were in a self-paced, blended format that required both in-class instructor driven components as well as online work with MML. Participants needed to complete the ATMLQ survey.

Potential generalizability falls within three areas. First, the population was solely from the United States, allowing for broader representation of nontraditional students. Second, the participants were from a variety of majors. Last, the ATMLQ survey was designed for students over the age of 18 years, which provided specific and overall results appropriate to nontraditional students' attitudes toward the use of technology and mathematics.

Limitations

Limitations are possible weaknesses or shortcomings that can affect the trustworthiness of a study (Marshall & Rossman, 2014). A limitation of this study was the population that was used. In this study, I focused on nontraditional students who were older than 25 years of age attending a local community college for the first time. These students also had time constraints due to family and work obligations that might have limited their willingness to participate, so no additional time was taken from these obligations. These participants might not accurately represent a larger population. Additionally, a limitation of this study was the transferability of the population used. The nontraditional students in the study represented an East Coast population that resides in suburban and urban areas. Therefore, caution should be used when generalizing the findings beyond the research.

Significance

This research filled a gap in understanding how nontraditional students' attitudes toward the use of technology and mathematics in a blended mathematics classroom were influenced by nontraditional students' use of the Knewton Adaptive Learning component of MML. This study addressed the growing group of nontraditional students who frequently struggle in the math classroom (Tennant, 2014). The findings of this study may provide insight into the struggles and attitudes toward the use of technology and mathematics that nontraditional students have when faced with math classes in general, and specifically the dynamics of taking a blended math class that uses MML. The insights from the study may inform professors of methods and processes that will provide additional support for this growing population, as well as approaches that may lead to classroom success, including the use of adaptive learning. The results may inform professors of the tools most understood and used by students, as well as their attitudes toward the use of MML and Knewton Adaptive Learning tools. This information may afford professors additional insights in order to provide instructional feedback, means to address negative attitudes toward technology in the classroom or MML specifically, or concerns faced by nontraditional students.

As stated by the National Center for Education Statistics (2012), this growing group of nontraditional students will change how the classroom looks, as well as how mathematics is approached. By examining how nontraditional students' use of Knewton Adaptive Learning component of MML and its influences on their attitudes toward the use of technology and mathematics, improvements in teaching and technology may be made. These changes may help to improve students' class grades and participation in class, as well as nontraditional student retention.

Summary

Nontraditional students are a growing population in college classrooms (Radford et al., 2015). Radford et al. (2015) contended that such students return to school with outlooks, requirements, and needs that differ from those of traditional students. They may not only have outside requirements placed on them by family needs and work constraints, but also have limitations on their ability to use technology and/or educational deficiencies, such as not using mathematics since their own high school days or a fear of mathematics (Henson, 2014; Willans & Seary, 2011).

There was a gap in the research regarding nontraditional students in blended classrooms and their use of technology, specifically adaptive learning methods. The purpose of this sequential explanatory mixed-methods study was to explore the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML and their attitudes toward mathematics and the technology used in a blended mathematics classroom at a local community college in the Philadelphia, PA region. This research may provide professors and college administrators with ways to help nontraditional students improve their attitudes toward the use of technology and mathematics in the blended mathematics classroom. This research may bring about positive social change in higher education, especially for nontraditional developmental math students (i.e., those students over the age of 25 who are placed in developmental math classes), by helping to address students' needs and attitudes toward the use of technology in mathematics classes so that students can meet the requirements of their courses.

Chapter 2 includes a review of the research literature on nontraditional students and their attitudes toward mathematics and technology in blended math classrooms. Chapter 3 contains a discussion regarding the study's research design and methodology. Chapter 4 analyzes the data collected during the study, both quantitative and qualitative. Finally, chapter 5 interprets the findings and presents recommendations and implications for the study.

Chapter 2: Literature Review

Introduction

The purpose of this sequential explanatory mixed-methods study was to explore the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML and their attitudes toward mathematics and the technology used in a blended mathematics classroom at a local community college in the Philadelphia, PA region. In this chapter, I examined literature related to nontraditional college students in regard to their perspectives and the obstacles they face with the use of technology as well as mathematics. Research on attitudes toward mathematics, technology in the math classroom, and the use of adaptive learning in the math classroom was also explored. Additionally, the conceptual framework of Dienes's theory of learning mathematics, which framed this study, is explored. The adaptive learning theory is also examined. The review of the literature focuses on concepts that were relevant to the study and contains citations to recent, relevant research found in a variety of scholarly journals and websites.

Traditional-age college students have grown up with technology such as computers and smartphones and do not think about the uses that such technology provides. As Henson (2014) stated, nontraditional students are not necessarily familiar with technology in the classroom. Lack of familiarity with learning technology may lead to uncomfortable situations for nontraditional students in college classrooms (Venkatesh et al., 2014). These students may need to learn not only the math topics that are presented, but also the technology that is used; they may even need a review of calculator use (Rodrigues, 2012).

MML uses Knewton technology, which involves adaptive learning techniques (Pearson Education, 2015). Pearson's MML provides students with a program that allows them to complete their math work while using various tools within the program package.

Nontraditional students have not been studied in regard to their attitudes toward the use of technology and mathematics in a blended classroom format. Understanding how technology influences nontraditional students' attitudes, both positively and negatively, may provide educators with methods to improve the learning process specific to nontraditional students.

Literature Search Strategy

The search for appropriate literature involved several search engines. The first search engine used was ERIC through the Walden Library system. This tool allows users to narrow publication dates as needed, as well as to limit searches to peer-reviewed scholarly journal articles. Another search engine used was Google Scholar. This search engine provided a way to easily limit the age of the articles retrieved, as well as to use multiple libraries. Google Scholar also made it possible to conduct searches for authors in all associated databases. The third database that was used was Education Research Complete. This provided the same search criteria as the others, permitting me to limit the age of the articles as well as the required search terms. All three search engines provided many of the same articles, but each also afforded access to journals that were unique to the search engine.

Key search terms used included the following: *nontraditional students, math attitudes, technology, technology in math classrooms, adaptive learning, adult learners,* *math theory, math technology, math anxiety*, and *mathematical framework*. These search terms were used individually and in combinations. Additionally, if an author was found to have written several articles, his or her name was also used in searches to make sure that any additional articles were accessed as appropriate.

In order to focus on up-to-date information, I prioritized literature written since 2013 in conducting searches. I found several pieces of seminal literature from 1959, as well as the 1990s, that provided background information on mathematical frameworks and theory, as well as information on mathematical attitudes. The remaining literature, which was from 2002 to 2012, provided information fitting the search criteria in order to provide a foundation for the study.

Learning Theory

The conceptual framework used for this mixed-methods study was Zoltan Dienes's theory of learning mathematics. Dienes (1959, 2000) contended that math should be learned as a means of personal fulfillment, suggesting that it should be learned through direct contact with the concepts and in such a way that it becomes part of the person. Dienes's theory, which was first presented in the 1960s, presents learning math as a game. The theory indicates that individuals progress through six stages in learning mathematics (English, 2009; Ernest, 1986; Gningue, 2016; Kim, 2009).

Stage 1 represents free play. This initial step involves the first interaction with the math concept, where the learner is becoming familiar with the situation it represents. Stage 2 is playing by the rules. This stage involves the introduction of the rules to "the game" that the concept represents. The next stage is the comparison stage, which involves comparing the rules of the current game with those of past games. The fourth stage is the representation stage. This stage helps to provide a means to map the representation of the concept to its rules and other “games.” The symbolization stage is the fifth stage. At this point, a symbol system can be used to describe the rules and systems that are being learned. The last stage is the formalization stage. This final step builds the axioms and theorems that form the rules to the game (Gningue, 2016). These six stages represent the learning process that students are able to follow in the MML. The lessons provide tools that students can use to connect new concepts with previous concepts, allowing them to understand how the rules are played, connect the concepts together, and use the new information to write new formulas and concepts (Dienes, 2000).

There are four underlying principles that contribute to the framework. The *dynamic principle* is represented by Stages 1, 2, and 3. These stages represent the understanding of a new concept at the basic levels. The *perceptual variability principle* suggests that the maximization of learning is approached when students gain a variety of physical contexts for concepts through games, manipulatives, or real-world examples (Gningue, 2006). The *mathematical variability principle* suggests that conceptual development is achieved when abstraction and generalization of the concepts can be understood (Dienes, 1959). The *constructivity principle* indicates that analysis must be preceded by construction of the principles being learned (Dienes, 1959). These principles and stages of learning must be put together and presented in a manner that allows for direct interaction with the concepts.

MML provides the tools that students need through various query methods (e.g., “how do I solve this” or “help me solve this”) that allow students to take new concepts and learn through steps how to build upon them (Pearson Education, 2015). Among the tools provided by MML, students must find those that work best for their learning while providing the support that they need. Nontraditional students’ attitudes toward technology may influence how they learn and what learning tools they use (Henson, 2014).

An adaptive learning system grounded in this theory presents content based on interactions with students and the content that is presented (Murray & Perez, 2015). This system allows for individualized learning, using methods and manners that work best for each student. The MML program uses this theory of adaptive learning in order to support, teach, and reinforce concepts in manners that are appropriate for an individual’s learning experience (Raines & Clark, 2016).

While adaptive learning systems and theory are relatively new, theories based on attitudes, specifically attitudes toward math, are not new. Often, attitude is spoken about but not specifically identified within such theories (Hannula, 2012; Zan & Di Martino, 2007). When it is defined, the definition may vary. The definition used for this study is based on the tripartite framework that defines attitude as consisting of three components: cognitive (beliefs), affective (emotions), and conative (behavior); (Hannula, 2012). These three components come together to form the attitude of a student toward mathematics and the use of technology in the mathematics classroom, which contributes to the student’s confidence toward the technology in the classroom (Moakler & Kim, 2014). This can color the way that the student looks at the subject, either negatively or positively, and often impacts his or her performance in the classroom (Hannula, 2012).

Review of Literature

Nontraditional Students

Nontraditional students are typically over the age of 25 and can attend either a 2-year or a 4-year college (National Center for Education Statistics, 2014). Adult learners often begin their college careers with life experiences to support their education, but they sometimes lack study skills and confidence in the classroom (Day, Lovato, Tull, & Ross-Gordon, 2011). Instructors often see nontraditional students' low level of self-confidence manifested in their desire for structured learning and understanding of instructor expectations (Ross-Gordon, 2011). Furthermore, students who see themselves as nontraditional, especially in terms of age, parental roles, and job experience, have a higher sense of resilience (Chung, Turnbull, & Chur-Hansen, 2017).

Often, nontraditional students are less interested in social events and having a good time while in college than their traditional-age peers (Newbold, Mehta & Forbus, 2010). Outside demands, such as family and work, may limit the time they have available. Many are also past the desire to party like a traditional student. Nontraditional students may feel increased social connections with both classmates and professors, even as their social participation decreases (Cocquyt, Diep, Zhu, DeGree, & Vanwing, 2017). This connection within the college setting helps them to feel part of the college community and helps with their persistence and positive attitude toward going back to school (Newbold et al., 2010).

Members of the growing nontraditional student population are typically highly focused, motivated, and ready to take learning seriously (Wood & Frogge, 2017; Wyatt, 2011). Many of these students have already spent at least a few years in the workforce, if not many years. Their experiences in the workforce often help them apply classroom concepts to real-world situations (Bohl, Haak, & Shrestha, 2017). Nontraditional students frequently rely on full-time work for their livelihood (Henson, 2014; Willans & Seary, 2011) in positions that demand critical decision-making skills (Jinkens, 2009). This experience may give nontraditional students the ability to multitask, to comprehend more detailed issues, and to see the benefit of advancing their career while taking their studies seriously (Johnson & Good, 2011; Markle, 2015). Often, college is seen as a last resort in order to advance in their careers, to start a new career, or to improve their situation (Francois, 2014; Johnson & Good, 2011).

Many nontraditional students return to college with a lack of self-confidence (Ross-Gordon, 2011). They expect a structured learning environment in order to succeed in the educational process (Tennant, 2014). Nontraditional students often feel unprepared for the classroom because they have not had any formal learning in years (Khiat, 2017; Tennant, 2014). According to Van Doom and Van Doom (2014), these students also prefer professors who are flexible and well organized. They often show a goal-focused mindset in their approach to higher education (Bohl et al., 2017).

Entering the classroom after years away can cause stress, apprehension, anxiety, and fear (Willans & Seary, 2011). Nontraditional students must relearn how to study after being out of the classroom. Many have forgotten the rules and requirements of the classroom (Jameson & Fusco, 2014; Willans & Seary, 2011). Additionally, female adult students often must juggle academic demands and family needs, especially when young children are involved (Osam, Bergman, & Cumberland, 2017).

The technology skills of adult students also affect their classwork. Many adult students lack basic computer skills for the classroom (Henson, 2014). According to Henson (2014), even with limited computer skills, nontraditional learners have a greater preference for using technology than their traditional counterparts. Many adult students feel that more assistance and training for the technology used in classes would be very helpful (Wyatt, 2011). Providing additional assistance, either in the classroom or in a tutoring session, can increase students' efficacy and comprehension when using computers (Jameson & Fusco, 2014).

