Abstract

For many decades students enrolling in college have been challenged by general education admissions requirements. One of the most challenging is attaining high enough placement scores in math, reading and writing. Of these three testing areas, math has been the most difficult to place into college level courses. Students who do not test high enough on placement exams are then enrolled into remedial education courses. A significant number of students in remedial education courses never matriculate to post-secondary courses and either drop out or don’t start their college education. Within higher education, two-year colleges have seen the greatest number of students failing out of college for this reason. This national issue has provoked many studies, however there has not been any significant method or tool validated to mitigate this problem. Adaptive learning technology has been making some strides in improving failure rates in math, however there has been little research to determine if this technology impacts students at two-year colleges where a great percent of students are nontraditional learners. The goal of this study was to determine if adaptive learning technology impacted math learning outcomes for nontraditional students. This study compared the means of the student groups enrolled into traditionally taught course sections versus those sections taught with adaptive learning technology. Independent samples t-tests were used to compare student outcomes in the same math courses when adaptive technology was used as compared to traditional instruction. This analysis showed little difference between the groups. While the researcher attempted to add qualitative information to the study, the students and faculty did not respond to several attempts to share their perspective.

Keywords: nontraditional learners, adult learning theory, stereotype threat theory, adaptive learning technology, two-year college, instructional methods
Acknowledgements

Going into this program, I thought that I would be able to complete within 3.5 years, however my work and family responsibilities, not to mention back surgery added to the duration. In any event, here I am ready to complete and apply all that I have learned to the next chapter in my life.

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Being the only child of nine to complete any post-secondary degree, it was very tough to explain why I could not attend many family gatherings over the years-I want to thank my family for their patience with me. More than anything, I want to thank my children and husband for hanging in there with me when I complained, couldn’t cook or was just too tired to listen to issues in their lives-I love them more than words can express.
Dedication

For my Father-Lawrence W. Fox: although you are not here to celebrate with me, you have always been my inspiration.
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Chapter 1: Introduction

Problem Statement

According to reports, two to three-billion dollars are spent annually on developmental instruction in post-secondary education (Bautsch, 2013; Pretlow & Wathington, 2011; Bailey, Jeong & Cho, 2010). Many secondary education institutions are not preparing their high school graduates for the educational rigor of four-year colleges (Bautsch, 2013; Spellings 2006). College applicants may not realize they are unprepared for college until they take a college placement exam such as the ACCUPLACER (Kraman, D’Amico, & Williams, 2006). Likewise, many adults seeking to improve their career outlook or pursue a college credential often turn to two-year colleges, yet soon find that they too do not hold the general education deemed adequate for full program admittance. These traditional and adult or nontraditional learners soon face the discouraging challenge of completing developmental courses commonly referred to as developmental or remedial education (Medhanie, Dupuis, LeBeau, Harwell, & Post, 2012).

Developmental education has become very common and is included in the curriculum at many two-year colleges (Provasnik & Planty, 2008). In the year 2000, 98% of public two-year colleges offered a minimum of one remedial course (Tierney & Garcia, 2008). Some estimate that as high as 63% of all two-year college students need at least one remedial course prior to being fully admitted into a program. A large percent of students fail to matriculate beyond their remedial coursework (Medhanie, et al., 2012; Tierney & Garcia, 2008). The issue of remedial education is not new to higher education and a solution has been quite elusive especially at two-year colleges where it applies to both traditional and nontraditional students. This quantitative study will analyze the outcomes of nontraditional learners in remedial math courses at a two-year
college to determine if adaptive learning technologies improve course completion rates and if the performance levels of nontraditional students are like those of traditional learners.

In 2013, as noted in a brief to state policymakers, remedial education programs cost the Nation (States and students) approximately $2.3 billion with estimates of twenty-eight to forty percent of all students needing to enroll in at least one remedial education (Bautsch, 2013) course. The curricular areas that students need development in are math, reading and English, with remedial math being the most difficult to successfully complete (Bahr, 2013). The burden of remedial education is primarily placed on two-year colleges (Levin & Calcagno, 2008; Tierney & Garcia, 2008). These higher education institutions have an added complexity concerning the delivery of developmental instruction for its student body due to both traditional and nontraditional students enrolling in programs each year. Data may discern students by age, gender, and other typical descriptors however; nontraditional college students are defined by more than just objective attributes.

Nontraditional students are distinguished by the pragmatic characteristics of adulthood, with some not actually meeting the legal age-definition of an “adult” (Hardin, 2008). These distinctions may include financial independence, caring for their child and/or parent, household headship, and part-time enrollment in higher education, (Hardin, 2008; Kenner & Weinerman, 2011). Nontraditional students generally have been out of school for several years and will need to improve basic educational knowledge (Pretlow & Wathering, 2013). Many test below college-level math score requirements and are placed in remediation (Bautsch, 2013). Many of these students will never enroll in the remedial course or any other course; essentially dropping out prior to starting a post-secondary credential (Bailey, 2009; Levin & Calcagno, 2008). Of all community college students beginning their college career at the remedial level, fewer than one
out of ten will complete an associate degree within three years (Doyle, 2012). Because of the volume of students failing developmental courses, researchers need to conduct studies to determine a best or better practice of remedial math instruction.

There have been many studies conducted by scholars presenting results on the failures of remedial education with many specific to math, (Bahr, 2013; Hamilton, 2013; Hoyt, 1999); however, there have been only a few that propose or investigate a sustainable model of improvement, and even fewer that specifically examine solutions for nontraditional learners. Proposed educational changes made at the systemic level need to consider the challenge of providing instruction that accommodates the nontraditional learner while at the same time providing appropriate instructional delivery for the traditional student at two-year colleges. This learning distinction is explored in the theoretical framework section.

Two-year colleges typically have an open access policy, allowing most students to further their education regardless of test scores (Gerlaugh, Thompson, Boylan & Davis, 2007; Levin & Calcagno, 2008). This policy increases the need for remedial education research-based solutions that apply to their student body yet there is little evidence presented that promotes improvement in remedial education. Scholars have researched remedial education from a variety of perspectives, ranging from the effectiveness of remedial education (Dai & Huang, 2014) to questioning if remedial education in higher education should exist at all (Bahr, 2008; Doyle, 2012). Other studies have recommended general instructional strategies, restructuring of the curriculum and developing new institutional structures, all with the goal of improving remedial learning student outcomes (Levin & Calcagno, 2008) yet the number of students failing developmental courses remains high. There is little rigorous and specific research to indicate whether technology-based educational delivery has an explicit impact on performance levels of
nontraditional learners and if that impact results in increased course completion rates.
Researchers Akbulut and Cardak (2011) conducted a content analysis study on adaptive educational technologies that addressed learning styles. They noted that 84% of the 70 studies they reviewed were based on the general learning style of traditional learners, none included or identified nontraditional learners (Akbulut & Cardak, 2011). The problem this study will address is completion of remedial math courses by nontraditional learners at two-year colleges and if the use of a specific adaptive learning technology improves student performance. It is only through specific examination of this large percentage of student populations in developmental math courses, can it be determined if this technology augments nontraditional student learning of mathematics.

**Research Justification**

Researchers have conducted many studies on remedial education. The focus has been on methods of instruction (Doyle, 2012), longitudinal studies conducted to follow remedial students placed in developmental education (Bailey, 2009) and analysis of using placement exams (James, 2006; Kowski, 2013; Medhanie et al., 2012; Scott-Clayton & Crosta, 2014), but the number of remedial failures remain consistently high (Bradley, 2011). In recent years, there has been an increased number of studies conducted on the benefits of using different technologies to improve remedial outcomes with the application of adaptive learning technology showing some positive outcomes (Akbulut & Cardak, 2012; Albert & Steiner, 2011). There is however, a significant gap in empirical research between modern adaptive learning technology and developmental math outcomes for nontraditional learners. The problem is, while nontraditional students make up a large portion of the two-year higher education student population, the distinct
needs of this learner population are seldom considered at the two-year college (Miglietti & Strange, 1998).

Although there is much to be concerned about regarding the completion rates of developmental math for nontraditional students, there is hope in the form of an emerging technology that employs personalized instruction that is exhibiting some successes in developmental mathematical education. Considering the number of students in a course and the complexity of each student, human-based personalization of instruction can be extremely difficult for faculty. There have been recent technological developments that apply personalization in the form of adaptive learning technology, that are robust enough to manage individualized learning (Walkington, 2013). These adaptive learning technologies have resulted in improvements in the area of remedial math outcomes for some student groups.

Adaptive learning technology (ALT), is built on a personalization platform by using artificial intelligence (Boykin & Xiao, 2009). By creating knowledge profiles specific to each student, the tool is capable of continuously assessing and developing learning for each student and allows them to work at their own pace (Boykin & Xiao, 2009). In theory, the premise that ALT is structured on seems like a plausible method to improve learning, however scholars do not know if this platform works well for the needs of nontraditional learners. Being that this population is a constant at the two-year college, it is imperative that an improved method of developmental math instruction is validated by research.

**Deficiencies in the Evidence**

Adaptive learning technology is an innovative and developing method of which to continuously update or assess and apply personalized teaching methods (Walkington, 2013). While there have been several research studies conducted to determine various ALT benefits and
effectiveness (Silverman & Seidman, 2011; Taylor, 2008; Walkington, 2013) research is
deficient around nontraditional student performance. Furthermore, there is little research being
conducted that evaluates the post-remedial course impact of applying ALT where both traditional
and nontraditional students learn together, which is the standard for most colleges (Day, Lovato,
Tull, & Ross-Gordon, 2011). Of importance are studies of specific adaptive learning
technologies because these intelligence tools are not created equal in ability or their approach to
learning. The need to solve the remedial math problem can mean big money for software
developers; as such many have thrown their hat into the educational technology ring to create
adaptive learning tools of varying quality and methodologies.

Experts in this area of artificial intelligence state, there are specific criteria that define a
truly adaptive technology (Waters, 2014). Among those attributes are the ability to constantly
assess the student’s knowledge, performance and engagement, and then provide an individual
learning path built on their responses (Galvin-Teich, 2014). The tool must be able to provide
immediate feedback (Waters, 2014). The adaptive response to remediation is data-driven based
on an intricate non-linear algorithm which provides real-time updates on student progress to
faculty (Mödritscher, Garcia-Barrios & Gütl, 2004; Yang, Hwang, & Yang, 2013). Based on this
knowledge, it is highly appropriate that specific research be conducted for each of the ALT
software packages. This study reviewed the McGraw Hill Education adaptive learning software,
Assessment and LEarning in Knowledge Spaces (ALEKS).

**Relating the Discussion to Audiences**

The need for remedial education is at epidemic levels, costing the Nation billions of
dollars. Two-year college administrators are required to dedicate large portions of their budgets
to support students that will most likely fail to complete a credential. The developmental
course(s) adds cost and semesters to a student’s time-to-complete but do not add to the student’s college credential (Tierney & Garcia, 2011). The importance of determining if a tool can increase persistence should pique the interest of educational policy makers, college administrators, faculty and especially students. Tierney and Garcia note, remediation is a public policy concern on the national, state, and institutional levels (2011). This problem not only impacts the student that is held hostage by developmental requirements, but it effects the economy being that the majority of students placed in remediation will not earn a credential and may never meet their full earning potential.

**Significance of this Research**

The consequences of remedial education are far reaching. Economically the impact is enormous with estimates ranging from $1.5 to around three billion dollars (Pretlow & Wathington, 2011) but the impact does not end with fiscal challenges. Remediation demotivates or discourages many students from any educational credential attainment (George, 2012). The costs and educational failures are so great that many of the four-year colleges and universities have stopped offering remediation leaving high school graduates and adult learners with little hope (Pretlow & Wathington, 2011). Community and technical colleges bear the burden to help those who need developmental coursework with the chance of earning a technical credential or transfer to a four-year college (Handel, 2007) but this structure is failing most of these students. In a study about the aftermath of remedial math, researcher Bahr (2013) cited Calcagno and Adelman’s description that remedial education is a burial ground for the aspirations of community college students seeking to improve their lives through education. The reality is, there are millions of students that are excluded from success because they cannot pass remedial math-this is a national problem.
Remedial math success is a pivotal determinant of student persistence at community and technical colleges, however there has not been much research that considers the application of ALT to positively influence student completion rates. It is imperative that researchers find a method to improve pass rates for remedial math students otherwise performance and success rates at community and technical colleges will continue to plummet. ALT has shown some success however in order to determine if this tool promotes math learning for nontraditional learners while at the same time not hampering the development of traditional learners, research needs to be extended.