Professors, or academic centers, may need to provide refresher courses on basic skills that college students need (Van Doom & Van Doom, 2014). Adult learners may have forgotten or only remember parts of good study habits, cognitive learning strategies, self-regulated learning, self-reflection skills, or time-management skills, in addition to computer skills (Khiat, 2017). Adult students tend to focus on learning goals, as opposed to performance goals (Hoyert & O'Dell, 2009). While learning goals are important to nontraditional students, learning skills and/or study habits play an integral role in the educational process for these students (Van Doom & Van Doom, 2014).

Attitudes Toward Mathematics

Attitudes toward mathematics have several components. DeBellis and Golden (2006) developed a tetrahedral model for the affective domain, or the noncognitive aspects of thought. In their model, the following elements are ordered by increasing stability: emotions, attitudes, beliefs, and values. Each area interacts with the other three to form the affective domain. Attitudes toward mathematics (ATM) and achievement in mathematics (AIM) are often the most recognized areas. According to Ma and Kishor (1997), ATM is more stable and less affected by AIM. Attitudes are typically considered to be affective responses that are relatively stable and can be either positive or negative feelings toward mathematics. Students who have positive attitudes are more motivated, understand the content more, and put forth more effort (Kargar, Tarmizi, & Bayat, 2010; Osam, et al., 2017).

Many students perceive mathematics as a difficult subject area (Skaalvik, Federici, & Klassen, 2015). Fear of mathematics is often passed from generation to generation (Gunderson, Ramirez, Levine, & Beilock, 2012; Maloney, Ramirez, & Gunderson, 2015). Jameson and Fusco (2014) studied 226 undergraduates from a medium-sized state university using the Abbreviated Math Anxiety Scale (AMAS), the Mathematics Self-Efficacy Scale (MSES), and the Self-Description Questionnaire III (SDQIII). The qualitative results from the three scales were used to explain differences in levels of self-efficacy, math anxiety, and concepts, broken down by the participants' age. Nontraditional students typically have lower levels of math self-efficacy but have approximately the same levels of math anxiety as traditional learners (Jameson & Fusco, 2014). Self-efficacy and anxiety have a direct correlation with students' attitudes toward mathematics and the use of technology (Hung, Huang, & Hwang, 2014). Further, Jameson and Fusco (2014) stated that as students' age increases, their self-efficacy, as well as their attitudes toward math, decrease.

A descriptive correlation study completed by Karger, Tarmizi, and Bayat (2010) used the Mathematics Anxiety Rating Scale (MARS-R) and the Mathematics Attitudes Questionnaire (MAQ) to examine 203 students from a public university in Malaysia. Karger et al. concluded that lowering math anxiety would contribute to improvement in students' attitudes toward mathematics. Karger et al. (2010) attributed consistent underperformance in mathematics to a poor attitude by learners, a position they shared with Benken et al. (2015). In a mixed-methods study involving 376 students in intermediate algebra classes at a large, urban California State University campus, Benken et al. examined the relationship between the amount of mathematics courses in high school and student readiness or preparation for college-level math courses.

Bonham and Boylan (2011), as well as Núñez-Peña, Suárez-Pellicioni, and Bono (2013), stated that college students' attitudes toward mathematics have an impact on their completion of and success within math courses. According to Hannula (2002), and later Hodges and Kim (2013), attitudes can change dramatically in regard to mathematics. Bachman (2013) concluded that cultivating a positive attitude toward the usefulness of developmental courses helps learners to improve their attitudes toward mathematics.

Fear of mathematics and related courses was shown best by the work of Hannigan, Hegarty, and McGrath (2014). Hannigan et al. examined the results of 121 first-year medical students who completed the Survey of Attitudes Toward Statistics instrument (SATS). A multivariable linear regression model was used to predict component scores based on age, sex, nationality, and previous education. Their study revealed that medical students, who typically have a strong academic sense, had negative attitudes toward statistics, which is part of the curriculum for medicine. Apparently, students' poor attitudes toward statistics are created by their association of statistics with mathematics. Eventually, the study indicated that medical students performed poorly in statistics as a subject, despite its utmost importance to the increasingly evidence-based medical profession. This underperformance can be heavily attributed to a poor attitude toward mathematics and associated subject areas (Hannigan et al., 2014).

Various researchers and curriculum developers have tried to explain students' attitude toward mathematics. Among the factors that have been thought to affect the attitude of learners toward mathematics in past studies is the lack of confidence, perception of their own abilities to complete the work, and feeling that the usefulness of mathematics is much less than is professed (Jameson & Fusco, 2014). According to Kiwanuka, Van Damme, Van Den Noortgate, Anumendem, Vanlaar, Reynolds, & Namusisi (2017), feedback from instructors has a negative effect on student confidence, creating a sense of low academic self-concept. Gilbert, Musu-Gillette, Woolley, Karabenick, Strutchens, & Martin (2014) conducted a study of 979 middle school students in six school districts across eastern Alabama. They stated frequent use of students' providing explanations of how or why they chose to solve a problem in a specific way (reform practices) helped create lower levels of self-efficacy for the students and improved their test scores.

Lizzio, Wilson, and Simons (2002) revealed that learners resented courses with a lot of drill and practice assignments. Nguyen, Charity, and Robson (2016) conducted a study of 453 postgraduate business students attending a United Kingdom university analyzing their completion of a module in their postsecondary business statistics class. The study by Nguyen et al. (2016) found older students have a more positive outlook toward their technology use in a statistics classroom with lower math anxiety. They continued that this lower level of anxiety and higher levels of confidence in the technology was due to their familiarity with the technology used. In essence, learners resented traditional teaching techniques. Students better welcomed analytic problem solving and interactive learning techniques (Nguyen et al., 2016). This, therefore, means that learners receive nontraditional learning techniques much better. Interactive learning has also been shown to reduce math anxiety (Beilock & Maloney, 2015); math anxiety is one of the causes of a poor attitude toward mathematics.

Furner and Berman (2003) reviewed 37 articles and studies, from 1978 to 2000, conducted by individuals, as well as the National Council of Teachers of Mathematics (NCTM), involving reducing and preventing math anxiety. This review examined causes of math anxiety, educator’s response, best practices for math instruction, preventing or reducing math anxiety, as well as teacher’s anxiety and family math. The review by Furner and Berman found that two-thirds of the American adult population fear mathematics. Furthermore, math anxiety is an important cause of the poor attitudes shown by learners toward mathematics (Karger, Tarmizi, & Bayat, 2010). Lack of confidence while completing mathematical problems has been found to create anxiety.

Today's society continues to downplay the usefulness of mathematics, as well as perpetuate poor attitudes and math anxiety among students, due to the emergence of technology. Zan and DiMartino have conducted studies in 2001, 2002, and 2003 regarding attitudes toward mathematics. An additional study in 2007, built on their prior research with expanded findings from an Italian project, focused on negative attitudes toward mathematics. The Italian Project surveyed 146 teachers at various schools and levels in Italy on teachers' beliefs toward negative attitudes students have toward mathematics. Mathematics is depicted as a difficult and useless subject that is only reserved for a selected few, according to Zan and DiMartino (2007). Prior bad experiences with mathematical problems and with mathematics teachers also contribute to the occurrence of math anxiety (Beilock & Maloney, 2015). Beilock and Maloney examined findings regarding mathematical anxiety in research from the following areas: psychology, education, and neuroscience. The majority of the studies examined were from the 2010s, with Beilock and Maloney focusing on how math anxiety impacts math achievement, causes of math anxiety and how it can be reduced. Learners reported being disgruntled with teachers and instructors who treated them badly when they failed to understand mathematical concepts (Beilock & Maloney, 2015; Gunderson et al., 2012; Mensah, Okyere, & Kuranchie, 2013; Rice, Barth, Guadagno, Smith, & McCallum, 2013).

A mixed-methods study of 131 undergraduate students, ranging in age from 18 to 41 with several different majors, conducted by O'Leary, Fitzpatrick, and Hallett (2017) examined the students' experiences with math at all levels and their associated math anxiety. Another study conducted by Johnson, Taasoobshirazi, Clark, Howell, and Breen (2016) examined 139 university students from a school of education at a large public, urban institute. This study looked at the motivation of traditional and nontraditional students in regard to attributions, self-determination, and expectancy-value. According to O'Leary et al. (2017), teaching math content at a fast pace contributes to poor understanding of the concepts, hence heightening math anxiety. Similarly, this is a reason why math anxiety and the subsequent underachievement in mathematics are far more common in traditionally aged learners than nontraditional students (Johnson et al., 2016). Apart from being delivered by way of traditional techniques, Bonham and Boylan (2011) asserted that the mathematics content of developmental courses is usually delivered in such a short time, hence breeding high levels of math anxiety.

Technology and Mathematics

Frey and Fisher (2008) showed that the Millennials, people born between 1981 to 1996, are easily fascinated with technology thus the introduction of computer technology in the classroom makes the classroom a better environment for learning. Further, the computer can be used effectively to make understanding of math concepts much easier. Ardies, Maeyer, Gijbels, and van Keulen (2015) studied 2,973 Flemish 1st and 2nd graders in order to examine the relationship between their attitudes toward technology and the following six aspects of attitude: interest, career aspirations, boredom, consequences, difficulty, and gender issues. An additional study by Bray and Tangney (2017) analyzed 139 published studies involving technology interventions in mathematics education. These studies found the ability of computers to show three-dimensional images, to reproduce virtual real-life situations, and problem solving made them very useful in the math classroom (Ardies et al., 2015; Bray & Tangney, 2017). Technology can open new routes to construct and understand mathematical concepts and problem-solving approaches (Bray & Tangney, 2017).

A quasi-experimental study conducted by Heflin, Shewmaker, and Nguyen (2017), with the purpose of evaluating the efficacy of mobile technology when used in collaborative learning environments, had 159 freshman university students participate. According to Heflin et al. (2017), traditional students, as well as some nontraditional students, are very familiar with technology, and because of this, the students are able to focus more on the concepts than the use of the technology. Gomez-Chacon and Haines (2008) revealed in their study in the 11th International Congress on Mathematical Education, that even though computer use in mathematics classrooms in Spain and England at the time of the study was somewhat attenuated; there was a strong positive correlation between increased computer use and improved achievement in mathematics. The students in the study revealed that the computers helped them to establish connections between various areas of mathematics. The relationship between algebra and geometry was one of these areas. However, commitment to the use of computers for learning mathematics was determined more by the learners' attitudes toward computers than their attitudes toward mathematics. The study also confirmed that generally, learners are open to using computers in learning mathematics; something, which Ardies et al. (2015) also illustrated.

Technology has been used in various other ways in math classrooms. Increased use of class blogs and wikis is one of these areas in which technology has been married with the classroom (Venkatesh et al., 2014). The study conducted by Venkatesh et al. examined a 50-item survey given to 14,283 students who attended 12 different universities in Quebec, Canada. Their study used an exploratory analysis to determine engaging lectures, along with information and communication technology used for group work and individual studying had a positive impact on students' perception of the effectiveness of the given course. With technology, learners can share information freely. Moreover, such technological advancements make it far easier for learners to access mathematical information (Venkatesh et al., 2014). A paper by Chilton (2012), examined the issues that were found when implementing a virtual classroom as well as its experiential learning framework in a graduate level MIS capstone project at a midwestern university. According to Chilton, video links can be used in teaching to make the learning more experiential even when the students are not in physical contact with the teacher. He goes on to say, proper execution of the course depends on several factors, the preparation by both students and professors as well as the performance of the technology used.

Technology has also seen the development of numerous software programs that are indispensable for college level mathematics. These tools include drawing tools that can be used to develop all kinds of geometrical shapes and charts, graphic calculators, dynamic graphing tools, and dynamic geometry tools (Goos, 2010). There are also tools for data manipulation and storage like Microsoft Excel and Microsoft Mathematics. A study completed by Gomez-Chacon (2011) included two parts: the first part consisted of a survey of 392 15- and 16-year-olds who were introduced to the GeoGebra software program, while the second part consisted of a case study of 17 of the participants. GeoGebra is a software tool that can assist learners in computing algebraic expressions (Gómez-Chacón, 2011). Gomez-Chacon's findings showed student attitudes toward computer usage in a math class were more closely related to their attitudes toward computers, than their attitudes toward mathematics.

Newman, Stokes, and Bryant's (2013) paper looks at the accelerating use of adaptive learning in higher education as a way for deeper and richer insights to be provided to institutions for evaluation of adaptive learning. Use of technology was first introduced in teaching mathematics for various reasons. First, as one of the key principles of adaptive learning and teaching, a change of scenario is important (Newman et al., 2013). Technology is one of the ways in which this change can be achieved. The study by Papousek and Pelanek (2015) examined adaptive educational system models and their optimal level of challenge through six million pieces of data collected through a geography adaptive learning system in the Czech Republic and Slovakia. According to Papousek and Pelanek, change of scenario alleviates boredom and enhances concentration and understanding of mathematics. Moreover, use of technology, the incorporation of graphing calculators, math programs, and learning tools such as MML, have been lauded for making ideas tangible (Papousek & Pelanek, 2015). Increased tangibility and the ability to visualize concepts from various angles greatly enhances learning in mathematics and is in accordance with the perceptual variability principle (Subong, n.d.).

Adaptive Learning in the Math Classroom

Adaptive learning is one of the many techniques that are being employed in teaching nontraditional college students mathematics (Henson, 2014). Henson studied 339 students in various classes at two community colleges in order to determine how computer-related factors affect nontraditional students' success, while Johnson and Samora's (2016) study examined the effectiveness of computer-based adaptive learning systems that are currently used in education. According to Henson, and Johnson and Samora, adaptive learning refers to a method of learning and teaching that is meant to address the specific concerns of the learning, while detecting patterns of successes and failures in order to choose appropriate content. Kleisch, Sloan, and Melvin (2017) conducted a study on faculty training of adaptive learning for nontraditional students, which integrated adaptive learning with faculty training and developmental models. According to Kleisch et al., providing training for adaptive learning tools so they can be used in the best way possible by both instructors and students, while incorporating both in-class instruction with the online component, is needed for students to be successful in the classroom. Murray and Perez (2015) conducted a study examining completion rates and scores of adaptive learning exercises of 105 students, compared to completion rates and quiz scores of objective-type quizzes of 113 students, in a university digital literacy course. Murray and Perez have shown that adaptive learning is more effective than traditional learning. Adaptive learning can be personalized according to the students' abilities or the methods that they learn best, while collecting data to improve future courses. However, with advancement in technology, there has been increased use of adaptive learning, but it is not yet widely available (Johnson & Samora, 2016). In automated adaptive learning, technology is used to design a learning tool that is suitable for students of all levels. This tool is made to have an interactive interface and to ensure that the student chooses whatever methods and tools they want to engage in by themselves (Huang, Craig, Xie, Graesser, & Hu, 2016). Moreover, in the case of mathematics, these tools are designed to give students exercises after an amount of content has been delivered. The exercises can be designed to have different levels of difficulty and the learner is allowed to start with what is most comfortable for them as they advance. This not only ensures proper grasp of content, but also encourages students who are weak to push on (Johnson & Samora, 2016; Papousek & Pelanek, 2015).

In adaptive teaching, there are various strategies by teachers that are meant to enhance the learning process. First, in interactive teaching, the instructor frequently changes tasks to be performed by the student (Goos, 2010). This is meant to alleviate boredom and maintain the concentration of students in the learning process. Moreover, in adaptive teaching, the teacher aims to increase interactions between learners, which could be achieved by cooperative learning, especially in the personalized design of adaptive learning (Johnson & Samora, 2016). Past research has shown that cooperative learning and working groups have the ability to enhance achievement in mathematics and enhancing attitude (Boaler, 2002).

Adaptive technology is different from personalized learning in that it is data-driven as well as non-linear in approach (Newman et al., 2013). The adaptive learning system changes and adjusts to the learner’s interactions, as well as mastery of material, according to Newman. Murray, and Perez (2015) concluded that adaptive learning is a game-changer for high education as it controls quality, cost, and access. The preliminary research that has been conducted by Murray and Perez, as well as Papousek and Pelanek (2015), shows compelling evidence of student persistence and engagement.

In addition, adaptive learning has seen changes in teaching methods and course goals (Goos, 2010). Adaptive learning is student-centered and as such, learning is predominantly directed by the learners themselves. This mode of teaching-learning, which is learner-directed, has been shown to be more effective in ensuring that the learners understand difficult mathematical concepts at a pace that is most comfortable for them (Abrami, Bernard, Wade, Schmidt, Borokhovski, Tamin, & Newman, 2008). Additionally, more comprehensive systems adapt to the needs of the students' learning environments using videos, case studies, animation, or simulations, which adjust to the specific goals and outcomes needed for the course (Murray & Perez, 2015).

Moreover, Goos (2010) noted that adaptive learning has seen more alignment of the curriculum with research and practice. This has been made possible through the integration of many real-life situations in mathematical problems that need to be computed in the classroom. Moreover, at the college level, mathematical problems are tailored more toward the students' future careers and situations that they may encounter in these careers as well as their mathematical skills that may be called upon in their careers (Goos, 2010). This enhances interest in mathematics by emphasizing the importance of this subject area in future careers of the college students.

A quasi-experimental design study conducted by Huang et al, (2016) followed 533 sixth grade students, from west Tennessee, in an afterschool program, over three years, in order to investigate the performance gaps in mathematics education related to the role of intelligent tutoring systems to reduce the math achievement gap between white and African American students. With the inception of adaptive learning, technology has become a necessity in teaching mathematics for nontraditional students (Henson, 2014). This is because adaptive learning requires the teacher to pay close attention to details for each student; this can only be possible in a purely personalized adaptive learning setup if the number of teachers is large enough to give every teacher only a few students with whom they can interact closely (Huang et al, 2016). However, with automated adaptive learning tools, it is possible for one teacher to monitor the needs of more learners. The MML program provides instructors with the tools to monitor the work that is being accomplished by the students as well as the amount of time and areas that they have used in their work (Pearson, 2015). The ability to see the work completed and the support tools used allows the instructor to determine areas that may need to be readdressed within the classroom.

The use of technology has helped in improving learners' attitudes toward mathematics; however, the use of new adaptive learning tools must also be beneficial to students in order for improved attitude to continue (Hajjar, 2011). The demonstration of practical applications of mathematics during the learning process, contributes to a more positive student attitude, increasing efficacy and reducing anxiety, therefore improving their attitudes toward the lesson focus (Jameson & Fusco, 2016; Hung et al, 2014).

Additionally, nontraditional students appear to be willing to learn and flourish in a technologically aided environment compensating with additional time and effort mastering the technology (Henson, 2014). Since nontraditional students are willing to put out the effort to use technology, Knewton Adaptive Learning tools within the MML must be useful and further learning in a manner that is easy to use and understand, so it perpetuates nontraditional students' willingness to use the technology. A quasi-experimental study conducted by Eyyam and Yaratan (2014) examined 41 secondary students in a private high school mathematics class in Cyprus looking at their attitudes toward technology, and the impact that the technology had on their achievements in the class. The use of educational technology had a positive impact not just on student performance in the class, but also on their progress in the subject. It also had to be in a manner that had meaning to the students (Eyyam & Yaratan, 2014).

Pearson's MyMathLab

Jamil and Chabi (2015) conducted a study that investigated 675 students at Qatar University's Foundation Program who used MyMathLab (MML) to complete the course to see the effect of Learning Management Systems, such as Pearson's MML, to improve math skills. Jamil and Chabi's findings indicate positive learning outcomes are contributed to by the use of learning management systems, such as MML, and innovative teaching. Pearson's MML is a learning tool that incorporates Knewton Technology for adaptive learning. MML is used to motivate students to continue classwork outside of the classroom by providing the means and tools needed to complete homework (Jamil & Chabi, 2015). MML provides the learner with many tools that can be used to learn the material, including “Help me solve this” and “View an example” functions as well as online access to the course book (Pearson Education, 2015).

The use of computer-based learning systems enables students to move forward and receive additional help via the program, as needed. A study conducted by Bol, Campbell, Perez, and Yen (2016) investigated self-regulation on metacognition and math achievement of 116 developmental math course students at a community college in Virginia using an experimental design. Self-regulated learning is required of students when using this form of technology since the learning is placed solely on them (Bol, Campbell, Perez, & Yen, 2016). Jamil and Chabi (2015) suggested that all students should take responsibility in completing their work as needed and suggested within MML. The learning environment provides the tools needed to learn, the students need to take the initiative to move through the processes (Pearson Education, 2015).

An additional tool that is provided within the program is the MML study plan. According to Pearson (2015), the study plan provides students with additional mathematical problems and guidance for improving their knowledge of the subject. When a student completes a homework, quiz, or test, the study plan is updated to reflect the student’s area of weakness so that better understanding of the concepts can be achieved. When the study plan is completed, the students typically show a very strong positive correlation with their overall math grade (Jamil & Chabi, 2015).

The technology used in the MML environment provides short videos, as well as the examples used in the help sections. Students tend to show a positive learning outcome when the technology is animated, as well as communicating with classmates and the instructor (Jamil and Chabi, 2015). Butler and Sears (2015) conducted an exploratory study involving fourteen students in an Intermediate algebra course at a southeastern United States public university, examining the role technology has on student anxiety and learning. They found anxiety caused by the use of MML, can lead to difficulties for some students, which can affect their attitudes (Butler & Sears, 2015).

Raines (2016) surveyed 125 students in a beginning mathematics class at a 4-year public southeastern United States university, after taking an MML midterm, in order to analyze student perceptions of MML. According to this study, a downfall to MML is the inputting of answers (Raines, 2016); which was also corroborated by Butler and Sears (2015). The answers must be exactly as the computer program requires, any additional spaces or incorrect symbols can cause the answer to be seen as wrong when the student had actually found the correct answer (Raines, 2016).

The homework that is required within the MML is set up to provide immediate feedback when a question is answered incorrectly. Many students find the immediate feedback a large benefit to completing and learning the content (Butler & Sears, 2015; Raines, 2016). Students also feel that completing the homework directly affects their learning the topic, and therefore their grades (Raines, 2016). Callahan's (2016) study assessed online homework implementation in a first semester calculus course against pre-implementation of the same course, comparing Fall 2011 students with Fall 2012 students as well as Spring 2012 students with Spring 2013 students from 212 American colleges and universities. In some cases, students were relying too heavily on the tools provided with the homework, using them to complete the tasks, but not learn the material

(Callahan, 2016; Raines & Clark, 2016; Raines, 2016). This had a direct effect on their grade in the course.

The tests and quizzes provided by MML often focus on procedures, as opposed to conceptual understanding of the content, which may not test for understanding by the students (Butler & Sears, 2015). This may lead the students to believe that procedures are more important than being able to solve a problem from a conceptual standpoint. However, students who complete their homework tend to have a higher test score (Raines & Clark, 2016; Raines, 2016).

Summary

While the number of nontraditional students is growing for numerous reasons, such as the need for a degree in order to advance at work or due to a change in career or as a means to increase their earning potential (Johns & Good, 2011), the research on how to best serve this population still needs to be examined at a greater level. This population is beginning their higher education with unique wants, needs, and expectations that requires greater research, specific to them, in order for them to be successful in their pursuit of a bachelor’s degree (Jameson & Fusco, 2014).

Research has focused on attitudes toward mathematics in many areas over the years (Benken et al., 2015; Hodges & Kim, 2013; Jameson & Fusco, 2014; Wolfe & Williams, 2014; Zan & DiMartino, 2007). However, in regard to the use of technology in the math classroom and its influence on attitudes toward the use of technology and mathematics in regard to nontraditional students, very little research has been conducted. The research on attitudes toward mathematics is limited in the areas of blended mathematics classrooms and adaptive learning. Current studies indicate adaptive learning has a positive impact on students so that they are willing to use the technology involved (Papouisek & Pelanek, 2015). Eyyam and Yaratan (2014) also stated when the use of technology in the classroom is positive, students tend to incorporate more of the technology into their learning processes. Classrooms that are instructed by faculty who use information communication technology well, such as the tools within blended classrooms and the MML platform, contribute to positive experiences for students (Venkatesh et al., 2014). While these areas contribute to an understanding toward nontraditional students' attitudes toward mathematics and technology in the classroom, they do not fully explain it.

The use of technology on a daily basis is commonplace to most people, so that incorporating it into the classroom has become a natural progression (Jesnek, 2012). Its use has evolved over the years from calculators to programs that allow students to advance their knowledge by providing the tools to customize their learning through adaptive learning and teaching (Erbas, Ince, & Kaya, 2015; Jesnek, 2012). Technology now provides the tools needed to graph or complete computational work, which has helped to influence students' attitudes toward the use of technology (Erbas et al., 2015).

Adaptive learning research is limited when specifically looking at nontraditional learners in the college setting, with very little on a blended mathematics classroom. While the adaptive learning environment is rapidly gaining ground in the classroom, the extent, uses, and acceptance by nontraditional students, as well as their attitudes toward the technology in the classroom, has not been adequately studied.

MyMathLab (MML) is a learning program that utilizes Knewton Adaptive learning in order for students to have a customizable learning environment (Pearson Education, 2015). The program provides homework as well as quiz and test usage. Students appreciate the homework function as it provides immediate feedback when completing the problems, as well as helping them when questions arise (Pearson Education, 2015).

Chapter 2 reviewed the literature that relates to nontraditional students, attitudes toward mathematics; attitudes toward technology and mathematics, adaptive learning and the MML program. In Chapter 3, the research design, rationale, and methodology used in the study is discussed, as well as data collection and analysis.