In recent times, there has been significant developments in the area of adaptive learning technologies. ALT has evolved from an on-line tutoring system to a full-fledge, topic-specific educational system that adjusts the learning content to the student based on interaction and assessment (Waters, 2014). It then determines (and continuously updates), the students learning path with the intent being instruction to specific student deficiencies (Waters, 2014). The inclusion of this type of technology within math remediation has resulted in both successes and some average outcomes (Craig et al., 2013). This technology is fairly new but there have been some studies conducted on its merits primarily in the area of student outcomes when compared to courses that provide traditional didactic instruction. There is however, a gap in the research regarding the use of specific ALT within remedial math courses at two-year colleges and the impact of performance and completion rates of nontraditional students.

The results of the proposed study will extend the research by evaluating the nontraditional student outcome in a remedial math course at two-year colleges in several ways. The researcher reviewed the completion rates of remedial math students using an ALT when compared to those utilizing traditional didactic instruction. The results of the study were used to
evaluate the student outcomes of the nontraditional student when compared to the traditional student in both the didactic course as well as the ALT course.

**Positionality Statement**

For more than twelve years I have worked in higher education both as an instructor and as an administrator. I have been a nontraditional learner for most of my life and have experienced many of the “life events” that define one as such. In my current position, I have worked on several grants that have explored the use of educational technology but none related to adaptive learning tools. As part of my position, I lead the instructional support area for faculty as well as direct the quality and content requirements of all curriculum for a two-year college that serves a lower-socioeconomic, majority-minority student population. This responsibility allows me to direct and create, and support workshops for faculty and staff development; however, I have no direct connection to students. It is also within my role as director of educational technology to support learning technologies. The request to implement educational technologies typically begins through a shared governance committee in conjunction with the Academic Technology Committee of which I am a non-voting member. This structure minimizes biases or opinions of one and allows faculty and students to participate in the experience of exploring appropriate technologies for learning. There are several third party adaptive learning technologies being applied to various courses, however the chance of this research showing bias towards one ALT is minimal due to the student outcomes being measured, not the quality or comparison of the technology.

**Bias and Data**

In my position, I have access and receive curricular, course outcomes, and other college data on a regular basis. Having access to the student course data at the College does provide me
with special information regarding student performance and completion. In addition to this knowledge, I am privy to many of the policies, processes, funding sources and operational nuances of the local technical college district along with some of those at the State level. I classify this knowledge as an opportunity, not as bias, and find defense for this position in the article, Decentring Hegemonic Gender Theory: The Implications for Educational Research, written by Shailaja Fennel and Madeleine Arnot, (2008). Fennel and Arnot (2008) contend that local information regarding the functioning around the educational entity is less important than the research. This data has brought attention to the state of the students in remedial courses at the College and has prompted me to study this area of concern but my goal is to find a method to improve student outcomes and give them hope to move into college courses. I find no interest in affecting the data as my goal is to find methods to improve education for students, not make the data, or a technology, or technology vendor appear any different than what the research discloses.

**Personal Bias**

In my opinion, there is no better feeling than changing someone’s future through educational opportunities. I grew up in a poverty-stricken area and attended the lowest educationally ranked high school within the Milwaukee public school system. I have experienced the feeling of being secondary to those of greater means but through education found a way out of economic oppression. I empathize with many of the students who come to the college only to become dismayed because they cannot pass a placement exam and are sent to “remediation”. I have often asked myself along with peers at the College this question: how many of you, if asked to complete the ACCUPLACER exam believe they would place out of remediation? Although I and my collegial peers have many advanced degrees and years of
professional experience, we truly have to consider this question. It is a goal of mine to find a mechanism that will consider the applicant’s current knowledge and experience and then develop only what they need in order to progress with their educational goals. This could be perceived as a bias but actually, it is a career objective.

**Research Purpose**

The purpose of the proposed study is to determine if adaptive learning technologies, specifically the McGraw-Hill Education tool ALEKS, improves math outcomes for nontraditional learners enrolled in remedial mathematics at two-year colleges and if so, is the completion rate and performance level equal to or higher than completion rates and performance levels of traditional students enrolled in the same course.

**Hypothesis and Research Questions**

**H0** - There is no difference in performance between traditional and nontraditional students in remedial math when using adaptive learning technology.

**HA** - The integration of adaptive learning technology within remedial math instruction results in different performance levels for nontraditional students at two-year colleges.

**Research questions.** Research Question 1-Does integrating adaptive learning technology within remedial math courses result in different outcomes for remedial math learners?

Research Question 2-Does the integration of adaptive learning technologies within remedial math courses impact the completion rates of nontraditional learners at two-year colleges?
Research Question 3-Do nontraditional learners perform at an equal to, or higher level than traditional learners in remedial math when adaptive learning technology is integrated within remedial math instruction?

Research Question 4-Does the student’s comfort level with technology impact the students’ successful completion in remedial math when the course utilizes adaptive learning technology?

**Theoretical Framework**

Adult Learning Theory (Malcolm Knowles, 1980) was determined to best substantiate this study, however Claude Steel and Joshua Aronson’s (2004) Stereotype Threat Theory adds to this study’s importance and validity. Adult Learning Theory provides the principles to understand how and why nontraditional students learn. This framework will guide the study as well as help the researcher along with the reader understand why the nontraditional student is or is not learning. Stereotype threat, while not the main theory for this study, does provide perspective as to why many minority students are specifically failing math.

**Adult Learning Theory**

Adult Learning Theory is often times referred to as andragogy, which stems from the Greek word for “adult or man” and provides a more appropriate learning model for nontraditional students (Thompson & Deis, 2004). Many believe it was first introduced by Malcolm Knowles (Knowles, Holton, & Swanson, 2012); however, andragogy has an extensive history prior to finding its way to Knowles. Scholar, Eduard C. Lindeman, launched the publication “The Meaning of Adult Education” in 1926 (Knowles et al., 2012). By way of this periodical, he brought awareness to the differences of instruction for children as opposed to adult learners. Many other scholars and renowned clinical psychologists extended the theory
Carl Rogers remarks on adult education indicated that it should be based on a student-centered approach. One of Roger’s basic hypotheses supports the independent use of ALT. He noted, “We cannot teach directly, only facilitate learning”, (Knowles et al., 2012, p. 48). While it is true, many have added to the framework of Adult Learning Theory, however it was Knowles that led the development of the theory’s six principles or assumptions that exist today. The six principles of Adult Learning Theory will be explored individually and the connection to ALT will be identified.

Many aspects of Adult Learning Theory also support the premise behind ALT. There are four original principles first introduced by Knowles. These principles are: 1. the need to know, 2. self-concept, 3. learner experience, and 4. readiness to learn (Knowles et al., 2012). Since the original introduction of the first four principles, Knowles added two more assumptions: orientation to learning and motivation (Knowles et al., 2012). The importance of this theory, in the context of this study, is that developmental educators need to understand the educational differences of the nontraditional learner and then use tools that support their success (Kenner & Weinerman, 2011). The inclusion of ALT into remedial math supports and aligns with the principles of Adult Learning Theory.

**Principles of adult learning theory.** The need to know or the “what's in it for me” approach is the first principle of Adult Learning Theory (Rodrigues, 2012). Adults are challenged with many responsibilities that demand their time, finances, and attention; as such they have a desire to know what they will get in return when they add more to their life. The "what's in it for me" perspective to life is understandable when one is juggling a full-time job, children and sometimes parents, along with economic challenges. These busy adults do not enroll into college on a whim. They need to know that the course or program they enroll in will
materialize into some type of gain. Because of this assumption, learning for nontraditional students has to show it is efficient (Hardin, 2008). ALT allows the students to fit learning into their own schedule and provides immediate feedback, thereby satisfying the need to know expectation.

The second principle of Adult Learning Theory is self-concept. Adults feel responsible for their own decisions, directions and learning (Rodrigues, 2012, p. 30). The adult learner is different from the traditional learner—they are autonomous and need to be engaged in order to make meaning out of learning (Rodrigues, 2012, p. 30). Adults will become resistant if others impose on their will. It is specifically noted that once resistance to this model of "training" occurs, the student shuts down (Kenner & Weinerman, 2011). This method alone attributes to the failure of many adult learners. The use of ALT in remedial math will afford students the autonomy they require and be seamlessly coupled with the resources they need.

The role of the learner’s experiences is the third principle. This assumption provides strong rationalization to support the integration of ALT into remedial math instructional delivery. Students enter the classroom with a unique and wide range of experiences and gaps (McGrath, 2009; Chaves, 2006). The need for educational tracks that are personalized is evident based on this assumption, which can be accomplished using adaptable methods of instruction. As such, greater emphasis needs to be placed on individualization of teaching and learning content (Knowles et al., 2012, p. 64). The need to consider the learner's experience is so profound in adult learning because it also promotes the learner's self-identity (Knowles et al., 2012, p. 63). Adults have collected a multitude of experiences and need to have that knowledge-base validated during learning. If this is rejected as non-important or irrelevant, the adult will feel rejected as a person, thus shutting down the learning process (Knowles et al., 2012, p. 65).
Readiness to learn is the fourth assumption; it states that adults will learn when ready based on a need to cope with real-life situations (Rodrigues, 2012). Adult learners that enroll in two-year colleges especially technical colleges do so based on a need or life-changing trigger (Hardin, 2008). This assumption also states that learning needs to be advanced at the pace of the student. This postulation is parallel with the conceptual model of ALT. Learning topics are offered, taught, and then assessed at the pace of the student (aleks.com, 2017). The system moves the student to a higher level of learning when it has been determined that the student is ready. Based on this parallel to assumption four, learning should improve with the inclusion of ALT in the remedial math class.

Principle number five, orientation to learning affirms that adults learn better, when the topic is tailored to realistic, practical situations (Rodrigues, 2012). The traditional method of drilling terms and concepts into the students’ head and then asking the student to memorize this information will not work. This assumption will test the ALT software in its presentation of the relevant and relatable math material. If the student does not connect with the math topics presented because there is no realistic perspective, then ALT may not work for this population (Knowles et al., 2012, p. 66).

Motivation is the final principle of Adult Learning Theory. The principle notes, while the adult learner does experience external motivating factors like increasing one’s salary, internal pressures are more potent and present a greater influence on the adults drive to improve quality of life (Knowles et al., 2012, p. 67). One of the underlying goals of andragogy is to increase the learner's independence from the instructor. ALT supports this direction as it provides independent guidance for learning that proceeds as the pace of the learner's readiness (Knowles et al., 2012, p. 67). Not all learners will progress at the same time. Provisions for the slow and
rapid learner need to be considered when instructing remedial math. In a traditional model this can be problematic considering the faculty to student ratio however with ALT, the need to adapt to the learner is built as part of the learning algorithm.

**Stereotype Threat Theory**

The college researched in this study has a 51% minority-student population (MATC Catalog, 2014). Like this college, many urban-based community colleges have a higher percentage of minority students but what makes learning remedial math for Hispanic and black students different from white students? When compared to white students, black and Hispanic remedial math students are at a significant disadvantage. In an early study conducted by Tate-Green (1990) of remedial students at Howard University, among the variables studied were: test anxiety, mathematics anxiety, and mathematics ability. Of importance was the finding that there were significant findings for the variables related to math and test anxiety (Tate-Green, 1990). The relationship between black students and test anxiety has been further studied and there has been research, which attributed the failures to stereotypes. The theory associated to this phenomenon is Stereotype Threat, which was first coined by Claude Steele, in his seminal study published in the article Thin Ice: Stereotype Threat and Black College Students (Steele, 1999).

The theory posits, when members of marginalized groups are placed in a situation that draws attention to the stereotype that is connected to their culture, such as black males not testing as high on math when compared to white males, they feel such an intense anxiety that they in fact fall prey to the stereotype and do poorly on a test (Aronson, 2004). Because of the anxiety they feel and the stereotype they fear being reduced to, they actually focus so much on the stereotype that they do much worse on a test than if they were tested in a room of similar race or culture (Aronson, 2004). Another interesting finding of their study is how young people are (age
when they begin to become aware of stereotypes (Aronson, 2004). This feeling is then carried through to adulthood (Hollis-Sawyer, 2011). The awareness that primarily minorities experience is intense and they become hyperaware of the differentiation imparted between the races, which then affects their success.

This theory is important to this study because the adaptive learning tool being studied incorporates assessment into the regular learning as opposed to separating assessments from learning activities. By not singling out assessment as its own event, anxiety should be reduced or even become a non-factor since assessment is not conducted separately; it is simply part of the progression of learning. As such, if anxiety is reduced, the performance and outcomes should improve.

**Summary**

Community colleges are struggling to fully admit adult learners into regular programs due to the overwhelming need for most students to complete remedial math courses. Adults or nontraditional learners represent a large population at community colleges. This group of learners has different challenges and needs than traditional learners however they are placed in courses along with traditional students and are taught as a group. Most often faculty maintain their traditional didactic methods, use a book, and a one-size-fits all approach as the instructional delivery.