Chapter 3: Research Method

There was a gap in the research based on previous studies regarding the use of technology by nontraditional students in blended classrooms, specifically adaptive learning methods (Jamil & Chabi, 2015; Johnson, & Samora, 2016; Murray & Perez, 2015). The purpose of this sequential explanatory mixed-methods study was to explore the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML and their attitudes toward mathematics and the technology used in a blended mathematics classroom at a local community college in the Philadelphia, PA region. The ATMLQ was used to gather information regarding attitudes toward the use of technology and mathematics in a mathematics classroom when an adaptive learning environment was used by nontraditional students. Qualitative data were gathered through interviews.

The following quantitative questions were addressed in the study:

RQ1. What was the difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology?

$H1_0$: There was no significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology.

$H1_1$: There was a significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology.

RQ2. What was the difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward mathematics?

$H2_0$: There was no significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitude toward mathematics.

$H2_1$: There was a significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitude toward mathematics.

The following qualitative questions framed the study:

RQ3. How did students perceive the influence of the Knewton Adaptive Learning component of MyMathLab on their attitudes toward the use of technology?

RQ4. How did instructors perceive the influence of the Knewton Adaptive Learning component of MyMathLab on students' attitudes toward mathematics?

This chapter contains information on the setting of the study, how students were recruited, the research design, my role as the researcher, and the study's participants. The instruments used and possible ethical considerations are also addressed.

Research Design and Rationale

The sequential explanatory mixed methods design was used for this study. Creswell (2009) stated that the sequential explanatory strategy is used when a researcher uses qualitative results to assist in explaining the quantitative findings of a study. The sequential nature of the study allowed for the survey to be collected first in order to gather quantitative data; I followed up with students through interviews. This design allowed for the qualitative results of the interviews to explain and interpret the findings in the quantitative portion. This allowed for convergence of findings gathered by both methods to strengthen and understand these findings. The use of only quantitative data gives only statistical information regarding students' attitudes toward technology in the mathematics classroom and hence affords a narrow view of what the students' attitudes are. The use of qualitative techniques allowed the study to capture rich and informative data about the inner thoughts and processes that nontraditional students used when working with the technology. When the qualitative data were combined with the quantitative data, a deeper level of data regarding the students' attitudes toward technology in the mathematics classroom was analyzed. Developed through a mixed methods approach, the findings indicated a more robust solution for improving the use of technology in the math classroom for nontraditional students.

Role of Researcher

I am currently a high school math teacher at a suburban public school district but worked previously as an associate math professor for DeVry University, where I taught classes that used MML. From the beginning of the study, bracketing was essential so that I could lay aside all preconceptions and biases (Tufford & Newman, 2010). As the researcher in this study, I laid aside my presuppositions regarding the usefulness of MML from my personal experience of using it as a teaching and learning tool, so that I did not interpret the data incorrectly. To ensure epoche and maintain trustworthiness, the quantitative component of this mixed methods study helped to counter biases or presuppositions from personal experiences.

For this study, I recruited students who were willing to complete the survey, and I conducted interviews with these same students, who additionally volunteered to be interviewed, from the community college in their mathematics classes that used MML in blended mathematics classrooms. I made initial contact with students through emails sent to all qualifying students in participating classes, in which I asked for their participation in the study. In order to control and manage bias in this study, I avoided surveying and interviewing any student with whom I had previous contact in the classroom. I transcribed each interview so that all information was accurate, including any difficulties in any of the interview sessions.

Methodology

The use of a sequential explanatory mixed methods approach was accomplished through a two-tier process. The first tier involved the collection of data using the

ATMLQ survey through SurveyMonkey. The second tier involved the interviewing of both professors and nontraditional students who had agreed to provide additional information after completing the survey.

Participant Selection

Students are considered nontraditional when they are older than 25 years of age and attending college for the first time (National Center for Education Statistics, 2014). The students in this study were in their initial mathematics class that utilized MML at the community college. An a priori power analysis determined that a minimum of 30 participants needed to be recruited to complete the survey from the two campuses (Malterud, Siersma, & Guassora, 2016). The power analysis used three groups for the calculations with a power of .80, effect size of .50, and a significance level of .05 and was calculated using the Power calculator found on the Statistical Decision Tree website (Statistical Decision Tree, 2018). The effect size of .5 was chosen because it provides for a generally accepted moderate effect, while the power of .80 falls within the generally accepted range of .80 or greater; additionally, the most commonly accepted significance level of .05 was used in the calculation for sample size (Zint, n.d.) The qualitative portion of the study used a purposeful sample with a minimum of 12 participants randomly selected from those who indicated willingness to be interviewed (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood., 2015; Teddlie & Yu, 2007). By choosing participants from the three ranges of attitudes as displayed on the ATMLQ survey, sampling strategy allowed for clear inferences to be drawn by including all levels within the study (Teddlie & Yu, 2007). When the participants agreed to be interviewed, their contact information was labeled as to which attitude range they fell within (high negative, neutral, or high positive), and they were assigned a number so that the computer could randomly draw the four participants from each group. The eight student interviewees chosen represented a range of attitudes toward technology in the math classroom, ranging from high negative attitudes to neutral and high positive ones. This allowed for the information gathered from the interviews to be compared and contrasted from each frame of reference regarding attitudes toward technology. A minimum of 33% of the instructors whose classes participated in the study were also selected on a volunteer basis. By interviewing 33% of the instructors, I was able to gather data on a variety of experiences and outlooks toward the use of MML from an instructor's perspective. The instructors chosen represented a range of years teaching as well as use of the MML platform.

Saturation occurs when all themes are discovered in regard to the study being conducted. According to Isman, Mahmoud Warsame, Johansson, Fried, and Berggren (2013), the number of participants necessary to achieve saturation may be as few as six, or it may be a much larger number; no set number is required. Teddlie and Yu (2007) suggested that the sampling strategy should be based on a feasible and efficient technique in order to gather enough information to transfer or generalize conclusions. The sample selected represented a variety of attitudes as indicated by the survey and represented all themes within the study, thus approaching saturation.

Limiting the sample to nontraditional students who were in their initial math classes at the collegiate level helped to provide data on initial attitudes toward technology in the math classroom, as well as attitudes toward mathematics. Students were only allowed to complete the survey by answering initial questions verifying the requirements for the study. If participants entered a birthday before July 1, 1993 and answered in the affirmative to indicate that they were currently in their first college math course, they were able to complete the survey. Each subsequent math course may affect a change in student attitudes toward the use of technology. By focusing on students in their initial classes, I was able to gain insight into their initial attitudes, as well as perspectives that may help in developing tools that will benefit nontraditional students at the beginning of their academic careers.

The instructors selected took part in the study on a volunteer basis. The instructors were all from classes that utilized MML in the classroom. The instructors selected represented a variety of outlooks, as indicated by initial questions regarding the number of years teaching as well as the number of years using the MML platform.

Instrumentation

The quantitative portion of the study included the use of the ATMLQ. This public domain tool measures the attitudes that students have not only toward math, but also concerning the use of technology in learning mathematics. This scale measures attitudes toward situations in which technology is used to learn mathematics and contains 37 items briefly describing various situations that reflect the use of mathematics with and without technology. Responses are based on a 5-point, Likert-type scale. The ATMLQ was developed by Fogarty et al. in 2001 and is intended for use with individuals ages 18 years and older.

The ATMLQ scales ranged from .84 to .92 using Cronbach's alpha internal consistency reliability (Fogarty et al., 2001). The Cronbach's alpha coefficient shows greater internal consistency when the number is closer to 1.0, so anything over .8 is considered good, while anything over .9 is considered excellent (Gliem & Gliem, 2003). During validation, the original questionnaire, which contained 37 items, was reduced to 34 questions. The test-retest validity ranged from .54 (Math-Tech scale), to .73 (Mathematics Confidence), and .78 (Computer Confidence); all three scales are used in the questionnaire as it is broken into three subsections. The Math-Tech scale was focused on during the validity process in order to improve the correlation and the overall validity of the instrument (Fogarty et al., 2001).

Basic demographic information was added to the ATMLQ. This information included age, gender, ethnic identity, number of semesters in school, time between periods attending school (i.e., time between current college experience and either high school or other college classes), and college math classes taken. Gathering these demographic data allowed verification of age and initial math class. Participants were also asked to provide contact information if they agreed to participate in the interview portion of the study.

The survey, as completed by the students, contained demographic information that allowed for verification of the students' age and college math classes completed. These two main questions allowed for any student completing the survey who did not meet the requirements of a nontraditional student in an initial math class to be removed from the data.

A final item was included on the survey explaining the purpose of participating in interviews regarding students' attitudes toward the use of technology in the blended mathematics classroom. When a participant agreed to the interview, he or she chose the affirmative answer and included contact information regarding his or her email address and his or her phone number.

The qualitative portion of the study included semistructured interview protocols established before the process began. This process allowed the participants to be asked structured questions so that everyone could respond concerning particular uses of technology in the classroom, while allowing for the participants to include additional information as needed (Harrell & Bradley, 2009).

I used an interview protocol of six open-ended focus questions as a guide specific to either nontraditional student participants or instructor participants (see Appendix A). The questions for the nontraditional students were developed to discover specific areas that are not addressed in the ATMLQ survey, such as what tools they found most useful and why. The questions specific to instructors were developed to discover how instructors viewed the use of MML within the classroom and how appropriate it was to their teaching methodology. The questions were reviewed by a panel of experts, and changes were made as suggested so that the interview questions were aligned with the research questions. Having the questions vetted by outside experts allowed for the questions to be clear and concise when asked, as well as ensuring that they addressed each area of research for the study. Each semistructured interview was approximately 15 minutes to an hour in length and was audio taped. The length of the interview provided enough time to answer the six questions, while also providing enough time for participants to elaborate on any question. The participants were asked to allow for approximately an hour for the interview in case the time went over. The interview did not end until the participant and interviewer felt confident that all questions had been answered thoroughly and that accurate information had been provided.

The ATMLQ survey provided sufficient data to answer the two research questions. The first quantitative research question, RQ1, concerned the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML in a blended classroom and their attitudes toward the use of technology. Section B of the ATMLQ questioned students' confidence when using computers. This section included statements such as "When I have difficulties using a computer, I know I can handle them" and "I find using computers confusing." Section C of the ATMLQ included specific statements regarding computers and graphic calculators when learning mathematics. This section included statements such as "I think using technology wastes too much time in the learning of mathematics" and "I want to get better at using computers to help me with mathematics." The results from Sections B and C were combined, which provided insights into students' attitudes toward technology in general and when used in the mathematics classroom. Section A of the ATMLQ survey addressed the second quantitative research question, RQ2, regarding the difference between nontraditional students' use of MML in a blended classroom and their attitudes toward mathematics. This section addressed questions regarding nontraditional students' confidence when learning mathematics and included statements such as "I do not have a mathematical mind" and "I enjoy trying to solve new mathematics problems." This section provided insights into nontraditional students' thoughts regarding their attitudes toward mathematics in general.

Nontraditional students from the classes selected received an email in their school email accounts with a link to the survey hosted through SurveyMonkey. Participants were instructed to use the link to take them to the survey. Once there, the initial questions determined if they qualified to participate in the survey. Each survey could only be completed once through the link. If participants entered the survey, they received one of two automatic replies. If they did not qualify, they received a reply thanking them for their time. If they did qualify and submitted the survey, they received an email thanking them for their participation. If participants did not respond, it was assumed they did not choose to participate in the study. Requests for participation were sent out three times over a 4-week period. SurveyMonkey was used for input and collection of raw data from the participants.

Operationalization of Variables

At the end of the ATMLQ survey, a section was included which allowed the participants to indicate what and how often MML tools were utilized. The independent variable for this study was the number of MML tools the nontraditional student used while completing the math assignments. These tools include the e-book, "help me solve this," use of the study plan, "view an example", and using additional practice (Pearson Education, 2015). The independent variable was broken into three categories using one tool, using two tools, or using three or more tools. The categories were assessed using the

5-point Likert-type scale to determine how often all the tools were used, from never to always.

The ATMLQ addressed the dependent variables, which included nontraditional students' attitudes toward the use of technology and mathematics in the classroom and attitudes toward mathematics, in general. The first research question, what is the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML in a blended mathematics classroom and their attitudes toward the use of technology, was addressed with the ATMLQ survey through sections B and C (Appendix B). These sections addressed statements regarding confidence when using computers, as well as the use of computers and graphic calculators in the learning of mathematics. The second research question, what is the difference between nontraditional students' use of Knewton Adaptive Learning components of MyMathLab in a blended mathematics classroom and their attitudes toward mathematics, was addressed with section A (Appendix B). Section A addressed statements regarding student confidence when learning mathematics. Sections A and B include 11 statements each, while section C includes 12. The number of questions in each section allowed for generalization to be determined for each section, as well as the individual statements to be analyzed within each section for a more detailed analysis.

Procedures for Recruitment, Participation, and Data Analysis

After receiving approval from the college, a list of instructors who teach entry-level math courses was provided by the Dean of the math department. I contacted the instructors asking to provide inquiry letters for their students. These letters were either emailed to the students or handed out in class based on the instructor's preference. The letters provided for the students contained information regarding the study and the requirements for participation as well as the access needed for the SurveyMonkey site. The students then self-selected participation. The initial two questions were regarding the student's birthdate and if the current math class was their initial math class in college. If both age and course requirements were met, the student was able to proceed with the survey. If the student did not meet either requirement, they were thanked for their time and the survey ended.

Additionally, the instructor of each class which was selected was emailed an inquiry letter requesting his or her participation in the qualitative portion. The letters provided for the instructors contained information regarding the study as well as the access needed for the SurveyMonkey site. The instructors then self-selected participation. The initial two questions were regarding the number of years they had been teaching, as well as the number of years they had used the MML platform. They were then asked for contact information in order to participate in the qualitative portion of this study.

All interested participants, recruited through the inquiry letters, were asked to complete an online survey during the last two to three weeks of their mathematics course. Once the student passed the initial two questions and was permitted to complete the survey, he or she was then directed to an informed consent form, which also served as a cover letter for the instrument. Instructors were directed to an informed consent form upon signing into SurveyMonkey that also served as a cover letter for the instrument. At the end of the nontraditional student survey, there was a check box for agreeing to the interview that included a statement of informed consent. The student also needed to include a phone number to contact him or her to schedule the interview. If students participated in the survey, but chose to not participate in the interview process, no further contact was made. An automatic email was sent when all participants completed the survey thanking them for their participation.

The interviews were completed after the survey data was collected and initial analysis began. A stratified random sample of twelve nontraditional student participants who agreed to the interviews was selected, four from each of the three groups of surveys; those who had high positive attitudes toward technology in the math classroom, those who had neutral attitudes, and those with high negative attitudes. Including individuals from each subgroup allowed for a variety of backgrounds and experiences to be studied and gave a range of outlooks by the participants. A stratified random sample of four instructor participants who agreed to the interviews was selected, two from each college. Including instructors from both locations allowed for a variety of experiences and gave a range of input.

The interviews took approximately 15 minutes to an hour and were conducted in person. The interviews used semistructured, open-ended questions (see Appendix A). This format allowed the participants to freely express their feelings, experiences, and attitudes. At the end of the interview, participants were asked to review all transcripts of their respective interviews for accuracy. Once the participants verified and/or corrected the transcripts, the participants were sent a final thank you email acknowledging their participation.

Data Analysis Plan

The data analysis plan addressed the following research questions:

RQ1. What was the difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology?

$H1_0$: There was no significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology.

$H1_1$: There was a significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology.

RQ2. What was the difference between nontraditional students' use of Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward mathematics?

$H2_0$: There was no significant difference between nontraditional students' use of Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitude toward mathematics.

$H2_1$: There was a significant difference between nontraditional students' use of Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitude toward mathematics.

The following qualitative questions framed the study:

RQ3. How did students perceive the influence of the Knewton Adaptive Learning component of MyMathLab on their attitudes toward the use of technology?

RQ4. How did instructors perceive the influence of the Knewton Adaptive Learning component of MyMathLab on students' attitudes toward mathematics?

The ATMLQ link was sent to all nontraditional students requesting their participation. The opening page to the survey contained two questions that had to be answered before the survey could be entered. The student had to have a birthday prior to July 1, 1993 and indicate he or she was in an initial college math course. If both were answered affirmatively, the ATMLQ survey opened up for the participant to complete. If neither question fell within the required parameters, the participant was thanked for their participation and the survey did not open. All surveys were only able to be entered once per link submitted so there were no duplicate surveys. Additionally, surveys were verified for duplication by ensuring unique birthdates were represented.

The ATMLQ surveys were downloaded from SurveyMonkey. For the quantitative data collected, descriptive statistics were initially calculated. This included age, gender, ethnic identity, amount of time between math classes, and level of initial college math class taken. Excel was used as a tool when I analyzed the data collected from

SurveyMonkey. When 10% or more of the data was missing from a participant's survey, the survey was deleted from the data. When less than 10% of the data was missing from a participant's survey, the average of all the other respondents was manually added to complete the survey so that it could be included in the data.

There are three sections within the ATMLQ. The first section looked at confidence when learning math and consisted of 11 questions. The second section examined student confidence when using computers and consisted of 12 questions. The final section examined how the student felt about computers and calculators when learning math and consisted of 11 questions. The three sections used a 5-point Likert-type scale (Strongly agree, agree, neutral, disagree, and strongly disagree) for responses. The sections were averaged based on each nontraditional student's response scoring the questions 1 thru 5 to give a summative score for the section. For all statements, both individual and summarized, 1 represents strong agreement while 5 represents strong disagreement with 3 being neutral.

Using Excel, the responses from the ATMLQ were analyzed. I used univariate analysis (ANOVA) to analyze the data for research question one and two, with student use of Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom for the independent variable. The first two research questions addressed the nontraditional students' attitudes toward technology in the mathematics classroom, as well as their attitudes toward mathematics. The independent variable identified three independent groups used for the ANOVA testing including: the use of one Knewton Adaptive Learning component of MML, the use of two different components, and the use of three or more components of Knewton Adaptive Learning components. These components included the use of the e-book, “help me solve this” component, use of the study plan, “view an example” component, and the use of additional practice. A one-way ANOVA looked for differences among the three groups. For this analysis, the dependent variables were students’ attitudes toward the use of technology in mathematics’ classrooms and students’ attitudes toward mathematics as measured by the ATMLQ. Any results with a *p*-value less than .05 were considered significant and supportive of the hypothesis.

The qualitative data analysis phase focused on the nontraditional student interviews and instructor interviews separately addressing research questions three and four. These questions addressed both nontraditional students’ and instructors’ perceived influence of MML on student attitudes toward mathematics. The interviews were transcribed so the information could be organized for analysis. Member checking was utilized in order to improve the accuracy, credibility, and validity of the transcripts (Harper & Cole, 2012). The respective transcripts were sent to each interviewee to be reviewed, corrected, and/or added to as needed. Categories for empirical coding, using emerging themes analysis, was based on keywords provided by students and instructors in the interview process once the member checking was completed (Tashakkori & Teddlie, 1998). As described by Tashakkori and Teddlie (1998), latent content analysis was used to determine the underlying meaning of the data as it emerged through the coding of the interviews. This method for coding was the most appropriate for the study as it allowed for any emerging themes to be determined while allowing for flexibility in looking for underlying themes (Suter, 2011). The coding took place after all interviews were completed, transcriptions occurred, and categories were determined. Dedoose software was used to organize the coding developed from the interviews in order to perform the analysis. The student interviews and the instructor interviews were analyzed separately looking for themes and patterns that were common between the two, as well as differences between two groups. These themes and patterns were used to describe, in a more detailed manner, the influence of MML and the Knewton Adaptive Learning tools on student and professor attitudes toward technology in the mathematics classroom. Any discrepant cases or divergent views found during the analysis of the interviews were noted and included in the final analysis as appropriate (Cho & Lee, 2014).

Threats to Validity

According to Tashakkori and Teddlie, (1998), the more representative your sample of individuals is from the study, the greater your external population validity will be met. In order to address this threat to validity, a representative group of participants from across the spectrum of Attitudes Toward Technology was used in the interview process, should multiple points of view be expressed by the participants. In the event multiple viewpoints were not expressed, analysis was still taking place using appropriate tools to determine relevance and differences with the data.

The greatest threat to external validity came from the fact that this study only included students who had attended a 2-year community. Students might have come from a wide range of cultural and socio-economic backgrounds, but students who fell into higher income brackets may not have been included in this group.

Since the ATMLQ instrument is self-reported, student perceptions can vary based on their experiences in the classroom in the immediate prior time frame of completing the instrument. Additionally, students who completed the instrument and either did not complete the demographic information, or were not accurate with the information, were a threat to internal validity.

Power analysis clarified how many nontraditional students needed to be included in the study to compute sufficient power to detect an effect (Suresh & Chandrashekara, 2012). For this study, an alpha value of .05 with a medium effect size of .75, and a power of .80 required a minimum of 22 nontraditional students to participate in completing the questionnaire. An alpha of 0.05 will decrease the probability of a Type I error, whereas the probability of rejecting the null hypothesis given it is true, is at a low level. The ATMLQ has a Cronbach alpha range of 0.84 to 0.92 for the three components, which enhances the reliability of the quantitative analysis.

Issues of Trustworthiness

A triangulation process was utilized with the interview data and the quantitative findings. The interviews were used to obtain as much information as possible from the participating nontraditional student in a respectful time frame. Students from all three levels of the ATMLQ were interviewed in order to obtain their insights. Procedures and data were made known to the participants. I categorized and coded the data. Member checking for accuracy and corrections as needed was utilized for each transcript in order to check validity.

Transferability is the degree in which the findings can be applied to other populations (Teddlie & Yu, 2007). It was hoped that 30 students, a number higher than the minimum stated by the power analysis, would participate in the study in order to generate findings that apply to nontraditional students living in the Philadelphia metropolitan area and attending a local community college. If less than 30 students participated, additional locations/classes within the community college would have been approached for participation.

Credibility and dependability were accomplished by all interview data being transcribed verbatim while utilizing member checking to ensure correct and complete responses in the transcripts. Extended quotes and rich descriptions were included in the findings. Confirmability of the qualitative analysis was accomplished through clarification of any researcher bias being fully disclosed that would influence the approach and interpretation of the study, including experiences, perceptions, and prejudices (Creswell, 2009).

Ethical Procedures

In this study, all persons contacted to participate were provided with an informed consent form that they were required to agree to in order to continue with the survey via SurveyMonkey. They were told that their participation was voluntary and they were not required to participate in the interview process.

All responses were kept confidential, and survey responses were anonymous. SurveyMonkey coded the participants' identities so any reference to the participants were not identified directly or indirectly. The coding was done in a sequential order by the submission date of the survey. Interviewees were not identified by name or any identifying information in any written material. All data collected via SurveyMonkey or through interviews was kept electronically on an external hard drive that was password protected with only the researcher having the password. The external hard drive is stored in a fireproof safe that only I have access to. The data will be stored on an external hard drive for 5 years, per Walden requirements, after which the hard drive will be wiped clean of all information.

Ethical procedures were addressed through approval of the Institutional Review Board (approval number 08-22-18-0344384) at Walden University. Site approval was sought from the college/university that I wished to use to collect data. The requirement of the college/university that was used to recruit participants was also followed.

Summary

In this chapter, the rationale for this sequential explanatory mixed-methods study was presented, as well as the methodology used. Procedures and strategies for collecting the data from the sample set were also outlined. This study used research questions that focused on obtaining quantitative and qualitative data in order to examine the difference between nontraditional students' use of the Knewton Adaptive Learning component of MyMathLab in a blended mathematics classroom and their attitudes toward the use of technology and mathematics. The study used a stratified random sample to select participants for the interviews. These participants were selected from those willing to be interviewed, after completing the questionnaire on SurveyMonkey. Additionally, methods of reliability and validity were given. Data analysis for the quantitative and qualitative components was also presented. All ethical considerations were outlined. The next chapter will present the results of the study.

Chapter 4: Analysis of the Data

This chapter provides an overview of the study, followed by an analysis of the collected data. The data collected from the study of nontraditional students and their attitudes towards technology in the math classroom are analyzed based on the research questions in the study.

The purpose of this sequential explanatory mixed-methods study was to explore the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML and their attitudes toward mathematics and the technology used in a blended mathematics classroom at a local community college in the Philadelphia, PA region. The study explored the attitudes of nontraditional students regarding three areas in the math classroom addressed in the ATMLQ (Fogarty et al., 2001): learning mathematics, using computers, and the use of computers and graphing calculators in the classroom.

Setting

In this study, I looked at students over the age of 25 who attended a Philadelphia, PA metropolitan area community college. The classes that were used for the study all used the Knewton Adaptive Learning component of MML as a requirement for the class. The classes included Elementary Algebra, Algebraic Concepts, and Introduction to Statistics. The campuses for the study were in two locations, an urban setting and a suburban setting of a Philadelphia-area community college. The students selected were in mathematics class in a college setting that utilized MML.

Demographics

Students were included in the study if they were enrolled in their initial math course during Spring 2019 or Fall 2019 and were over the age of 25 years. The students who participated in the survey were then able to volunteer to participate in the interview process of the qualitative portion of the study. The professors who were interviewed volunteered to participate in the qualitative portion and were initially contacted through informative emails sent out regarding the study from the department chair.

The participants of the study ranged in age from 27 to 54 years. However, the participants were predominantly between the ages of 30 and 34 years. There were 16 females who completed the survey and 14 males. The 30 participants attended classes on both the urban and suburban campuses. Nineteen of the participants attended the suburban campus, while 11 were from the urban location. Not all students completed the race/ethnicity question on the survey. Of those who chose to answer that question, eight were African American, four were Caucasian, and one selected other.

The students who completed the survey were from the three classes chosen to participate. Twenty-three of the students were in the Elementary Algebra classes, one student was in the Algebraic Concepts class, and six of the students were in the Introduction to Statistics class. All student participants listed the classes as their first college math class.