Various research studies have presented information indicating that personalization of instruction improves learning outcomes, however this methodology is almost impossible for faculty to implement (Walkington, 2013). In recent times, educational software like McGraw-Hill’s ALEKS, which is built on a personalized platform, proposes to improve mathematical outcomes (EGA, 2013; Epper & Baker, 2009). There have been studies which resulted in
improved math outcomes for some groups (Silverman & Seidman, 2011; Taylor, 2008; Walkington, 2013) however there has been little to no research to determine the effects of adaptive learning outcomes on nontraditional students. This study will seek to identify outcomes for nontraditional learners in two-year colleges who have been placed into remedial math. Since nontraditional learners signify a majority of the population at two-year colleges, this study is extremely important for college administration and faculty, but most importantly the results will inform the nontraditional learner who is placed in remediation.
Chapter 2: Literature Review

For many decades, the average age of students enrolling at community colleges has been 28. In recent history, President Obama has proposed legislation, America’s College Promise Act of 2015, indicating the first two years of college be offered for free at community and technical colleges (Stinson, 2015). This initiative may change the student demographic at two-year colleges adding to its population a significant increase in traditional learners. This demographic shift will impact many processes at two-year colleges that adopt The Promise. One thing will remain the same—the need for remedial education. A significant number of adult-learners and traditional students entering or returning to higher education will need to take remedial mathematics courses due to the students’ low placement examination scores. The college completion rate of those who fail remedial math courses is very low, therefore it is imperative that community colleges find a way to improve success rates, particularly in remedial math courses. This quantitative study examines the practical application of a specific ALT to determine if there is a significant difference between remedial mathematics outcomes for nontraditional learners versus traditional learners at two-year colleges.

Organization of the Chapter

The purpose of this quantitative study is to determine if ALT is an effective tool to improve the remedial math outcomes for nontraditional learners at two-year colleges and to determine if the tool is better suited for nontraditional when compared to traditional students. The issue of remedial or developmental learning failures is a National concern. The enormous costs and the disparaging impact on student drop-out rates of those students referred to remedial education is at a critical stage (Bettinger & Long, 2009; Pretlow & Wathington, 2013). National data collections indicate that a large percentage of students enrolled in remedial education are
nontraditional learners yet little research is available regarding remedial math solutions, options, or hope for this student population. For this reason, this study focused on the current state of remedial education at a two-year college along with determining if a method that is gaining popularity, ALT, is a tool that can be used as an andragogical intervention for nontraditional students.

The research being presented will include a synthesis of the purpose of two-year colleges and why remedial education is a primary concern at these institutions. An extensive review of the literature that identifies the characteristics and specific challenges faced by nontraditional students will be provided. Research was collected from the following databases: EBSCOhost, Gale Cengage, SAGE Knowledge, Taylor & Francis Online, and Google Scholar. An overview of personalized learning and an explanation of ALT and its’ alignment to adult learning principles will follow. Results of previous trials and pilots to improve remedial math outcomes will be shared to demonstrate the research and work that has and has not resulted in success within various educational settings. More specifically, use trials of adaptive technologies will be explored to support the application of ALT in remedial math at the post-secondary level. The researcher will identify a specific ALT to be used in this study and explain what differentiates this tool from others claiming to be founded in personalized learning. Finally, the researcher will provide a summation of the literature that supports the justification for this study.

**Purpose and Disposition of Two-Year Colleges**

Post-secondary institutions that offer two-year or short-term credentials typically are referred to as community colleges or technical colleges. According to the National Center for Education Statistics, a community college is a two-year institution that offers programs that lead to associate degrees, diplomas, certificates or their equivalents (NCES, 2017). Technical
colleges are similarly defined; however, there is more emphasis placed on offering students hands-on training for career-based learning. Since these definitions have no differentiating bearing on remedial education, for this research, these colleges will be grouped and referred to as, two-year colleges.

Two-year colleges have many purposes with one of them being, to teach and graduate students with vocational credentials. They accommodate underserved, minority and first-generation college student populations. Two-year colleges typically do not have the admission requirements imposed at many four-year institutions. Because of their ease of access, two-year colleges have a greater population of students who will need many support services, along with developmental education (Bettinger & Long, 2009). In addition to this norm, many times two-year colleges admit students that were not accepted at a four-year college because they were determined to not be academically ready (Jaggars & Hodara, 2014). In recent history, many four-year colleges have closed their doors to remediation and have directed those students to the two-year institutions (Bettinger & Long, 2005). In fact, both secondary education as well as four-year colleges expect remediation to take place at the two-year college even though many claim the education needed should have taken place in K-12 (Bautsch, 2013; Bettinger & Long, 2009).

The percent of students needing remediation has grown as large as ninety-five percent at some two-year colleges with many failing to ever complete a credential (Attewell, Lavin, Domina, & Levey, 2006; Merisotis & Phipps, 1998). The impact of having a large population of remedial students takes a toll on student success which is demonstrated in the college outcomes. Besides poor outcomes, remedial courses don’t allow the student to earn college credits, they are not transferable, they add time to completion, and increase costs. While these implications of
remedial courses are disparaging, one of greatest concerns is the failure of many students to matriculate from remedial courses into college level courses and programs (Hagedorn, 1999; Scott-Clayton & Rodriquez, 2015). This failure has caused some to refer to remediation as the bridge to nowhere, remedial hell or some other negative title that insinuates a failure to complete (Bryk & Treisman, 2010; Complete College America, 2012). Bearing in mind, remediation is primarily conducted at two-year colleges (Hodara & Jaggars, 2014), and that there is no consistent solution in place to increase its effectiveness, it is no wonder that student success is challenging and poor outcomes for remedial education remain rampant.

**Two-year Colleges and Remedial Education**

The need for remedial education is not new or just a two-year college issue, it has been an enigma to post-secondary institutions for hundreds of years and requires attention. As noted by Abraham, Saxon and Barnes (2014), the need for developmental education can be traced as far back as 1636 at Harvard when students needed additional instruction in Latin. Many cite the cause for remedial education is the lack of education within secondary schools and the disconnect between K-12 and college level expectations (Bautsch, 2013). In addition, in recent years many legislators and four-year college representatives have been trying to centralize remedial education within the two-year colleges. In fact, City University of New York (CUNY), phased out remediation at their four-year schools and moved it to their community colleges, (Bettinger & Long, 2005). Furthermore, several states including Florida, Virginia and Arizona, have prohibited remedial education from being offered at their four-year colleges (Bettinger & Long, 2005).

There is no doubt of the push to move the concentration of remedial instruction to two-year colleges. In 2000, it was noted by the National Center for Education Statistics, that 97% of
public two-year colleges offered remedial math courses (as cited in, Trenholm, 2006). This movement to defer the majority of developmental courses to two-year colleges presents monumental challenges at these institutions. Quoting Bahr (2013) in his reference to Bailey and Morest (2006), “Consequently, the promise of equity in U.S. higher education hinges in no small part on the success of remedial education in community colleges” (p. 662). To gain a greater understanding of the condition and burden of remedial education on two-year colleges, further exploration of the student demographics needing remedial education is warranted.

According to the American Association of Community Colleges ([AACC], 2014), community college student demographics include, 57% women, 19% are Hispanic, and 14% are black. Unfortunately, these demographic groups are among the most challenged with passing remedial math courses, with older women reporting higher levels of math course stress than others (Hoyte, 2010). To add perspective, the California Community College system alone maintains 112 institutions, and serves over 2.9 million students (Silverman & Seidman, 2011). In 2007, 84% of their 336,528 students assessed, placed below college level math expectations (Scott, 2009, as cited in Silverman & Seidman, 2011, p. 268). This information provides justification based on the mere numbers of students in need, but there are other reasons why it is imperative that remedial math instruction at two-year colleges warrants additional research.

Among the purpose or mission at many two-year colleges, is both student completion of a credential and matriculation of its graduates into a four-year college (Treat & Barnard, 2012). One of the predictors of two-year college associate degree attainment is completion of remedial math courses (Silverman & Seidman, 2011). Studies have contained information indicating students who complete their remedial math courses are more likely to transfer into a 4-year college (Silverman & Seidman, 2011). It follows then, that successful completion of remedial
math courses is essential to overall student success. In a report written by Robert S. Feldman, and Mattityahu Zimbler, for the McGraw-Hill Research Foundation (2012, p. 3), they quoted the following from the Education Commission of the States in 2010: 27% of students who were required to complete at least one remedial math course went on to earn a bachelor’s degree. This may seem discouraging when adding the statistic that 46% of students who placed into a basic skills class failed to even begin their coursework (Feldman & Zimbler, 2012). Even more important, other studies have provided evidence that among the remedial course types, (writing, reading, and math), math has the lowest pass rate (Bailey, 2009; Bailey et al., 2010; Hoyte, 2010).

Given this information, remedial math looks to be the most difficult of the developmental courses to pass and presents the greatest barrier to two-year college student success. In addition to the previously noted challenges of remedial education, the two-year colleges have an added issue due to the diversity of their student population. Many four-year colleges only need to plan for traditional students (those who recently completed high school). The two-year school needs to provide education and resources for both traditional students and adult learners, (also referred to as nontraditional students). These two groups of students require very different learning strategies as well as support services (Imel, 1994; Kasworm, 2014). Nontraditional learners present their own challenges when returning or starting their post-secondary education and are the focus of this study, additional information and research will be presented to justify this examination.

Research and information was presented in the prior sections on one of the purposes of the two-year college. Providing development for those who test at a remedial level has become one of the duties significantly impacting the success of many of its’ students. Reference was
presented regarding the most challenging remedial subject—math. Next, is an explanation of the challenges students at two-year colleges face with regards to instruction in remedial math.

Two-Year College Students—Traditional/Nontraditional Differences

The majority of two-year colleges experience both the benefits and challenges of being open-access institutions (Mullin, 2012). Open-access means that students with a variety of ages, knowledge levels, and educational goals can enroll. In 2009, the number of college enrollments for 25-29-year-olds and 30-34-year-olds more than doubled (Baime & Mullin, as cited in Mullin, 2012). Also, the number of students under the age of 18 enrolling into community colleges increased from 1.6% in 1993 to 7% by 2009, (Mullin, 2012). Consequently, the range of student learning needs based on age and learning experience may impact the methods of instruction at two-year colleges. This dichotomy of learners requires exploration to determine if they can perform comparatively if all are taught together.

Traditional learners at two-year colleges. Traditional students are defined as those who enrolled in college shortly after completing high school, are 18-24 years old, attend college full-time, are dependent on a parent, and live on campus (Jameson & Fusco, 2014). In the context of two-year colleges, traditional students may not live on campus due to lack of on-campus housing. These students too face their own set of challenges that prevent them from completing remedial courses including the amount of time since their last math course, placement errors, immaturity, etc. The issues nontraditional students contend with are quite different from traditional students and deserve specific attention.

Nontraditional learners at two-year colleges. There is a significant importance of investigating the nontraditional student challenges and characteristics because of how it effects their success in post-secondary education. Nontraditional students make up a large percentage of
the population of all students enrolled in higher education however the amount specifically at two-year colleges is significantly higher than at four-year institutions. According to the American Association of Community Colleges (2014), the average age of all community college students is 28, of note 14% are over the age of 40. Many of them are enrolling, either part or full-time into community or technical colleges to further their education as either a stepping stone to a four-year degree or for employment and/or promotional reasons. According to Thompson and Deis (2004) these learners could be referred to as “nontraditional”.

The term nontraditional student is usually associated with those students who are older than twenty-five (Kim, 2002). A large study of nontraditional students was conducted by the U.S. Department of Education in 1996 lead by Horn and Carroll. Interesting enough, this study helped define the specific characteristics of nontraditional students yet when most refer to nontraditional students the primary reference is to age. While age does help delineate this group, other characteristics contribute more to understanding the nontraditional student complexity.

In research by Susan Choy (2002) she provided information to help improve insight towards nontraditional student challenges. The following is part of the nontraditional definition. Nontraditional students typically enter post-secondary education years after completing high school (Choy, 2002). They attend part-time, while working full-time. They are considered financially independent as determined by financial aid standards (Choy, 2002). Many have dependents ranging from a spouse, to a child or children. In addition, many also have parents or others that rely on them for financial as well as other forms of support. It is important to understand this definition when conducting research with this group. The researcher needs to consider specific life-demands these students experience and the correlation between the number
of characteristics a student can identify with and how it implicates their post-secondary education success (Choy, 2002; Kim, 2002).