Four professors volunteered to be interviewed for the qualitative portion of the study, two females and two males. The professors currently taught at or had in the past taught at the urban and suburban campuses. All instructors interviewed had over 4 years of teaching experience, with three reporting over 10 years. The instructors had varying lengths of experience with MML, from 4 years to over 10 years.

Data Collection

The ATMLQ was used for the survey with optional demographic questions as well as questions regarding what tools within the MML were used and how often. The survey was housed on SurveyMonkey, where potential participants were given a code as the initial point of entry into the survey. All participants had to verify their age and verify that they were currently in their initial college math course before they could continue with the survey. At the end of the survey, the students were able to volunteer contact information to participate in the qualitative portion of the study.

At the beginning of the Spring 2019 and Fall 2019 semesters, the math department chair sent out an informative email regarding the study. The professors who participated in the study replied to the email with contact information to set up class visits. The data were collected over two different semesters from students who qualified in four participating classes. The purpose of the study was explained to all classes visited during this time frame. The classes that were selected were visited around Week 4 of the semester so that the students had prior knowledge of MML and their typical use of the tools incorporated within the platform. The classes were visited again approximately 3 weeks later to ask for additional participants who qualified for the study and were willing to participate in the qualitative portion of the study.

Flyers were also hung on campus inviting students from the specific courses whose classes had not been visited. The flyers included the requirements for study participation, an overview of the purpose of the study, and the link to the survey in SurveyMonkey. The flyers were hung in common areas where the math classes were typically held. There was also a phone number provided for any additional questions that participants might have.

Participants accessed the survey online via SurveyMonkey between May 1, 2019 and September 30, 2019. Thirty returned surveys were required, according to the power analysis for the sample size discussed in Chapter 3. The data collection efforts were discontinued at the end of September, when 30 surveys were submitted, with the remaining interviews taking place in September and October.

Questions in the interview portion of the study for the student participants addressed issues from the subscales of the survey. The questions were open ended and allowed for the gathering of information not included in the survey (Creswell, 2009). The questions explored students' familiarity with technology, MML tool frequency of use, and how MML influenced their attitudes toward the math class (see Appendix A).

Professors who were interviewed were also asked open-ended questions that allowed for gathering of their input on students' use and comfort with MML in their classes (see Appendix A). The questions explored the comfort level that the professors saw students exhibit regarding MML, students' participation in class and with MML, and the difference that the professors perceived between classes that used MML and classes that did not.

Interviews were conducted between May 2019 and June 2019 and then resumed from September 2019 through October 2019. All interviews were conducted while the professors were teaching the classes and the students were enrolled in the classes. The majority of the interviews were conducted face to face. However, one of the professor interviews and two of the student interviews were conducted via phone. Phone interviews were used because schedules and locations could not be easily coordinated. The interviews ranged in length from 5 to 20 minutes, and participants were given additional time at the end of the interview to include any information that they felt was relevant but not asked.

The interviews were recorded via a recording app on an iPhone so that they could be saved electronically. The transcripts were then prepared, and all interviewees verified them for correctness. The quantitative data were uploaded from SurveyMonkey, where the surveys were completed and stored online. The exported file was saved as an Excel file. Once saved, the data were opened in Minitab to analyze the data.

Problems with data collection included multiple attempts to set up classroom visits with the professors as well as to request student participation in the study. It took multiple attempts to contact professors and schedule dates to visit their classes to present the study to their students. Each class required two to three visits to explain the study and ask the students to participate in the survey. During each visit, a handout with the link that would take individuals to the survey was also given. Student email addresses were collected from any student who was interested in participating so that the link, as well as reminders, could be sent. Two surveys, in addition to the 30 that were kept, were dropped from the initial round because the participants were not over the age of 25 and were not able to complete the survey. Participants indicated initial willingness to take part in interviews by including their email and/or phone number on the survey. It took several attempts to reach the survey participants who agreed to be interviewed and schedule interviews with them. Multiple emails and phone calls were needed to set up times and places to conduct the interviews. Additionally, participants completed all requested demographic information on the surveys, except for the race/ethnicity question, for which only 13 of the 30 completed surveys included data.

Quantitative Data Analysis and Results

The survey used for the study, the ATMLQ, addresses three specific areas: confidence when learning mathematics (CLM), confidence when using computers (CC), and feelings toward computers and calculators when learning mathematics (CCLM). All three of the scales are scored in a positive direction, such that the higher the computed outcome, the higher the confidence level.

Table 1 shows descriptive statistics for the 30 students who participated in the study. The students on average were in their 30s and had been out of high school for 15 years ($M = 15.4$, $SD = 5.74$). Nontraditional students are considered students who have been out of school for a minimum of 7 years. Students in the Algebraic Concepts class comprised 80% of the participants, and Introduction to Statistics students comprised 20% of the participants. Most of the participants were in their first year of college while taking their initial math course (63.3%). Sixteen females (53.3%) and 14 males (46.7%) completed the survey. Finally, data on race/ethnicity indicated that 26.7% of participants stated Black/African American, 13.3% stated White/Caucasian, and 3.3% stated other, with the remaining 56.7% declining to answer the question.

Table 1

Demographics

Variable	*n*	%
Gender		
Female	16	53.3
Male	14	46.7
Race/Ethnicity		
Black/African American	8	26.7
White/Caucasian	4	13.3
Other	1	3.3
Decline	17	56.7
Current math course		
Math 100	22	73.3
Math 107	2	6.7
Math 111	6	20
Semester in college		
1–2	19	63.3
3–4	10	33.3
5–6	1	3.3
Years since high school		
8–13	12	40
14–19	12	40
20–25	4	13.3
26–31	1	3.3
32–37	1	3.3

Note. Demographics for overall sample ($N = 30$).

Research Question 1

Research Question 1 examined the difference between nontraditional students' use of MML and their attitudes toward technology in the math classroom. This question is best answered by examining the data from the third section of questions in the ATMLQ regarding students' feelings about computers and graphic calculators in the learning of mathematics (CCLM). The data examined for Research Question 1 included the usage levels of MML tools by nontraditional students.

A one-way ANOVA was conducted to test for statistical significance when students used the MML tools. The one-way ANOVA was used to examine differences in groups determined by the reported level of use of MML tools. The ANOVA groups consisted of Group A, whose members used MML tools frequently; Group B, whose members used MML tools most often; and Group C, whose members used MML tools every time they used MML, as seen in Table 2.

Table 2

One-Way ANOVA for CCLM Versus Frequency of MML Use

ANOVA: Single-factor CCLM Description: Alpha 0.05								
Group	Count	Sum	Mean	Variance	*SS*	*SE*	Lower	Upper
Group A	5.00	197.00	39.40	22.30	89.20	1.79	35.72	43.08
Group B	17.00	627.00	36.88	10.36	165.76	0.97	34.88	38.88
Group C	8.00	296.00	37.00	25.71	180.00	1.42	34.09	39.91
ANOVA								
Sources	*SS*	*df*	*MS*	*F*	*p*-value	*F* crit	RMSSE	Omega sq.
Between groups	25.70	2.00	12.85	0.80	0.46	3.35	0.35	-0.01
Within groups	434.96	27.00	16.11					
Total	460.67	29.00	15.89					

The *p*-value for the ANOVA results for CCLM (*p* = 0.46) shows no significant difference between the use of the MML tools and students' attitudes in regard to computer and calculator use when learning mathematics. The null Hypothesis 1 was not rejected at the .05 level; therefore, there was no significant difference between nontraditional students' use of the Knewton Adaptive Learning component of MML in a blended mathematics classroom and their attitudes toward the use of technology.

Research Question 2

Research Question 2 examined the difference between nontraditional students' use of MML and their attitudes toward mathematics. This question is best answered by examining the data from the first section of questions in the ATMLQ regarding students' confidence when learning mathematics (CLM). The data examined for Research Question 2 involved the level of use of MML tools by nontraditional students. A one-way ANOVA was conducted to test for statistical significance when students used the MML tools. The one-way ANOVA included three groups determined by the level of use of MML tools in order to get a more accurate picture of the students' attitudes and their use of MML. The ANOVA groups consisted of Group A, whose members used MML tools frequently; Group B, whose members used MML tools most often; and Group C, whose members used MML tools every time they used MML, as seen in Table 3.

The *p*-value for the ANOVA results for CLM (*p* = 0.24) shows no significant difference between the use of the MML tools and students' attitudes (see Table 3). The null hypothesis is not rejected at the .05 level; therefore, there was no significant difference between nontraditional students' use of Knewton Adaptive Learning component of MML in a blended mathematics classroom and their attitude toward mathematics.

Table 3

One-Way ANOVA for CLM Versus Frequency of Use

ANOVA: Single-factor CLM Description: Alpha 0.05								
Group	Count	Sum	Mean	Variance	*SS*	*SE*	Lower	Upper
Group A	5.00	164.00	32.80	92.20	368.80	3.65	25.31	40.29
Group B	17.00	463.00	27.24	75.54	1209.06	1.98	23.17	31.30
Group C	8.00	198.00	24.75	31.64	221.50	2.89	18.83	30.67
ANOVA								
Sources	*SS*	*df*	*MS*	*F*	*p*-value	*F* crit	RMSSE	Omega sq.
Between groups	202.14	2.00	101.07	1.52	0.24	3.35	0.50	0.03
Within groups	1799.36	27.00	66.64					
Total	2001.50	29.00	69.02					

Qualitative Data Analysis and Results

The findings for the qualitative study were guided by eight questions for either the professor or the student who volunteered to participate in the qualitative portion. These questions contributed to an understanding of the perceptions and attitudes that both the professors and the students had toward the use of MML in the classroom (see Appendix A). The responses for the questions were coded into five themes for the professors as well as five themes for the students. These themes were similar to the topics used in the ATMLQ survey. The questions allowed for the participants to add information that they felt was relevant to their use of, comfort in, and attitudes toward the MML.

The initial codes that were discovered during the interviews with students included *attitudes toward MML*, *did not help with MML*, *helped improve with MML*, *math attitude*, *use of MML*, *help me solve this and other tools*, *familiarity with* *technology*, and *amount of time spent using MML*. The theme of familiarity with technology included the code *familiarity with technology* as well as *amount of time spent using MML*. The second theme of MML tool use included the codes *use of MML* and *help me solve this and other tools*. The third theme of attitudes toward MML included the codes *attitudes toward MML*, *did not help with MML*, and *helped improve with MML*. Theme 4, feelings toward mathematics, included the codes *math attitude* and *amount of time spent using MML*. The final theme for students, MML improved class learning, included the codes *did not help with MML*, *helped improve with MML*, as well as *use of MML*.

The initial codes which were discovered during the interview with the professors included: *students approaching professors*, *MML impact on student learning*, *impact of student age on MML use*, *students' sense of intimidation with MML*, and *increasing use by students*. The first theme for professors, Same level of MML use included the codes *MML impact on student learning* and *increasing use by students*. The second theme, increased frustration for nontraditional students, included the code *students approaching professors*. The third theme, Intimidated by MML, included the code *students' sense of intimidation with MML* and *impact of student age on MML*. The next theme, Impact of MML on teaching included the codes *students approaching professors* and *increasing use by students*. The final theme for professors, MML impact on learning outside of classroom, included the codes *increasing use by students* and *students approaching professors*.

Analyzing the data was initiated when all interviews were uploaded to the Dedoose online program. They were uploaded as both transcripts and audio files in order to determine themes and to code the data. Categories were determined by similar comments, ideas, and answers given during both the professor and student interviews. Patterns within the categories were then found within each group of interviews and themes were determined. The coding was done using the Dedoose program making each color-coded response noted under the appropriate categories. The program then allowed for comparisons to find where the similarities and differences were for each set of interviews.

The professors who were interviewed included two males and two females. The professors had from 4 years of experience teaching at the college level to 20 years of experience. Additionally, they had used MML anywhere from 4 years to over 10 years in their classes.

Research Question 3

Research Question 3 examined how students perceived the influence of the tools used in MML on their attitudes toward the use of technology. Five themes were determined during the qualitative analysis. These themes included familiarity with technology, MML tool use, attitudes towards MML, feelings towards mathematics, and MML improved class learning.

Theme 1 for Students: Familiarity With Technology

Five students considered themselves to be very familiar with technology, while three students felt they had some familiarity with technology. The eight students used computers, tablets, and/or smart phones in their working environment, as well as at home. Three of the students mentioned they did not use technology in their math classes in high school and it seemed strange at first to do so, as “it was not how I learned when I was in school”. One student said they typically had problems using graphing calculators, either hand-held ones or computer-based ones and this added to some frustration.

Theme 2 for Students: MML Tool Use

None of the students used the textbook associated with MML, they all felt it was a waste of time when the other tools were available. All students felt they learned as much if they just worked the problems. One student did not use MML at all. Other than stating he “hated the program”, he also offered the reason why “the format, you can’t write it down, the way they explained the answers was confusing, pen and paper was much more helpful.” Another student said he always started with view an example, “to get an idea of what was going on”. Three of the eight students mentioned they used help me solve it the most, as they found it helpful with stepping their way through the problems, while two other students mentioned using view an example as the method that helped them the most. One student said the quizzes were one tool which helped her know where she needed to study the most in order to pass the tests.

Theme 3 for Students: Attitude Toward MML

Three students had a positive attitude towards MML, while only one had a negative attitude towards it, the remaining four students had a neutral attitude towards the program. One student stated, “at first I wasn’t sure about the class, but in the long run it is good since I can work at my own pace.” Two other students also mentioned working at their own pace throughout the class was very helpful to them. Many of the students felt moving at their own pace was helping them to succeed and understand the concepts better because of it. The students also thought that being able to ask questions during the class was like a normal class but having the tools to help outside of the class made the most difference in their success.

Theme 4 for Students: Feelings Toward Mathematics

Three of the eight students had a negative attitude towards mathematics, the other five students had a positive attitude towards mathematics. "I can do the work at my own pace" was mentioned as a contributing factor by several students. One student commented, "some things that you think you know, you don't actually know until you go back and keep practicing. So, this gives me the chance to get better. I go back to old questions just to redo them again to make sure I know it." Since the student had the chance to go back again and again to grasp a concept, she stated she had lost her negative attitude towards math as she was finally understanding the work at her pace.

Three of the students thought MML made the class better since they did not "have to hear the professors talk the entire time." They felt that the professor's teaching for a smaller part of the class and enabling the students to complete the MML work helped them to understand the concept without feeling confused or frustrated by a continuous lecture. One of the students had a negative attitude towards mathematics and did not use MML since he liked "pen and paper" and felt MML was contributing to his dislike of math.

Theme 5 for Students: MML Improved Class Learning

The last theme was derived from comments which were added by the students throughout the interviews that they thought were important. Five students felt MML helped them improve their math abilities, while the other three students did not make comments regarding this. One student enjoyed using MML to learn math. She said, "it makes me think deeper, if I don't pass it, I go back and try to solve it. I go back and keep trying my best, it makes it stick." Another student stated, "I can do it at my own pace, it's easier that way." This particular sentiment was stated by all of the students interviewed, with the exception of the one student who did not use MML for the classwork. The student who did not like MML and felt it took away from his learning stated, "the way it was laid out, it became more frustrating the more I used it".

Research Question 4

Research Question 4 examined how professors perceived the influence of the tools used in MML on students' attitudes toward mathematics. Five themes were determined during the qualitative analysis. These themes included same level of MML use, increased frustration for nontraditional students, intimidated by MML, impact of MML on teaching, and MML impact on learning outside of classroom.

Theme 1 for Professors: Same Level of MML Use

The first question in the professor interviews regarded the use of MML by the students and how comfortable the professor felt the students were at the beginning of the course. The professors did not believe there had been a change in the amount of use of MML by nontraditional students versus traditional students. One professor stated there is often a learning curve for nontraditional student, more than the younger students, when it comes to the applications. Professors acknowledged the program was different than what many nontraditional students were used to using in a math class. The professor who had taught the longest at the college level felt the nontraditional students saw it as “one more piece that they have to conquer besides just doing fractions”. Another professor felt that nontraditional students often need to learn to use the program, especially when entering answers so the program reads them as the correct answer. This process can lead to a higher level of frustration for many students, nontraditional and traditional alike.

Theme 2 for Professors: Increased Frustration for Nontraditional Students

All professors believed nontraditional students had a harder time initially working with MML which leads to added frustration for the students. One of the professors believed the amount of time older students spent on MML was longer and caused frustration with working on the computer for that length of time. Another professor stated “they (nontraditional students) are not always as tech-savvy as the other students, but for the most part I don’t have many issues with it.” The professors, in general, agreed the older students have more patience to learn the program and not give up as easily as the younger students do.

Theme 3 for Professors: Intimidated by MML

When the questions were asked during the interview, the professors often stated many of the same reasons and interpretations of the students’ feelings towards MML. Two of the four professors believed nontraditional students felt much more intimidated than the younger students. As one professor put it, “the older the student is, the more they seem intimidated by the computer work. They did not grow up using the tools in the classroom and it definitely makes a difference." One of the male professors also believed there was a significant difference, with the older students feeling more intimidated than their younger counterparts. He stated, "when you get to those students in their 50s or 60s there is a major hurdle for them [with the MML]".

Theme 4 for Professors: Impact of MML on Teaching

Three-quarters of the professors felt there was no change in the amount of time students spent asking for additional help with the problems while in class. The professor who taught for 20 years did say "it takes away from the student teacher relationship. When I do collect homework, I am able to see their work and where they made mistakes and make comments. It shows them that you are really looking at their work and not at how many you got right or wrong." Another professor stated "the students still ask for help and clarification on the work during class time. They work at their own pace now, so there are often questions from all areas of the class work they need to complete."

Theme 5 for Professors: MML Impact on Learning Outside of Classroom

The professors spoke about MML helping the students when they were not in the classroom. One professor stated the benefit of MML came from out of class time, he stated MML "helps bridge the gap for the five days that I don't see them [the students]". This was also mentioned by two of the other professors. Another point the professors made was the number of questions that students can practice with helps them with the concepts. However, one professor stated that a student had told her last semester "I feel like doing it online is giving me a false sense of reality, I can use the example to do it, but when I do it myself, I can't do it."

Evidence of Trustworthiness

All interviews were completed after the student had been in the math class for over half of the semester so they would have a complete understanding of MML and the expectations within their classes. Students who chose to be interviewed showed a variety of attitudes towards technology in the math classroom, as found in their ATMLQ survey. This allowed for both positive and negative views regarding mathematics and the MML program. All interviews were transcribed and member checking completed by each student for accuracy and completeness within 8 days of the interview. The ATMLQ survey was completed by 30 students, which was the minimum required by the power analysis, so no additional locations were needed.

Summary

The Attitudes to Technology in Mathematics Learning Questionnaire (ATMLQ), was used to collect information regarding nontraditional students', those over the age of 25, attitudes towards the use of MyMathLab (MML) in beginning college level mathematics classes. The students attended a community college near Philadelphia, PA. The college has four campuses, which are located in both suburban and urban areas. One urban and one suburban location were utilized for the study. The students attended one of two preliminary math classes at the college level that used the Knewton Adaptive Learning component of MyMathLab.

Thirty students completed the survey during the spring and fall semester of 2019, of these students, eight volunteered to be interviewed regarding their thoughts and attitudes towards the use of technology in their math classes. These students represented a variety of students, and had a range of attitudes (negative, neutral, and positive) towards both mathematics and technology. They were a fair representation of the data gathered via the survey. Additionally, four professors were interviewed to contribute their insights into their students' use of and attitudes towards MML and mathematics.

There was no significant difference between the frequency of use of MML tools and students' attitudes towards the use of technology in the math classroom according to a one-way ANOVA calculation. The frequency of use of their attitudes using MML and tools and students' attitudes toward learning mathematics show no significant difference either.

The qualitative portion of the study gave more insight into how the students saw MML and its use in the classroom. Most nontraditional students are now accustomed to using technology in their work environment as well as at home, as mentioned during the interview process. This could be anything from smart phones to tablets to computer systems that they use on a daily basis. However, these students were not familiar with or initially comfortable with using MML and its tools as a learning system for mathematics. Their knowledge of technology is helpful, but many are still behind compared to their younger counterparts as they are not familiar with entering or using this technology specifically for mathematics, as mentioned by both students and professors during the interviews.

Chapter 5 discusses the conclusions drawn from the data analysis of this findings in this study. Limitations and implications are addressed that were found also. Recommendations and areas of study may be further researched are also discussed.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this sequential explanatory mixed-methods study was to explore the difference between nontraditional students' use of the Knewton Adaptive Learning component of MML and their attitudes toward mathematics and the technology used in a blended mathematics classroom at a local community college in the Philadelphia, PA region. I conducted this study in order to provide professors and colleges with information that may help them better serve their nontraditional population enrolled in initial math courses. Additionally, the qualitative portion provided insights into how nontraditional students looked at the use of technology as well as their professors' views of nontraditional students' use of the technology.

The null hypothesis for Research Question 1 was not rejected, therefore, there was no significant difference between nontraditional students' frequency of use of MML tools and their attitudes toward the use of technology in math classes. The interviews allowed me to explore nontraditional students' use of technology outside of the classroom and how students felt about its use in the classroom. Students reported substantial positive feelings toward MML and their ability to complete the coursework, regardless of their use of technology outside of the classroom. The null hypothesis for Research Question 2 was not rejected; therefore, there was no significant difference between the frequency of students' use of the MML tools and students' attitudes towards mathematics. However, nontraditional student interviews showed that regardless of the students' attitude toward mathematics, MML was overwhelmingly seen as a very useful tool in succeeding in the math class because it allowed them to work at their own pace.

An interpretation of the findings in this study is presented in this chapter, along with limitations of the study. Recommendations for and implications of future studies are also discussed in this chapter.

Interpretation of the Findings

There are many tools that can be utilized in MML. The students did not use the textbook associated with MML but used many of the other tools that were provided. The tools that were used most often included “help me solve this” and “view an example.” The students, in general, felt that the tools were useful and provided help in understanding the concepts that were being covered. This point supports previous findings by Bray and Tangney (2016) that technological tools help students find new pathways to support their learning. The professors who were interviewed also felt that the tools helped the students with the work when they were outside of the class so that they could have additional learning support. Having the resources to study and do the work outside of class also lets students work at their own pace without feeling as pressured to get the work done. MML may not be for all students, but it does offer tools that can be used by a variety of students in an individualized way. This finding is in agreement with findings from Van Doom and Van Doom (2014), Papousek and Pelanek (2015), and Woods and Frogge (2017). These studies also found that the adaptive nature of the program provides more engagement and further learning for nontraditional students as well as additional time allowances outside of the classroom.

There was no strong positive attitude toward the use of MML; only three of the eight students interviewed felt positively toward it as a program. The lack of positive attitude is supported by the findings of Beilock and Maloney (2015), who reported that interactive learning helped students reduce their math anxiety, even when they did not have a positive attitude toward the subject. The students did agree that being able to move at their own pace with the work was very helpful and contributed to their success with the program and in the class. These results are in agreement with a study by Eyyam and Yaratan (2014) that found that students with a positive perception of educational technology, with continued use, had positive attitudes toward the use of it. However, this study does not agree with the work of Oliver and Stallings (2014), who found that nontraditional students may have more challenges than their traditional counterparts when it comes to blended classes and working online outside of the classroom. The professors felt that students did better with MML because it provided a learning tool to supplement instruction when the students were not in class.

Five of the eight students interviewed had a positive attitude toward mathematics. This may have contributed to student success and completion of the work with MML. These students were more willing to go back and review their work and use the MML tools in order to master the concepts. They felt that the tools helped them succeed at understanding a concept by being able to practice it again and again at their own pace. According to Raines (2016), 97.6% of the 125 students surveyed in her study believed strongly that online homework helped to improve their success with mathematics for the course. This study agrees with those findings, but only at a 62.5% rate for the study participants.

Three of the four professors interviewed believed that nontraditional students were more intimidated by MML than their younger counterparts. They felt that this was due to older students not having used computers in high school, especially in their math classes. This finding is in agreement with Jameson and Fusco (2014) and Wyatt (2011), who stated that nontraditional students often felt the need for additional training in computer programs in order to succeed in class. This also leads to frustration for nontraditional students, as they are not only relearning math concepts that were forgotten, but also learning the program they must use to do the work.

The professors also stated that nontraditional students used MML at the same rate as traditional students. Venkatesh, Croteau, and Rabah's (2014) study also supported the finding of MML's effectiveness, the tools support metacognition as well as the adaptive learning used by MML. A concern that one of the professors had was the availability of the internet for her students when they were not in the classroom. This would possibly affect traditional and nontraditional students at the same rate.

The findings show that MML is a good tool for nontraditional students to use regardless of their attitudes toward technology or mathematics. MML provided a way for students to practice the concepts in a manner that worked for them, using tools such as "help me solve it" or the quiz functions, which allowed them to work at their pace and level of current achievement. Papousek and Pelanek's (2015) study also indicated that the adaptive nature of programs such as MML allows students to proceed with work at an appropriate level and therefore has a positive impact on students' willingness to work with the system. Allowing the students to revisit the content as often as needed and the provision of additional problems helped the students master the concepts and succeed in the class. This also agrees with the findings in Willans and Seary's (2011) study, where they found that although nontraditional students felt stress and trepidation due to being out of the classroom for a length of time, the tools in MML gave the students support to complete and succeed with the work.

MML may not change or improve attitudes toward mathematics in the classroom. However, it does not seem to increase negative attitudes that students come to class with. If students do not like math, they may still not like math, but they have tools they can use to master concepts that they may not have been able to master before. Older students may not have as easy of a time learning the program initially, but they do overcome the problems working with the software. This study is not in agreement with Butler and Sears (2015) or Raines (2016), in that the entering of answers and the way that answers must be entered caused additional stress for nontraditional students. However, the study does agree with Butler and Sears (2015) as well as Raines (2016), that MML allows students to work at their own pace and improve their knowledge base while succeeding in their math classes.