Of added importance is the fact that many of the characteristics that identify a nontraditional student are also listed as characteristics that increase students’ risk of failing to succeed in college (Calcagno et al., 2008; Green, Marti & McClenny, 2008; Mullin, 2012). Horn and Carroll (1996) also asserted that the increase in the quantity or accrual of “adult-like” characteristics negatively impacts nontraditional student success. The statistical research conducted by Horn and Carroll for the National Center for Education Statistics happened quite some time ago (1986 to 1992), yet the results and findings are still relevant today and to this study. Of importance is the Scale of nontraditional status (Figure 1), that Horn and Carroll (1996) created. They identified levels of nontraditional status based on the number of characteristics the student could identify with:

<table>
<thead>
<tr>
<th>Minimally nontraditional</th>
<th>1 nontraditional characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately nontraditional</td>
<td>2 or 3 nontraditional characteristics</td>
</tr>
<tr>
<td>Highly nontraditional</td>
<td>4 or more nontraditional characteristics</td>
</tr>
</tbody>
</table>

*Figure 1: Scale of nontraditional status-Horn and Carroll (1996)*

Results from other research indicate, that for students who possess two or more of these characteristics, only 25% will earn a credential (Green et al., 2008). Other descriptors that define the nontraditional student include: delayed enrollment into college after completing high school, being a single parent, being financially independent, and those who did not receive a standard high school diploma (Horn & Carroll, 1996). The impact from these characteristics results in nontraditional students take longer to complete and are at a higher risk for leaving school during
their first year (Choy, 2002; Imel, 1994). In addition to characteristics, reasons why nontraditional students start or return to formal education differ from traditional students.

Nontraditional learners typically attend college based on a life-triggering event such as divorce, loss of employment or a career change (Hardin, 2008, p. 50). Because nontraditional learners most often are juggling a full-time job, taking care of children, parents or both, they have additional struggles that add to the stressors that effect learning outcomes (Hardin, 2008, p. 50; AACC, 2014). Interesting enough, Choy’s research (2002), found that two-thirds of nontraditional students perceived their primary role as an employee as opposed to a college student. Besides understanding the nontraditional learner’s characteristics and the challenges they face, it is also important to review the group as learners and to determine if they learn or need to be taught different than traditional students.

**Teaching the Nontraditional Learner**

Nontraditional learners have many challenges based on their specific characteristics and life circumstances. It is also proposed that nontraditional learners maintain specific learning needs and preferences, as collectively studied and documented by scholar Malcolm Knowles, (Forrest & Peterson, 2006; Holton, Swanson, & Naquin, 2001). The study of adult learning began many decades ago and while Knowles may be the most renown researcher associated to this learning model, there were others that contributed to its’ current state.

**Adult Learning-The Theory**

One of the pioneering scholars addressing the concept of adult learning was Eduard C. Lindeman (Knowles et al., 2012). The launch of his publication “The Meaning of Adult Education’ in 1926 was meant to bring an awareness to the differences between traditional students and adults however, Lindeman did not promote the separation of adults from young
learners. He sought to promote the bi-directional strategies of knowledge sharing and development as opposed to the traditional didactic methods typically used (Knowles et al., 2012, p. 39). With that being said, Lindeman did make available, a list of assumptions about adult learners (Knowles et al., 2012, p. 38):

1. Adults are motivated to learn as they experience needs and interests that learning will satisfy.
2. Adult’s orientation to learning is life-centered.
3. Experience is the richest source for adult’s learning.
4. Adults have a deep need to be self-directing.
5. Individual differences among people increase with age.

Throughout the years, adult learning theory has been extended by several prominent clinical psychologists including, Carl Jung, Abraham Maslow and Carl Rogers (Knowles et al., 2012, p. 38). Carl Rogers remarks on this augmentation to the traditional educational structure, specifically conceptualizing a student-centered approach around the five noted assumptions. Of importance is Rogers’ admonition that we cannot teach another person, only facilitate learning (Knowles et al., 2012, p. 39). He also noted that learning is improved when the self is relaxed or free from threat. One additional hypothesis added by Rogers of importance to this study, is the application of differentiated learning methods to promote significant learning (Knowles, et al., 2012, p. 44). Differentiated learning is another term sometimes referred to as personalized or adaptive learning (Teich, 2014). While the foundation of adult learning principles has many scholarly contributors, Malcolm Knowles is probably the most notable in this area of educational theory. He refined the theory, has been coined as the first to call it andragogy, and added assumptions specific to the adult learner (Knowles et al., 2012). Much of the research for this
study was derived from scholarly work either authored or co-authored by Malcolm Knowles, however explanation of the relationship between andragogy and ALT is warranted.

**Andragogy and its Connection to Adaptive Learning**

Adaptive learning technology is an electronic means to implement personalized learning. This researcher asserts that many of the principles of adult learning theory support the use of these tools as a method to improve remedial math outcomes. This section will defend the use of personalized learning as a best practice for two-year college education. Adaptive learning technologies as a method to implement personalized learning will be explained. Explanation of how the principles of adult learning theory align with the framework of ALT will then be substantiated.

The nontraditional learner typically has specific goals, and wants to complete them in a very timely and efficient manner. Cercone (2008) noted that adult learners are different from traditional college students and listed several characteristics of importance. Adult learners have familial responsibilities, they work part or full-time, and must manage situations regarding transportation, childcare, and financial responsibilities, all of which can affect learning (Cercone, 2008). Considering the responsibilities burdening the adult learner, it is important that time spent in learning institutions is resourcefully managed. To mitigate the mathematical requirements, instructional methods of remedial courses needs to be efficiently delivered with the adult learner in mind. Research conducted as part of a report titled, Improving Students’ College Math Readiness: A Review of the Evidence on Postsecondary Interventions and Reforms (2013) Hodara noted that academic under-preparedness in math not only affects success in math courses but can have an impact on a persons’ overall general well-being. Because college degrees have a definite connection to many other lifestyle benefits such as career
satisfaction, civic responsibility, and a healthy lifestyle, removing the math completion barrier is essential to the adult learner’s general advancement in life (Hodara, 2013).

In another study titled, The Opposing Forces that Shape Developmental Education, authors, Jaggars and Hodara (2013) noted as a recommendation, that a modularized approach which assigns students only the specific content and assessment they struggle with, be used as a means for improving developmental course outcomes (Knowles et al., 2012). These research studies bring forth evidence that developing ones’ math skills and the method used to teach math courses, are in need of alignment to the nontraditional learner. With nontraditional learners comprising the greater percentage of all students enrolled at two-year colleges (yet keeping in mind the needs of traditional students), research to determine methodological fit to improve remedial math outcomes for both groups is imperative. Methods used to improve remedial math outcomes for nontraditional learners must not impose on the learning outcomes for traditional students. This challenge leads the researcher to review methods of instruction that can be applied or personalized for both groups.

In the next section, personalized learning will be reviewed to determine if it can be implemented as a method to improve remedial math outcomes. The researcher then explains how technology can personalize learning. Finally, a specific tool will be identified along with reasoning why this tool is believed to be appropriate for this study.

**Personalizing Learning for Two-year College Students**

Personalized learning has been identified as one of the instructional methodologies that positively influences student learning outcomes (Samah & Ali, 2011). While this method is not a new concept, it has been gaining attention in educational research and application. Personalized learning is the effort and practice to take into consideration the individual student
characteristics, needs and style to learn and utilize flexible instructional practices within the learning environment (Jenkins & Keefe, 2002). In other words, personalized learning encourages the teacher to meet the student where they’re at and support them as they develop necessary skills and content knowledge (Grant & Basye, 2014). Consider though, not all students can progress at the same time. Provisions for the slow and rapid learners need to be considered when personally instructing remedial math.

At two-year colleges where a classroom can have up to twenty-five students, this could become problematic. Tending to the student’s personal learning needs may seem like a model that would increase successful outcomes however this method, using only human intervention is almost impossible to apply to more than a few students. The amount of time a faculty would need to dedicate to each student and their specific knowledge level and learning style would soon become unsustainable. To accommodate nontraditional students learning needs and apply personalized methods during instruction, faculty and schools are turning towards an educational technology that may help improve outcomes while still using a personalized approach. The next section presents foundational information supporting the claim that ALT aligns with the personalized needs of nontraditional learners.

**Andragogical Methods Paired with Adaptive Learning Tools**

Adult learning theory or andragogy stems from the Greek word for “adult or man” and provides a more appropriate learning model for nontraditional student (Thompson & Deis, 2004). The problem facing many adult learners who enter two-year colleges is math readiness. According to the book, Community College Leadership and Administration, forty-percent of all students enrolling in public two-year colleges need remediation with at least one-third needing remediation in mathematics (Navarez & Wood, 2010). Other studies support forty-percent as a
general remediation average however, they also contend that nontraditional remedial students enroll at an even higher remedial-need rate (Attewell et al., 2006). Upon learning of remedial placement, many students are emotionally challenged with the fact that their current knowledge level is not high enough to begin their regular coursework. Besides the toll this designation places on the newly enrolled student, there are other negative factors contributing to the label of being a remedial student.

The costs associated with remedial instruction are typically higher than regular college courses due to the diverse needs of the students (Navarez & Wood, 2010). In addition, the tuition for a remedial math course may not be covered by financial aid. An issue more specific to the student is confidence to complete the remediation course(s) (Navarez & Wood, 2010). These problems compounded with the challenges of an adult learner can make success with remedial math seem insurmountable. However, by altering the way nontraditional learners are taught, this may improve remedial math outcomes and overall student success. Miglietti and Strange (1998) conducted a study with 61 adult learners and 95 traditional students in several courses. They found that by utilizing adult learning methods the adult learner experienced a greater sense of accomplishment especially in math courses (Miglietti & Strange, 1998). Based on this and other research, various teaching methods should be explored to meet the needs of this majority student demographic.

Administrators and faculty have been aware of the nontraditional student majority demographic at the two-year college however, little has been done to provide instruction better suited for their learner needs (Hardin, 2008). Instructors can no longer apply pedagogical methods to all of their students. They must consider the validity of andragogical methods in order to improve student completion and success however there is doubt that most two-year
college faculty know what andragogy entails. Thompson and Deis (2004) believe that many faculty focus on pedagogy whereas many have not even heard of the term andragogy. This may be because two-year faculty, especially at a technical college are not developed to be educators, they are subject-matter experts. The typical required credential to teach at community and technical colleges is either a bachelor’s degree or masters with 18 graduate hours in the teaching field (Twombly & Townsend, 2008). These faculty may also have concerns regarding managing multiple educational needs of a diverse student body. The challenge then is, if a course has both younger and adult learners, how does the faculty address learning needs of both groups.

Indigenous educational settings do not allow for separation of student groups based on student characteristics or demographics. Course sections have a variety of students ranging in age, race, socio-economic background as well as educational knowledge level. Because of this learner melting pot, personalized learning is almost impossible when the instructor has only himself to guide the instruction. In a study of 777 students enrolled in either remedial or college-level math, Mesa (2012) found that faculty do not discern the types of students they teach by varying competencies and demographic characteristics, they just teach to the class. Given the challenges nontraditional learners experience along with the needs of traditional learners, providing instruction for both groups may benefit from technological assistance. Specifically, effective personalized learning for both groups may be manageable using technology. Adaptive learning technologies, a computer-assisted method to personalize instruction can assist with the varying styles and levels of knowledge in a particular class (Vandewaetere, Desmet, & Clarebout, 2011).
Personalizing Learning with Adaptive Technology

There are many names used to identify adaptive learning tools, those commonly identified are: personalized learning, differentiated learning, and hypermedia. The name most typically applied among vendors of this type of tool is adaptive e-learning technology (Shute & Towle, 2003). For the purpose of this research, the technology will be referred to as ALT. To determine if ALT should be considered as a solution to the remedial math problem, research was conducted to review prior studies and results.

While conducting a general search on the use of adaptive learning tools, a study was identified that focused on elementary age students using adaptive technology and showing positive results, in the areas of pupil satisfaction and success (Klinkenberg, Straatemeier, & van der Maas, 2011). In addition to these findings, another study conducted using adaptive learning tools with 207 students in grades three through six resulted in high success rates and lowered anxiety because the level of learning accommodated the student (Jansen et al., 2013). Moreover, a study conducted on 104 middle-school students by Ku, Harter, Liu, Thompson and Cheng (2007) showed positive results of students with lower-level math knowledge scoring significantly higher on post-tests utilizing a personalized instructional program. These studies have provided some promise on the use of ALT however there has not been much research conducted that investigates the nontraditional learner’s response to this type of instructional tool.

These findings demonstrate there is some improvement for elementary level students who have been taught with adaptive learning technologies. However, the adolescent learner requires different types or methods of instruction than does the adult learner. More work needs to be conducted with nontraditional learners to determine if there is a correlation between adaptive learning technologies as a viable tool to improve remedial math outcomes.
Research on adaptive learning experiments at the post-secondary level, resulted in a study that was conducted using college level students in an accounting class (Baxter & Thibodeau, 2011). The outcomes indicated that students in the course section that used adaptive learning tools did significantly better than those taught in other sections of the same course using traditional methods. The study results were further validated because the same instructor taught all sections of the course within the study (Baxter & Thibodeau, 2011). This information supports the use of adaptive learning in one post-secondary topic however, the students involved were not identified based on traditional versus nontraditional characteristics, nor was the course remedial math. From a 2009 report about technology solutions in community college math courses, it was estimated that about 40% of community colleges used assistive technologies in math courses however evidence from controlled experiments is lacking (Epper & Baker, 2009). Based on the lack of research specific to nontraditional students in remedial math utilizing ALT, more investigation is warranted.

**Andragogy and Remedial Math**

The premise of this researchers’ position is founded on the principles of adult learning theory as both a method of instruction at the two-year college and as a theory or model that aligns with the intent of ALT. In the following sections andragogy will be explained as a method of instruction suited for the two-year college instruction. In addition, insight and examples as to why this researcher believes ALT aligns with andragogy as a strategy to improve remedial math are offered.

In the article, It Does Matter How We Teach Math (2012) author Kathleen K. Rodrigues refers to Malcolm Knowles principles of andragogy as, “the art and science of helping adults learn”. The principles within the theory provide distinct guidance on the learning needs and best
practices for instructional delivery for adult learners. The initial premise is that adult learners learn what they need to know (Rodrigues, 2012). This position informs math faculty that they need to identify and accept what the learner already knows in the math curriculum and provide instruction on only that which the student needs to learn. This principle alone supports the need to offer personalized learning methods. Imel (1994) reminds us that information about the students’ learning state can be determined by assessing the learning needs prior to creating learning direction or plans.

The second principle of andragogy, self-concept, states adults are responsible for their own learning direction (Rodrigues, 2012). The adult learner is different from the child or secondary learner—they are autonomous and need to be engaged in order for learning to be meaningful (Rodrigues, 2012). Nontraditional learners may even feel resentment if others are imposing on their will. It is specifically noted that once resistance to this model of “training” occurs, the student shuts down (Rodrigues, 2012). This phenomenon may contribute to the remedial math failure of many adult learners.

The third assumption claims, adult learners’ experiences are very significant to their process of learning (Rodrigues, 2012). This point is imperative when faculty are determining appropriate teaching methods and strategies. Faculty need to include instructional moments that allow the adult learner to refer to points of prior knowledge and experiences as a means of learning (Hoyte, 2010). Based on Knowles third standard, adult learners learn better when prior learning and learning styles are integrated into instruction (Rodrigues, 2012). These students come to class with a great wealth of life experiences both personal and professional and they want to share. This enthusiasm should be used as learning moments that are to be purposefully
included with the instruction. Part of Knowles third assumption is recognizing the learning style of the adult learner.

Determining learning style can be difficult for a teacher to include in a class size of 20-25 students but technology can assist with this part of the instructional plan. There are tools such as Assessing the Learning Strategies of Adults (ATLAS), (Rodrigues, 2012) that will facilitate the identification of whether a student learns visually, using auditory means or is a kinesthetic learner. A learning technology tool like Protus, as noted by authors, Klasnja-Milicevic, Vesin, Ivanovic and Budimac, (2011) that identifies the style of the learner and then creates content and assessments that align best to that student’s learning style, can assist the faculty immensely. Once the learning style is determined, the system will provide information to the instructor (or will develop its own modules), that teach to each student’s needs. These tools however, would require a change from didactic, lecture-based teaching in order to increase academic integration of the nontraditional student into the collegial environment (Kenner & Weinerman, 2011).

Instructional methods that include technology require the instructor to act as a facilitator to guide the instruction. Facilitation with the adult learner as opposed to teaching in front of the adult learner is an expectation of andragogy. In fact, in the book, Understanding and Facilitating Adult Learning (Brookfield, 1986) the author reminds us that facilitators of learning envision themselves as resources for learning, instead of the traditional didactic teacher who may believe he/she has all the answers.

Knowles fourth assumption claims that adult learners must be ready to learn (Rodrigues, 2012). Interpretation of this assumption can include both the students’ cognitive ability to learn and practical readiness to learn. The assumption posits that adults will learn when ready based on a need to cope or adjust to real-life situations. Adult learners that enroll in two-year colleges
do so based on a need or change to their life (Kenner & Weinerman, 2011). This assumption also states that learning needs to be built on the pace of the student (Knowles et al., 2012). This premise is parallel with the conceptual model of adaptive learning technologies; the technology progresses at the speed of student. Learning topics are offered, taught, and then assessed. The system moves the student to a higher level of learning when it has been determined that the student is ready.

In addition to cognitive readiness, the instruction method needs to consider the complex schedule adult learners may have, teaching moments and access to learning content must be flexible and easily accessible. The adult learner needs to be able to study and access learning content during lunch breaks, in the evening when they have put children to bed and other times outside of traditional hours. Technology plays an integral part in managing this assumption of andragogy due to its continuous and untethered availability.

The fifth principle states that adult learners have an orientation to learning or are problem-centered; they need to apply what they have learned to either work or personal situations (Rodrigues, 2012). This assumption has a direct connection to mathematical instruction, by contextualizing math concepts to real world experiences, the adult learner will retain what is learned instead of dismissing it as too abstract (Hoyte, 2010). The traditional methods of one-size-fits-all teaching approaches will not work as well as individualized instruction (Vandewaetere et al., 2011). This principle will test the ALT in its presentation of the math material. If the student does not connect with the math topics presented because there is no realistic application, the ALT may not work for this population (Knowles et al., 2012).

The sixth assumption is very complex, it maintains that adult learners respond to external motivation yet internal motivators are more powerful (Rodrigues, 2012). The definition of
motivation quoted by Pew from Brennen, “Motivation has been defined as the level of effort an individual is willing to expend toward the achievement of a certain goal (Pew, 2007, p. 14). External motivators (employment, promotion, others relying on the student for support/care), are very relevant to the nontraditional learners at two-year colleges. As noted before, these students enroll at two-year colleges typically to improve some life event effecting their familial, financial or employment conditions, all of these are external motivators. According to this assumption, faculty also need to include internal or intrinsic motivation when creating learning plans and expected outcomes (Rodrigues, 2012).

Internal motivators for adults may include, self-efficacy and esteem as well as a desire to improve one’s own repertoire of knowledge. This is one of the more difficult components of andragogy to accept when teaching at two-year colleges, however faculty need to understand the difference in teaching adults as opposed to traditional students. Faculty need to recognize that when teaching children, they are transmitting and controlling the environment, whereas when educating adults, the focus is on facilitating critical thinking of the content (Pew, 2007). In alignment with this essential principle of adult learning, ALT has built-in tools and events that promote student confidence and motivation and in turn increase self-esteem and pride. In a study conducted by Martin and Carro (2009) depicting the mobility of adaptive learning, they reported that students noted motivational increases regarding learning and collaboration with their classmates. These studies further validate the cooperative relationship or alignment adaptive learning tools have with andragogy.

This section provided plausible alignment of andragogical principles to support the implementation of adaptive learning technologies. While some of the principles resonate stronger with ALT, a connection between the Theory of Adult Learning by way of personalized
instruction using technology can be identified. In the following section, a specific adaptive learning tool will be explored along with supporting data and research.

**Adaptive Learning Technology and the Adult Learner**

To substantiate the claim that ALT in remedial math should improve nontraditional student learning outcomes, more information regarding the technology along with the learning platform needs to be investigated. The following sections provide additional information and discernment regarding good quality adaptive learning software. In addition, specific examples as to why this researcher believes ALT aligns with andragogy as a strategy to improve remedial math learning are presented.

Adaptive learning technologies have been referred to as, personalized learning systems or hypermedia learning systems and have been around for quite some time. In an article written by Kara and Sevim (2013) they noted that these systems used to be called teaching machines and date back at least to the 1950’s. These systems allowed students to learn from a computer but used rote memorization techniques. Noted behavioral psychologist B. F. Skinner was involved with the development of an early form of teaching machines (Kara & Sevim, 2013). His system was more hardware centric and was based on programmed instruction. Skinner proposed that by offering immediate reinforcement after a correct result, this would induce learning. While this hypothesis worked in the laboratory, the method failed in the traditional classroom due to the teacher’s inability to provide timely reinforcement. Another issue with early models was that teaching paths were based on prescribed tasks or frames defined by an instructor. These frames still presented a very linear approach for all students (Kara & Sevim, 2013). Technology available today is far more dynamic and interactive allowing for personalized learning, feedback
to occur very timely and knowledge to be demonstrated as opposed to simply committing
information to memory.

As previously noted, the current common name for these tools is ALT. This platform
refers to a methodology that considers the current level of knowledge a student has (assessment
of prior knowledge), and the concepts or content needed to be learned to pass a course (Kerr,
2016). Immediate and continuous feedback is also a part of the functionality and some include a
mechanism to test the student’s confidence in what they do or do not know. There have been
many vendors claiming their systems are adaptive, however a truly adaptive learning system
adjusts to the learner’s interactions with the content and suggests material, based on continuous
mastery of a subject and the learners profile (EGA, 2013; Kerr, 2016). According to a survey
conducted by Tech & Learning (Teich, 2014),

“Adaptive learning systems are software-based technologies that automatically customize
curriculum to the knowledge level of the learner. The algorithms actively track and
access student performance to provide feedback to the teacher and student about the
student’s progress on an ongoing basis”.

This definition of ALT supports Knowles fifth principle of adult learning theory that learning
must be relevant to the adult learner (Rodrigues, 2012). It also aligns with the principles of self-
concept and the importance of learner experience inasmuch that learning with this type of
technology promotes independent development based on personalized engagement (Spence &
Usher, 2007). Because the methods of ALT align with adult learning principles, one can assume
this technology would improve learning outcomes for nontraditional students, however no
evidence was located.
Studies have been conducted on the benefits of applying ALT at secondary educational institutions with positive results and outcomes for high school students (Walkington, 2013). Based on other successes, it is justifiable to consider its application in courses that are comprised of adult learners, these students should also experience improved learning outcomes. However, in order to optimize learning, the tool must take into consideration the learning assumptions and styles of the adult learner. Adapting a hypermedia learning system to an individual’s cognitive learning style can improve the learner’s performance and perceptions of the learning tool (Mampadi, Chen, Ghinea, & Chen, 2011).

One of the more well-known adaptive learning tools, the Assessment and LEarning in Knowledge Spaces (ALEKS), as noted in the article, “The Impact of a Technology-Based Mathematics After-School Program Using ALEKS on Student's Knowledge and Behaviors”, details about the tool were provided (Craig et al., 2013). The technology has a built-in artificial intelligence system based on an advanced theoretical framework that determines the baseline knowledge level of the student (Craig et al., 2013). From this baseline, it designs instruction and assessment that are constantly updated for the learner (Craig et al., 2013). This constant assessing and updating provides a personalized learning experience for each student and aligns with principles recommended for adult learners.

Adaptive learning tools allow the adult learner to fit learning into their busy and sometimes hectic lives because of the ability to access the system via the internet and from mobile devices. Research informs us that when adult learners have access to the class content on mobile devices, they will use time available to work on assignments (Martin & Carro, 2009). Most adult learners have access to mobile technology either at school or by means of personal computers or laptops, tablets, or even smartphones (Lenhart, Purcell, Smith, & Zickuhr, 2010)
The accessibility factor increases the probability that the adult learner will access the learning tools outside of the traditional classroom. This probability aligns with Knowles fourth assumption that adult learners need to be ready to learn (Rodrigues, 2012).

In this section information was presented regarding the principles of adult learning theory and how they support the ALT framework. Several of the principles were expanded on specifically as they align more directly than others. Next, data will be presented to explore a phenomenon that impacts minority students, especially in math classes that ALT may help minimize.

**Adaptive Technology and Stereotype Threat**

Stereotype Threat Theory asserts that black and other minority students feel an intense anxiety when completing math examinations (Aronson, 2004; Steele, 1999). Many urban-based two-year colleges have a higher percentage of minority students than four-year colleges (Calcagno et al., 2008). When compared to white students, Black, Hispanic and even female remedial math students are at a significant disadvantage when it comes to processing math curriculum (Steele, 1999). In an early study conducted by Tate-Green (1990) of 132 remedial students at Howard University, among the variables studied were: test anxiety, mathematics anxiety, and mathematics ability. Of importance were the significant findings discovered related to the correlation between math testing and anxiety (Tate-Green, 1990). Further, Tate-Green (1990) found that placement test scores were a greater indicator of math anxiety than teacher comments. Considering remedial math student’s placement scores are on the lower range, one can assume that anxiety for these students is high.