While the nontraditional students in the study may have used MML at the same rate as their younger counterparts, frustration was felt at the beginning of the class when learning how to use the program in addition to learning mathematics. The study indicated that the adaptive nature of MML involves multiple tools that allow individual students to learn in the method best suited for them. All students can find the types of tools they are comfortable with and that help them learn in the best way possible to understand each concept. The ability to move at the pace needed by students during the learning process helped to contribute to their success with both the program and the class. The additional support that students received when work was completed outside the classroom was another contributing factor to student success in the class. While not everyone in the study had a positive attitude toward mathematics, students' willingness to learn and practice the concepts was not a contributing factor to student success based on their attitude. Overall, the study found that the use of MML had a positive impact on the students, providing them with multiple methods to learn the material, providing support outside of the classroom, and allowing them to practice and reinforce concepts as needed.

Limitations of the Study

There were two limitations to this study. The first dealt with the sample size of the study. The study was completed by 30 nontraditional students, eight of whom volunteered for the interview portion as well. Four professors volunteered to be interviewed. Over a period of two semesters, nontraditional students in their initial math class were invited to participate in the ATMLQ survey as well as the interviews. The majority of participating nontraditional students were in the night classes that the college offered. This may have contributed to the limited number of participants because nontraditional students typically have jobs during the day and limited time available. However, the students represented a variety of attitudes toward mathematics and the use of technology in the math classroom, as demonstrated in their completed surveys. Therefore, according to Teddlie and Yu (2007), this was a reliable measure of nontraditional students' attitudes toward technology in the math classroom.

A second limitation was related to the location of the study. The study was conducted at a Philadelphia area metropolitan community college. The classes used in the study were held in both urban and suburban locations but were limited to the Philadelphia area. Transferability may be restricted to rural settings or outside of the east coast region.

Recommendations

Recommendations for future studies are based on the study's main findings and results in the context of the supporting literature. The first recommendation is based on the results regarding the use of MML tools by nontraditional students. The students did not use the book for the class, which was housed in the MML application. Encouraging nontraditional students to initially read the book for each topic before starting the work might lead to a quicker and deeper understanding of the material. This goes along with the findings of Butler and Sears (2015) that students using MML were able to follow procedural knowledge but not conceptual understanding when solving the problems within the program. Future quantitative research studies should be conducted to explore the level of understanding that students gain when using the textbook within MML, as compared to when they do not use the textbook, to see if there is a significant difference in content knowledge.

The second recommendation is based on nontraditional students' feelings of intimidation in using the MML program to learn math. Beilock and Maloney (2015) stated that students who experienced anxiety due to math typically had greater mathematical abilities than they were able to demonstrate. Tennant (2014) stated that nontraditional students were often more motivated than their traditional counterparts, yet their math classes were a barrier to their persistence. A basic computer class that teaches or demonstrates a variety of computer applications and programs may help many nontraditional students feel more comfortable with the program being used in the mathematics classes they will need to take. Therefore, research should be conducted exploring the use of prerequisites that involve basic computer classes to determine if this improves student perceptions of the program's usability. Additional data collected could determine whether MML students who had a prerequisite computer course have more positive outcomes in their mathematics courses.

The third recommendation is based on students working at their own pace. During follow-up interviews, all students and professors commented on the ability to work at their own pace using the MML program. Students working at their own pace can lead to problems for students if they move too fast or too slow in getting the work completed. Raines and Clark's (2016) study showed a logical correlation between the amount of homework completed and higher test grades. However, it also suggested that students may, on occasion, rely too heavily on MML tools and receive lower test grades. Students may work too quickly, resulting in them not gaining a deep understanding of a topic, even if they pass the knowledge test, or they may work too slowly, being hesitant to move on to a new topic. Further research should be conducted with students in classes that have a proposed timeline of completing work for the class versus those who work at their own pace. Findings will confirm if there is a difference in the attitudes that students feel toward the work and the subject when they are able to work independently.

The fourth recommendation is based on additional math courses continuing to use MML within the requirements of the courses. According to Serin (2017), technological devices can change student attitudes toward mathematical learning, creating more interest in the subject as well as motivation to succeed. Additionally, Davidson and Petrosko (2015) stated that courses conducted in person with an online component (such as MML) contributed to student persistence. Researchers would benefit from additional studies of nontraditional students' use of MML in later math classes and their attitude toward its use. It would be beneficial to determine whether each additional mathematics course used by students improved their understanding and/or attitudes toward the subject as well as their persistence in college.

The last recommendation is related to the limitations of this study. This study was completed with students at a community college only. Therefore, this study should be replicated in a private college that also uses Pearson's MML in students' initial math classes to determine if results are similar.

Implications

The findings from this study produced two areas of implications for positive social change for nontraditional students, especially those in lower level math courses. First, as professors recognize the level of intimidation that their nontraditional students face in coming to a math class when coupled with computer work, they can find ways to alleviate the stressors that nontraditional students are facing. According to Kleisch et al. (2017), faculty development should assist instructors in several areas: encouraging students to use technology as a tool for self-directed learning; incorporating instruction and adaptive learning technology; and connecting student learning, feedback, and discussion boards seamlessly. Many of the students interviewed stated that if they had understood how the computer was used in the class before the start of the semester, they might not have been so intimidated at the beginning of the class. Two of the students had put off taking the class as long as possible because of the use of technology. Professors and college administrators may be able to improve attitudes toward the first math class taken by nontraditional students by being proactive in demonstrating how and for what purposes MML is used in the classroom during their new student orientation program.

A second implication for positive social change is with respect to nontraditional students. As nontraditional students acknowledge and become proactive in dealing with their lack of computer knowledge, strategies to combat stressors and intimidation can improve their success in the classroom. According to Henson (2014), even though nontraditional students had fewer technical skills than traditional students, they had a greater preference for using technology in the classroom. Initial math courses taken at college are typically considered gatekeeper courses and limit many nontraditional students from successfully obtaining their degree. Ahmed, Minnaert, Kuyper & van der Werf. (2011) stated that enhancing students' self-concept with skill development strategies may be more effective than addressing student anxiety. When students voice their concerns, frustrations, and stresses found in mathematics classes that use technology such as MML, guidance and additional resources can be obtained to promote positive self-concept regarding both math skills and computer use in the class. This may help nontraditional students succeed in college and obtain their degree.

Each student is different in how they learn best, and what approach they take to study. The nontraditional student population is growing, adding to an increasingly diverse learning population with different backgrounds regarding the use of technology (Henson, 2014; National Center for Education Statistics, 2014. The integration of this study's findings to inform how MML is used in mathematics classes may impact effective implementation of teaching methods and approaches used to improve attitudes towards technology in the mathematics classes. The use of mixed methods in this study to determine nontraditional students' attitudes towards the use of MML in the classroom gave insight into the areas which most concerned these students. As stated by Serin (2017), technology can change student attitudes towards mathematics and is therefore important to address. The use of tools in MML which provide feedback and allow students to progress at their own pace, according to many of the study participants, was a key to their success in the class. Using the empirical data from the study to validate the feedback from interview participants enabled me to provide information many nontraditional students felt was important to their success with the technology and in the class.

Conclusion

The findings of this study support assisting nontraditional students to prepare for technology required in their mathematics courses. This conclusion aligns with research regarding past use of technology and knowledge of technology for nontraditional students (Khiat, 2017; Papousek & Pelanek, 2015; Venkatesh, Croteau, & Rabah, 2014). The study shows evidence that the majority of the students acknowledge the benefits of MML but have some trepidation regarding the use of the technology, which agrees with the findings of Jamil and Chabi (2015). The findings also suggest professors, as well as college administrators, need to acknowledge the frustration and attitudes nontraditional students come to class with regarding the use of technology and MML. This is found in student comments regarding their putting off beginning mathematics classes due to fear of not only the subject but also the use of a computer program in the class, that they know little about. Nontraditional students expressed their desire to work at their own pace and were satisfied with MML allowing them to move on at their own pace with the tools they require to be successful, which agrees with the findings by Bol, Campbell, Perez, and Yen (2016). The professors expressed positive reactions to the resources provided by MML including a variety of learning tools to support the nontraditional students when not in the classroom.

To improve the implementation of technology in the mathematics classroom for nontraditional students, one must understand if the ease of use and level of stress decreases as students' progress through their mathematics courses. Past studies looked at the use of MML components and student attitudes towards what they can offer to learn the material but was not specific to nontraditional students and their unique needs. Beginning mathematics courses are the gateway to college success and students earning their degrees. This has a direct effect on completion of college and future success of the student.

As with past studies, (Bol, Campbell, Perez, & Yen, 2016; Jamil & Chabi, 2015), this study found nontraditional students do not necessarily have a positive attitude towards mathematics or the use of MML in the classroom, but found success in using the MML tools, nonetheless. Moving at their own pace was one key component of their success. This was repeated by students and professors alike. The contribution of this study is most noticeable in two areas. First, nontraditional students use and learn from MML much as their traditional counterparts do, despite any deficits in their use of technology. Secondly, the findings disagree with that of Oliver and Stallings (2014); nontraditional students, according to this current study, do not have challenges in blended classes or with the online component of the work. Nontraditional students are now becoming more tech savvy and are keeping up with their traditional student counterparts, as they find the extra help provided by MML and working at their own pace works best for them to succeed in the class.

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Appendix A: Open-Ended Focus Questions for Interviews

Student Participant	Instructor Participant
What is your familiarity with technology in your personal/work environment?	Do you see MML and Knewton Adaptive Learning as useful tools for students? Were students comfortable with MML at the beginning of the course?
What tool(s) in MML did you use most frequently?	Do you see a trend toward specific MML tools being utilized more frequently? Was there a difference based on age?
What did you find most useful about that tool(s)?	Did the students feelings of intimidation or comfort with using the MML change over the course of the class?
What tool(s) in MML did you use least frequently? Why was it not useful to your learning the content?	Have you noticed a change in student attitudes when MML is incorporated in a class?
Do you believe the use of MML was a factor in achieving success (passing the course)? Yes: how? No: why?	Do the students approach you more or less frequently with questions when they use the MML tools?
How do you see MML influencing your attitude toward mathematics?	How do you see MML influencing students' attitudes toward mathematics?

Appendix B: Attitudes Toward Technology in Mathematics Learning Questionnaire

A. The following statements refer to your confidence when learning mathematics. Please indicate the extent to which you agree or disagree with the statements by ticking your preferred option.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I have less trouble learning mathematics than other subjects.					
2	When I have difficulties with mathematics, I know I can handle them.					
3	I do not have a mathematical mind.					
4	It takes me longer to understand mathematics than the average person.					
5	I have never felt myself able to learn mathematics.					
6	I enjoy trying to solve new mathematics problems.					
7	I find mathematics frightening.					
8	I find many mathematics problems interesting and challenging.					
9	I don’t understand how some people seem to enjoy spending so much time on mathematics problems.					
10	I have never been very excited about mathematics.					
11	I find mathematics confusing.					

B. The following statements refer to your confidence <u>when using computers</u>.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I have less trouble learning how to use a computer than I do learning other things.					
2	When I have difficulties using a computer I know I can handle them.					
3	I am not what I would call a computer person.					
4	It takes me much longer to understand how to use computers than the average person.					
5	I have never felt myself able to learn how to use computers.					
6	I enjoy trying new things on a computer.					
7	I find having to use computers frightening.					
8	I find many aspects of using computers interesting and challenging.					
9	I don't understand how some people can seem to enjoy spending so much time using computers.					
10	I have never been very excited about using computers.					
11	I find using computers confusing					
12	I'm nervous that I'm not good enough with computers to be able to use them to learn mathematics.					

C. The following questions refer to the way you feel about computers and graphic calculators in the learning of mathematics. (The word technology is used here to mean computers and graphics calculators.) Please indicate the extent to which you agree or disagree with the statements by ticking your preferred options.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Computing power makes it easier to explore mathematical ideas.					
2	I know computers are important but I don't feel I need to use them to learn mathematics.					
3	Computers and graphic calculators are good tools for calculation, but not for my learning of mathematics.					
4	I think using technology is too new and strange to make it worthwhile for learning mathematics.					
5	I think using technology wastes too much time in the learning of mathematics.					
6	I prefer to do all the calculation and graphing myself without using a computer or graphic calculator.					
7	Using technology for the calculations makes it easier for me to do more realistic applications.					
8	I like the idea of exploring mathematical methods and ideas using technology.					
9	I want to get better at using computers to help me with mathematics.					
10	The symbols and language of mathematics are bad enough already without the addition of technology.					
11	Having technology to do routine work makes me more likely to try different methods and approaches.					

Please indicate which MyMathLab tools you have utilized and how frequently.

		Never	On Occasion	Frequently	Most times	Every Time
1	**Read the associated section in the *e-book*.**					
2	**Used the *"Help me solve this"* tool,**					
3	**Used the *study plan* to determine the areas that need to be worked on.**					
4	**Used the *"view an example"* tool.**					
5	**Used *additional practice* to better clarify and understand a concept.**					