The relationship between Black students and test anxiety has been further studied and has been attributed to stereotypes perceived by this group of students (Tate-Green, 1990). The term
associated with this phenomenon is Stereotype Threat (Aronson, 2004). Steele and Aronson explain, when members of these groups are placed in a situation that draws attention to the stereotype that is connected to their race such as black males not performing well on math when assessments compared to white males, they feel such an intense anxiety that they manifest the stereotype (Aronson, 2004). Because of the anxiety these students feel and the stereotype they fear being reduced to, they actually focus so much on the stereotype that they do much worse on a test than if they were tested in a room of similar race or culture (Aronson, 2004).

Interesting enough, researcher Jennifer Hoyte (2010) adds, adults returning to college experience similar anxiety due to factors like, lack of confidence, inability to see math relevance and teaching style not matching learning style. Because many of the urban two-year colleges have a large minority student population, determining if different teaching methods and tools can improve this issue is important (Bailey et al., 2010). While there have been studies and information regarding this phenomenon, there has not been much research conducted regarding other educational methods or tools being used to improve remedial math anxiety for nontraditional minority students.

This section has provided studies and other research on the development of ALT from its beginnings as a tool to help students memorize to a technology that teaches. In addition, correlations between the premise of ALT and the theory of adult learning have been hypothesized. This connection between the two paradigms provides the basis for this researcher’s position that ALT should improve the learning outcomes for nontraditional learners enrolled in remedial math. In the next section the specific tool being used in this study will be examined. Information of its functionality and ability will be shared along with prior studies and outcomes.
Why ALEKS?

There are many software systems identified as adaptive learning systems however some are merely content recommendation systems that establish a baseline of student learning needs but fail to continuously adapt with the students’ development (Waters, 2014). ALEKS, an acronym for Assessment and LEarning in Knowledge Spaces (ALEKS), published by McGraw Hill Education presents many of the aspects that qualify it as a true adaptive software. It uses research-based artificial-intelligence to very quickly and accurately determine each student’s knowledge level and readiness to learn (aleks.com, n.d.). ALEKS then informs the student of those topics they are most ready to learn (Baxter & Thibodeau, 2011). In addition, ALEKS continuously updates the students’ state of knowledge, providing the student with learning modules consisting of appropriate topics while reinforcing what was already learned (Baxter & Thibodeau, 2011). When ALEKS determines the student is ready to learn the next concept it then provides a personalized learning path for the student using the same environment, and when appropriate the student is discretely re-assessed and moved forward or allowed to continue developing at their own pace (Baxter & Thibodeau, 2011). The student is provided with a visual tool (pie chart) to show their success as well as what remains, which in turn builds self-efficacy and educational confidence (Taylor, 2008).

In addition to the artificial intelligence platform, ALEKS can be described as a hybrid system. It allows the instructor to participate in the control and configuration of the topic and content. This method has demonstrated significance in a study using ALT in a college anatomy and physiology. Researchers Griff and Matter (2013) speculated that these tools perform best when course goals are closely aligned with texts. This can be achieved when the adaptive software includes input from the faculty who have developed the course competencies and
objectives. Another benefit with the ALEKS software is that it is web-based, allowing students to access learning options using an internet connection and various computer platforms including mobile, smart devices. This contributes to the students’ ability to learn at their own pace as well (Baxter & Thibodeau, 2011). While the functions built into the ALEKS tool are important, the theory that is the backbone of the ALEKS architecture is also of significance.

The artificial intelligence construct of ALEKS is derived from Knowledge Space Theory (KST), (Baxter & Thibodeau, 2011). In essence, this theory contends that a student’s competence is identified by a knowledge state (Baxter & Thibodeau, 2011). Falmagne supported the notion that knowledge state claims there is a particular set of problems that an individual is capable of solving (as cited in Baxter & Thibodeau, 2011). The theory then contends that if a knowledge state can be pre-determined, then an efficient learning path can be identified, and a mechanism will then exist for both assessing the students current understanding, and teaching the topics not yet learned (Baxter & Thibodeau, 2011). This method of continuous assessment and instruction may seem a bit complicated and one may wonder if it is effective given the intricacy when applied to software for remedial students.

Practical application of KST in ALEKS enables continuous fine tuning of instruction based on interactions between the student and ALEKS (Hu, Xu, Hall, Walker & Okwumabua, 2013). This process works to identify the students’ knowledge state and determine weaknesses or gaps (Hu et al., 2013). Based on the students’ current knowledge state or understanding of a domain, the specific learning path is identified to productively teach the topics not yet mastered (Baxter & Thibodeau, 2011). This method of learning and assessment all within the same software environment may provide ease of learning and reduce test anxiety being that there are no “high stakes” assessments. There is a flow of learning and evaluation without the pressures
of specified and separate assessment presented in traditional math classes. In theory and practice, ALEKS may offer a method to improve the remedial math outcomes for many college students. To fully justify the use of ALEKS for my research, a review of prior studies is warranted.

Results of a literature review around the use of ALEKS in higher education proved to be quite sparse however, a few were located. Hu et al. (2013) found that by using ALEKS in an undergraduate behavioral statistics course with a subset of 1,309 students, students with prior lower placement scores did better using ALEKS online than those in traditional lecture-based instruction. In fact, black students performed better than did white students using ALEKS online (Hu et al., 2013). During another ALEKS study using the software with an undergraduate algebra course, researchers realized a 21% increase in pass rates (Hagerty, Smith, & Goodwin. 2010). They also experienced a 300% increase of enrollments into the next math course along with 25% improved attendance. One of the attributions to this success was the personalized nature of ALEKS, minimizing boredom from those students ready to move forward while not leaving those who needed added instruction behind (Hagerty et al., 2010).

While there were not many studies located while conducting a general search, there were several identified on the aleks.com website in their Case Studies/Research Papers sections. While one must consider these papers are used to promote the tool, the results still need to be considered as valid. In a 2007 case study at Missouri Western State University, an open enrollment institution, where about 70% of incoming students are placed in developmental mathematics, use of ALEKS in developmental math courses resulted in 78% course completion rate compared to a nationwide average of 50% (aleks.com, n.d.). More significant, is that when students are removed from the formula for lack of attempting to use the software, Missouri
Western claims a 96% success rate of course completion (aleks.com, n.d.). Thus far these studies have presented positive results, however there are studies that resulted in lackluster outcomes.

Taylor, conducted a study on 93 college freshmen enrolled in an intermediate algebra class with 54 of those students using ALEKS and 39 enrolled in traditional lecture (2008). She found that math achievement increased with ALEKS and that math anxiety decreased but that only some of the students felt a positive attitude towards math after using this form of computer-mediated instruction (Taylor, 2008). This is an important point to consider and researchers Thomas and Higbee state that attitude can affect the ability of students to learn math (as cited in Taylor, 2008). In another study conducted at the University of Alabama, researcher Boykin (2009) brought up the fact that ALEKS not only allows, but depends on the student to learn outside of the class. This form of self-discipline competes with outside distractions and responsibilities. Due to this study being conducted on a group that has many societal influences that competes for the students’ time, this needs to be a consideration.

The information and research remarked upon in the previous paragraphs identified results that primarily support the use of ALEKS in remedial math. However, like with many proposals to implement change, there are concerns regarding the inclusion of a computer-based technology as the major source of math instruction. While these studies were predominantly conducted in math-centric courses, none have specifically discerned the impact of adaptive learning on the nontraditional student. This researcher’s study will add to the research information not previously located.
Summary

Two-year colleges are struggling to fully admit enrollees into regular programs due to the need for remedial math course completion. While two-year colleges experience student enrollments direct from high school, research from the American Association of Community Colleges (2014) cites the student age is an average of 28. Besides the acknowledgement of the two-year college students’ age, colleges must take into consideration the realities of adult student life that identify them as nontraditional. Spouses, children, full-time employment along with a multitude of other complexities must be considered when planning curriculum and supporting the nontraditional learner. Even though age and characteristics may differentiate this student population from traditional students, one common problem is remedial math failures. A method to address the continued problems with passing remedial math justifies the need for added research but one tool may not work for all.

There is an entire theory that claims adult learners need to be taught differently. Principles of andragogy identify approaches and considerations that should be incorporated into instruction when teaching adult learners. Within two-year colleges, most applied instructional methods do not consider the principles of andragogy, faculty are still attached to the pedagogical theories that truly belong with secondary education and traditional student instruction. In order to teach the way nontraditional students learn, faculty must apply the principles of adult learning theory posited by Malcolm Knowles using a personalized approach.

Research indicates that personalized learning is recognized as a superior approach to instruction (Vandewaetere et al., 2011) however, it remains almost impossible for faculty alone to implement. Because two-year college classrooms do not segregate traditional learners from nontraditional learners, a method to personalize instruction may be the only means to improve
remedial math outcomes. Adaptive learning systems provide a method to personalize instruction while allowing faculty to apply andragogical instructional methods. Utilizing this strategy more than likely means a complete review and transformation of the way remedial math is taught. Epper and Baker (2009) reviewed 30 schools that implemented the Program in Course Redesign (a whole course redesign). Results of 25 schools in this study showed significant increases in student learning (Epper & Baker, 2009). Examples like this affirm that to make real improvements to learning it takes substantial change but in order to induce change, research finding needs to substantiate the value of the change. Implementation of adaptive learning systems of instruction have resulted in some positive outcomes for remedial math students. However, more research needs to be conducted to reinforce claims that this tool as a method to improve remedial math outcomes for various learner types such as nontraditional students.

Conclusion

Andragogical principles recognize that nontraditional learners learn differently than younger students and states that in order for learning to occur there are six assumptions that need to be incorporated in the curriculum and learning methodology (Rodrigues, 2012). Some research indicates that applying adaptive learning systems to remedial math courses improves math scores and student pass rates. By utilizing adaptive learning tools, this author posits that remedial math pass rates will rise and thereby increase overall student success rates at two-year colleges. Successful adult learners will then be able to either go on to complete their intended program or improve their immediate earning potential by acquiring employment. The intrinsic value of successfully completing their math course(s) may prove to have even greater results than expected should it reduce anxiety and provide motivation to further their education at a four-year college instead of completing a two-year degree.
The author recognizes this change will be a large undertaking for faculty and reminds college leaders that faculty development will also factor into this change. Authors Johnson, Wisniewski, Kuhlemeyer, Isaacs, and Krzykowski, (2012) stated, “Although learning is an espoused value in higher education, faculty learning is often overlooked or disregarded”. They further remind two-year colleges that many times when technology is introduced, faculty are merely shown how to use the tool but are rarely shown how to include it in their teaching or within the context of the course (Johnson et al., 2012). In any event, two-year college faculty cannot maintain the current methods of instruction of remedial math courses and believe outcomes will improve. Authors, Jaggars and Hodara remind us that, “enforced consistency across a system may guarantee nothing more than uniform implementation of an ineffective policy”, (2013, p. 576). Two-year colleges must explore both the method and the tools used to teach this large population of students in order to address the educational crisis in this country. To continue to apply existing practices will leave the students and the schools in the same condition as they are today-failing.
Chapter 3: Research Design and Methodology

The purpose of this research is to determine if ALT is an effective tool to improve the remedial math outcomes for nontraditional learners at two-year colleges. This chapter will present research methodology and design, study population and sampling, data collection and analysis, along with statements addressing data validity and reliability. In addition, an explanation regarding the protection of human subjects will be provided. The specific ALT being used for this study is the McGraw-Hill Education tool ALEKS. This study is founded on the premises of two theories: Adult Learning Theory (Knowles et al., 2012) and Stereotype Threat (Steele, 1999).

According to Knowles, Holton, and Swanson (2012) adults learn differently than younger students. Principles to instruct adults or nontraditional learners should be founded on the following: the need to know, the learner’s self-concept, the role of the learners’ experiences, readiness to learn, orientation to learn and motivation (Knowles et al., 2012, pp. 63-67). These learning behaviors have been noted to resonate even more with nontraditional learners (Ross-Gordon, 2003). This homogenous culture that populates many two-year colleges learns best when faculty consider their development, experiences, and needs or goals at given points in their life or educational experience (Kenner & Weinerman, 2011). Adult learning theory may contain “adult” in the title however, other researchers include choices and characteristics that provide more substantial information than age alone. The attributes presented by Horn and Carroll (1996) such as family responsibilities and work hours, create an improved picture of why untethered instruction may improve attrition in remedial courses.

While age alone may be the sole factor to determine legal adulthood, the characteristics that differentiate nontraditional learners are of greater importance when studying appropriate
instructional methods. Considerations for the challenges that face nontraditional learners such as time management may seem trivial, but when a student must also work, and/or care for others, finding time to learn is paramount to success. It is due to existing research of nontraditional learner characteristics on the risk of attrition (Horn & Carroll, 1996), that this study will review findings through the lens of adult learning principles.

The theory of Stereotype Threat has some similarities to Adult Learning Theory, specifically to the principle of self-concept. Clinical psychologist, Carl Rogers hypotheses stemmed from his work on personality and behavior which he extended into education (Knowles et al., 2012, pp. 44-46). He recognized that significant learning can be threatening to a learner and that providing a supportive and accepting environment is important to learning (Knowles et al., 2012, pp. 44-46). This position was part of the foundation for adult learning theory but also aligns with the basis for Stereotype Threat Theory (STT). STT states that when a person who is part of a group that is categorized as being lessor, they can feel such intense anxiety or fear of the stereotype that they indeed perpetuate the stereotype (Steele, 1999). Math has been identified to be the most difficult remedial subject to successfully complete (Bonham & Boylan, 2012). In studies conducted by Steele (1999), he found that STT did impact math outcomes. While this study is not solely based on STT, data collected allowed the researcher to compare outcomes in remedial math based on ethnicity and gender. Blacks, Latinos and women are identified as being affected by the tenets of STT than other groups (Aronson, 2004). This premise is being reviewed to determine if the use of adaptive technology minimizes STT for nontraditional learners. The students enrolled in the remedial math ALEKS sections, will complete math assessments in ALEKS as part of their learning as opposed to assessments being singled out as an event. This change may reduce test anxiety.
Substantiated by these two theories, the aim of this research and study was to determine if nontraditional students enrolled in remedial math achieve better outcomes when ALT helps facilitate remedial math instruction. Both theories guided the justification to review a technological tool that is founded in personalized learning of remedial math. Thus far, there has been little evidence to support the use of instructional tools or methods to attain improved remedial math outcomes.

**Study Hypothesis**

A generalization of the hypothesis for this study was that nontraditional learners in remedial math courses experienced higher completion rates and outcomes when using ALT. This type of study had not been previously conducted and the need to first establish quantitative results was paramount to moving forward with recommendations of the use of ALT with remedial math courses. The study’s specific null and alternate hypotheses along with research questions were as follows:

H₀ - There is no difference in performance between traditional and nontraditional students in remedial math when using adaptive learning technology.

Hₐ - The integration of adaptive learning technology within remedial math instruction results in different performance levels for nontraditional students at two-year colleges.

**Research questions.** Several research questions were created to support or reject the hypothesis. To answer the research questions, student groups were created based on characteristics attributed to traditional or nontraditional students. In addition, the method of instructional delivery-adaptive technology (ALEKS), or non-adaptive technology further defined the groups. Table 1 provides an illustration of the study groups.
Research Question 1-Does integration of adaptive learning technology within remedial math courses result in different outcomes for remedial math learners? This question was asked to help establish the impact of ALEKS on student outcomes in general. The hypothesis can be stated as:

\[ H_0: \mu_{12} = \mu_{34} \]

\[ H_A: \mu_{12} \neq \mu_{34}. \]

Research Question 2-Does the integration of adaptive learning technologies within remedial math courses impact completion rates of nontraditional learners at two-year colleges? This question directed the study to focus on nontraditional students who enrolled and completed remedial math. An analysis to determine if there was any difference in completion rates specifically with nontraditional learners in an ALEKS-based remedial math course was conducted. The hypothesis can be stated as:

\[ H_0: \mu_2 = \mu_4 \]

\[ H_A: \mu_2 \neq \mu_4. \]

Research Question 3-Do nontraditional learners perform at an equal to, or higher level than traditional learners in remedial math when adaptive learning technology is integrated within
remedial math instruction? The third question prompted a comparison between traditional learners and nontraditional learners in remedial math courses specifically taught with ALEKS. Levels of success using grade scores and ALEKS posttest results, of the two learner groups were compared to determine if one group performed higher than the other within the same courses using the ALEKS tool. The hypothesis can be stated as:

\[ H_0: \mu_1=\mu_2 \]

\[ H_A: \mu_1 \neq \mu_2. \]

Research Question 4-How did students perceive the usefulness of the ALEKS software towards their understanding of the course material? This question and survey was posed to the students in the control group, who used ALEKS. Since the students in the ALEKS course sections primarily used a learning technology tool, it was expected that the personal experience with technology would provide insight regarding anxiety and/or remedial math success.

Information to help answer the first three questions was derived from course completion data and grades, along with ALEKS data. To determine if students were traditional or nontraditional, student characteristic information was collected as part of the student data request to the institutional research department at the study site. Information on sex and ethnicity was part of the data collection requested of the institutional research department. This data provided generalized information of the impact of ALEKS on student populations where STT may be a factor.

**Research Design and Rationale**

A quantitative approach to this study was determined to be the most appropriate method due to the empirical nature of comparing difference in completion and success rates of traditional versus nontraditional students and adaptive versus non-adaptive instructional methods.
Remedial courses are not electives or major areas of study—they are basically a means to an end (Bonham & Boylan, 2012). A student assigned remedial courses needs to complete those subjects in order to continue their college path. To determine the most effective and efficient method as a means to that end, is of incredible significance to many students, faculty, and college administrators. The results of this study are founded in numerical data which require an objective approach. As noted by Creswell (2012) the research design leads the researcher to determine and apply the type of study. This study determined how one variable impacts another variable, as such, using quantitative methods are most appropriate (Creswell, 2012, p.13).

**Study Details**

This quantitative study utilized a quasi-experimental design, conducted at Milwaukee Area Technical College (MATC), an urban, minority-majority, public, two-year, college located in the Midwest. The total population is approximately thirty-five thousand students with a 51% minority demographic and an average student age of thirty (MATC Fast Facts, 2015-16). The college also has a large adult population and in 2016 reported 55.8% of all students are twenty-five and older, as indicated in Table 2, provided by MATC-Institutional Research Department.

Table 2

**Enrollment Age Distribution-MATC 2016**

<table>
<thead>
<tr>
<th>Age</th>
<th>Percent of Student Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>43.8%</td>
</tr>
<tr>
<td>25-29</td>
<td>16.6%</td>
</tr>
<tr>
<td>30-34</td>
<td>11.6%</td>
</tr>
<tr>
<td>35-44</td>
<td>14.2%</td>
</tr>
<tr>
<td>45-54</td>
<td>8.3%</td>
</tr>
<tr>
<td>Age Group</td>
<td>Percentage</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
</tr>
<tr>
<td>55-61</td>
<td>3.1%</td>
</tr>
<tr>
<td>62 and older</td>
<td>2.0%</td>
</tr>
<tr>
<td>Unknown age</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

This college is representative of many other colleges’ that have experienced low pass rates in remedial math. Though this study’s concentration focused on the achievement outcomes of nontraditional learners, actual classrooms are not segregated by student age. In comparison, this study included evaluation of the effects of instructional strategies upon traditional learners to determine if ALEKS impacts their learning outcomes.

MATC has five schools and a pre-college division with credentials ranging from three-credit certificates to seventy-credit associate degrees. It also boasts over four-hundred articulation agreements with four-year colleges. The School of Liberal Arts offers courses in remedial math for those students enrolling in college but with ACCUPLACER and/or ACT scores below the placement cut scores for college level math. MATC offers remedial math courses using both traditional methods of instruction as well as, course sections that incorporate the supportive and adaptive software. ALEKS is one of the adaptive software tools used in remedial math. The courses identified best for this study were Pre-Algebra (109) and Elementary Algebra with Applications (110). Both have a course type identifier of MATGEN. The courses last for sixteen weeks, are worth three credits, cost $446.25, but are not transferrable to a four-year college nor do they satisfy program math requirements. The course descriptions are as follows:
MATGEN-109 “This course will help prepare you for your required Math course. This course introduces many basic topics in algebra and arithmetic processes. This transition course prepares students to succeed in their next math class.” (matc.infonline.edu, 2017).

MATGEN-110 “This course will help prepare you for your required Math course. This course offers traditional algebra topics with applications. Learners develop algebraic problem-solving techniques needed for technical problem solving and for more advanced algebraic studies. Topics include linear equations, exponents, polynomials, rational expressions, and roots and radicals. Successful completion of this course prepares learners to succeed in technical mathematics courses.” (MATC Catalog, 2019, p. 274).

**Remedial Math Placement**

Students that enroll at MATC are asked to provide an ACT score or are tested using ACCUPLACER. Most often the arithmetic ACCUPLACER score is used to determine placement in a math course. If the student presents an ACT math score of less than 17, he is assigned to a MATGEN remedial math course. The majority must complete the ACCUPLACER test because a high number of applicants are not direct from high school and have not taken the ACT. Students that score between 34-63 on the arithmetic ACCUPLACER, are recommended to enroll in MATGEN-109. If the student scores at least a 64 on the arithmetic ACCUPLACER test, he is encouraged to enroll in MATGEN-110. As noted, placement in either MATGEN-109 or 110, (based on either ACT or ACCUPLACER scores), is only recommended. Counselors and/or advisors explain the test results and recommend the math course placement. Some students follow the recommendation whereas others who have a higher ACCUPLACER arithmetic score may choose to enroll in remedial math.
While the two-year college selected to conduct this study is also the researcher’s current employer, MATC’s student population is reflective of many other urban two-year colleges. In addition, the college has been using ALEKS for a couple years, allowing faculty to learn the software along with best practices of instruction prior to this study. MGH has been providing additional training and support for students and faculty in order to minimize issues related to the software, access and navigation.

**Study Population and Groups**

This study involved defining student type as traditional or nontraditional based not only by age, but also the characteristics as previously defined (Choy, 2002; Horn & Carroll, 1996). This researcher was able to collect data on the following characteristics of a nontraditional student:

- Age (25 and older)
- High school completion type
- Post-Secondary enrollment year (delayed more than 2 years after high school)
- Enrollment status (full-time or part-time)

The Scale of nontraditional status (Horn & Carroll, 1996) indicates that students range from minimally nontraditional to highly nontraditional based on the number of characteristics they identify with. For this study, students that identify with two or more of these characteristics will be considered nontraditional.

In general, there was one independent variable in this study-instructional method which guided most of the research. The independent variable, instructional method is associated with the control group of traditional instruction (non-adaptive), and the treatment group of an instructional method used ALEKS (adaptive). This IV impacted the dependent variable of
Student learning outcomes where outcomes were the grade scores and completion rates. Student groups (based on characteristics), were identified as either traditional or nontraditional as shown in Table 3.

- Control Group: those students (both traditional and nontraditional), enrolled in the MATGEN course sections that use traditional methods of instruction
- Treatment Group: those students (both traditional and nontraditional), enrolled in the MATGEN course sections that use the ALEKS tool to facilitate learning

Table 3

<table>
<thead>
<tr>
<th>Study Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
</tr>
<tr>
<td>Control</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Treatment</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

This study reviewed the use of the adaptive learning software, ALEKS from McGraw Hill Education which is identified as a personalized learning tool. The ALEKS technology tool contains a math assessment pre-test used to establish the student’s baseline knowledge. The assessment is a standardized criterion-reference evaluation containing between 20-30 open response questions and is completed using a computer connected to the internet (aleks.com, n.d.). Based on the assessment outcomes, ALEKS determines what math topics the student is lacking
and what the student needs to specifically work on to achieve learning mastery of the math topic (aleks.com, n.d.). ALEKS then creates a knowledge-state pie-chart that provides a visual representation of what the student needs to learn and to what degree as seen in Figure 2.

![Figure 2: ALEKS, Knowledge-State Pie Chart](image)

According to Fraenkel et al., (2011) this type of assessment focuses on a goal for each learner to achieve. The study’s treatment group used ALEKS as part of their MATGEN course. The control group was not allowed to use the ALEKS adaptive learning tool. Data collection on the completion and success levels of student groups was collected at the completion of the courses.

**Rationale**

This study used a quasi-experimental design due to the researcher’s inability to control the student type enrolling in either the control or treatment sections. Students are assigned to a course but self-enroll in the course section and it would have been intrusive for this researcher to interfere with college processes. Interesting enough, the use of ALEKS in remedial math at MATC is not promoted or marketed to potential students as a means to succeed in the course. This lack of information minimizes research bias as students enroll in a section of the MATGEN
courses with little to no knowledge that it is or is not being taught with an adaptive learning software.

MATC has been using the MGH tool ALEKS, specifically to improve remedial math outcomes for a few years. In fact, faculty that teach the course that follows the remedial course MATGEN-109, voted to use ALEKS in all sections (M. Jenkins, personal communication, June 16, 2017). Not all MATGEN sections were taught with ALEKS; the remedial math faculty teaching MATGEN courses used either traditional instruction methods, ALEKS, or other software that is non-adaptive. The decision to use ALEKS is determined by faculty and can change from term-to-term. This study ran during the fall term of 2018. There was a total of twenty-four MATGEN-109 sections offered during the term along with thirty-three sections of MATGEN-110. Of the MATGEN-109 sections, three included instruction with ALEKS. Five of the MATGEN-110 sections used ALEKS.

To ensure faculty are educated on the use of ALEKS, MGH implementation specialists provided instruction and guidance to the faculty teaching the ALEKS sections. In addition, students in the ALEKS sections received a live tutorial from the same MGH specialist. This strategy is utilized to minimize issues students may have with familiarity and navigation of the tool. It is for these reasons this researcher believes MATC is an appropriate site to conduct this study.

Data Collection

Discussion regarding this study was first presented to the Dean of Liberal Arts and the Associate Dean who oversees the math department. The Associate Dean of the math department provided a list of sections of the MATGEN courses that were either using ALEKS or were using traditional instruction. MATC holds what is called “Census Day” which occurs about two weeks
after the start of the term. This day is reserved as a deadline for students to drop or withdraw from courses without penalty. The study began after this event to minimize incomplete participation data from those enrolled in the wrong course and other enrollment errors.

The study announcement and information were shared with the math faculty assigned to the identified MATGEN courses/sections via email. Faculty were asked to announce the study to their students to minimize fear of spam (email) or apprehension to respond to the survey(s). The faculty also had the option to invite the researcher to speak with the students to further explain the study and answer any questions. No requests were received by the researcher. To encourage participation, students in the ALEKS sections were informed of a random drawing to win one of five, ten-dollar gift cards. To be eligible for the drawing students were required to complete the consent to participate, the student characteristic survey, and the end-of-course survey. Besides the agreement and two short surveys, there was nothing more required from the student participants.

A request for student email addresses enrolled in the selected sections of the MATGEN courses was made to the MATC-Department of Institutional Research (IR). To ensure all students were older than eighteen, the researcher asked that only student emails from those 18 years or older were provided. An email request to participate (Appendix A: Informed Consent to Participate in educational research), in this study was sent to the students enrolled in each of the sections selected for this research. The wording in the Informed Consent was provided by the college where the research was conducted. The email contained a general explanation of the study, language to inform students they will not be identified by name, along with assurance that participation in this research would have no impact on their grade. Contact information of the researcher was provided as well. The email noted that by selecting the link this stood as an
agreement to participate. Once the link was selected an online form opened, built with 123ContactForms, (a password-protected, web-based forms tool). Participants were asked to affirm their agreement to participate by selecting the “I Agree” button. After selecting the button, participants were asked to complete the survey (Appendix B).

Student characteristic data was requested from IR at MATC using the course section numbers associated with both the traditional sections and ALEKS sections of the remedial math courses. Student data was de-identified by the Director of IR to ensure confidentiality. For the purpose of this study, the student’s age was collected but was only one indicator of traditional or nontraditional discernment. Both the student gender and student race/ethnicity were collected in order to provide information relevant to Stereotype Threat Theory. Additional data to help identify students as traditional or nontraditional, either not collected or deemed inconsistent by MATC’s IR department (indicated in Table 4), were included in the student survey. Students were asked to affirm specific nontraditional characteristics such as financial independence and family status as listed in Table 4.

Table 4

*Student Characteristics List and Justification for Use*

<table>
<thead>
<tr>
<th>Student Characteristic</th>
<th>Level of Measurement</th>
<th>Part of Nontrad definition</th>
<th>Provided by IR or Survey?</th>
<th>Justification/Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School completion type</td>
<td>Nominal</td>
<td>Yes</td>
<td>IR provided</td>
<td>Nontrad Indicator</td>
</tr>
<tr>
<td>Year last attended high school</td>
<td>Nominal</td>
<td>Yes</td>
<td>IR provided</td>
<td>Nontrad Indicator</td>
</tr>
<tr>
<td>Gender</td>
<td>Nominal</td>
<td>No</td>
<td>IR provided</td>
<td>Stereotype Threat</td>
</tr>
<tr>
<td>First generation college student</td>
<td>Nominal</td>
<td>Yes</td>
<td>IR provided</td>
<td>Nontrad Indicator</td>
</tr>
<tr>
<td>Variable</td>
<td>Scale</td>
<td>IR/IRR</td>
<td>Research Indicator</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>---------</td>
<td>--------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Full-time/Part-time student</td>
<td>Nominal</td>
<td>Yes</td>
<td>IR provided</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>Nominal</td>
<td>No</td>
<td>IR provided</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Continuous</td>
<td>Yes</td>
<td>IR provided</td>
<td></td>
</tr>
<tr>
<td>Are you currently employed?</td>
<td>Nominal</td>
<td>Yes</td>
<td>Asked in survey</td>
<td></td>
</tr>
<tr>
<td>If so, about how many hours a week do you work?</td>
<td>Continuous</td>
<td>Yes</td>
<td>Asked in survey</td>
<td></td>
</tr>
<tr>
<td>Can someone claim you as a dependent when filing taxes?</td>
<td>Nominal</td>
<td>Yes</td>
<td>Asked in survey</td>
<td></td>
</tr>
<tr>
<td>Did you complete high school/GED?</td>
<td>Nominal</td>
<td>Yes</td>
<td>Asked in survey</td>
<td></td>
</tr>
<tr>
<td>If so, when?</td>
<td>Nominal</td>
<td>Yes</td>
<td>Asked in survey</td>
<td></td>
</tr>
<tr>
<td>Do you have dependents besides a spouse that rely on you financially?</td>
<td>Nominal</td>
<td>Yes</td>
<td>Asked in survey</td>
<td></td>
</tr>
</tbody>
</table>

**Study Variables**

There was one independent variable for this study, instructional method. The control group used a traditional instructional method with mainly didactic lecture. The treatment group included ALEKS within the instruction. Upon completion of the sixteen-week remedial math course, the course outcomes were compared to determine if nontraditional students perform differently from traditional students in the same courses using the adaptive learning tool. Besides the student characteristic data, a request was made to IR to provide the student performance results.
The ALEKS section data included ALEKS pre and post-test scores, final grades and enrollment status. Data collection from the non-ALEKS course sections included, final grades and enrollment status. This data was used to answer questions one through three along with the study hypothesis. The end-of-course survey was sent to the ALEKS section students. Information from this survey was to be used to answer Research Question 4.

To ensure the results were not just a chance occurrence and have a higher level of reliability, comparative data from multiple sections of the remedial math courses was needed. The researcher included all of the ALEKS sections for both MATGEN-109 and 110. Three sections of MATGEN-109 and five sections of MATGEN-110 used the ALEKS adaptive software. To ensure a good sample size for student groups, eight sections of MATGEN-109 along with four sections of MATGEN-110 were selected from those teaching using traditional instruction. Sections of both MATGEN courses that used other software to support instruction were not selected for the study.

All students enrolled in MATGEN courses were placed using the same process. The students have either provided an ACT math score less than 17 and/or completed the ACCUPLACER arithmetic test with results ranging between 34 and 63. This baseline consistency improved internal validity. Collection of course results data was requested from the IR Department.

**Course Outcome Data**

Data for the control group includes; ACCUPLACER scores, final grades, and completion outcomes (dropped or completed). The ACCUPLACER score provided information on the students beginning math level. The final grade scores were used as a measure to determine student success. Completion outcomes were used to determine if there was any difference in the
completion rates versus drop rates in the ALEKS sections when compared to the non-ALEKS sections. Additional data was collected from the ALEKS sections.

ALEKS administrative tools provide additional data that helped determine student success. These data include ALEKS pie completion scores, beginning knowledge state and progress made (aleks.com, n.d.). In addition to this information, the students in the ALEKS sections were required to complete a pre-test. This test is called the ALEKS Math Placement test and allowed the researcher to increase internal validity when comparing the traditional versus the nontraditional students’ outcomes and success rates in the ALEKS treatment course sections.

Information to help determine the level of comfort and experience students had with using a computer and software to assist with learning was asked as part of a 9-question, end-of-course survey (Appendix C). The goal of this survey was to provide information regarding: the students’ technology experience, comfort level with ALEKS, and what type of device was used to access the ALEKS software. As part of the survey, an open-ended question asking students to share their feelings about using the ALEKS tool was included. This insight was to be used to answer research question four. In addition to the student data collection, interviews with at least three of the faculty using the ALEKS tool was intended. This information was to be included to help determine the faculty perspective on using ALEKS.

All data collected was saved to the researcher’s external hard-drive. Each data information file was protected using alpha-numeric passwords. In addition, the entire external hard-drive was encrypted with Microsoft’s BitLocker encryption software. This device is kept in a container and locked in the researcher’s personal desk when not in use.
Population and Sample

MATC was selected to participate in this study because the student population is like that of other two-year colleges and its’ experience of poor pass rates in remedial math are comparable with other two-year urban public institutions. To ensure the results were not just a fluke and had a higher level of validity, multiple sections of the same remedial math courses were used. Because this study used a quasi-experimental design there were limitations regarding control of the sampling pool however the researcher was able to collect data from a fairly large sample which contributed to the validity of the experiment. In addition, an accepted statistical analysis tool was used to examine the data.

Based on college information, most remedial math sections at MATC have an enrollment percent of around 58 of nontraditional students (based on age). The section maximum is 25 students, thus the maximum amount of possible adult learners per section would be estimated around 14-15. The college typically runs about 60 sections total of the two courses. Based on these rules, the maximum pool would total around 1,500 students. The pool was substantially lowered due to many of the sections not using either ALEKS or traditional method of instruction. Because there were less than six sections being taught in the control group, the researcher selected all sections that used the ALEKS tool. This resulted in three sections from MATGEN-109, and five sections from MATGEN-110. Eight sections total were identified for the ALEKS treatment group. Interesting enough MATC did not follow the 25-student maximum per section rule. The decision to add students beyond the 25 student maximum is at the discretion of the faculty.

Student enrollments ranged from 14-39 per section. Because the college allowed up to 39 students in one section, the researcher did not have to interfere with the course sample and
was able to conduct the study with a good sample size. This sampling structure is termed
convenience sample as it is the normal size for the classroom, thus the student groups are
convenient for the study (Fraenkel et al., 2011). Table 5 provides information on the possible
total population and sampling structure, based on the rules of the college.

Table 5

*Proposed Participant Population and Sample*

<table>
<thead>
<tr>
<th>Population Type</th>
<th># of Sections</th>
<th># of Students per sections</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Pool</td>
<td>60</td>
<td>25</td>
<td>1500</td>
</tr>
<tr>
<td>Sample</td>
<td>12</td>
<td>25</td>
<td>300</td>
</tr>
<tr>
<td>Actual Pool</td>
<td>57</td>
<td>25a</td>
<td>1425a</td>
</tr>
<tr>
<td>Sample</td>
<td>20</td>
<td>14-39</td>
<td>605</td>
</tr>
</tbody>
</table>

*Because MATC did not follow their 25 per section rule, cannot determine actual.

**Data Analysis**

Initially characteristic data was collected and categorized to help the researcher determine
if a student could be defined as traditional or nontraditional. Information collected from IR were
collated and normalized to a student number using Microsoft Excel. Students that identified with
at least two nontraditional characteristics, were identified as nontraditional. The sample was not
large enough, to further categorize nontraditional students as minimally, moderately, or highly
nontraditional.

Outcomes data (final grade score/ALEKS posttest), were aligned to the three research
questions. Initially, to set-up RQ 1, differences between the ALEKS course sections and the
traditionally taught sections were compared. The statistical test applied was the Independent
Samples \( t \)-test with one independent variable, instructional method, being compared across two student groups. The dependent variable was the student’s final grade scores.

Research Question 2 was an inquiry of the impact of ALEKS on nontraditional students. Nontraditional student course completion means were compared from the ALEKS sections and traditionally taught sections. A 2x2 Crosstab analysis with Pearson Chi-Square statistics was used to answer the question. The data was used to review the completion rates of nontraditional students in the two different instructional course types. The instructional groups were identified as traditional instruction and as ALEKS instruction. Grade score values were not used to determine how well the student did, only that they had a grade value. The students either completed or did not based on earning a final grade. To identify these two possibilities, the researcher assigned the following values: 0=non-completion (if no final grade) and 1=completion of the course (student earned a final grade). Both traditional and nontraditional students enrolled in the control and treatment sections without much knowledge of instructional method. This added to the study’s reliability.

Research Question 3 compared the nontraditional student outcomes to the traditional student outcomes in only the ALEKS sections. The basis was to determine if there was a difference in these outcomes using the final grades scores and ALEKS posttest scores. An Independent Samples \( t \)-test was used to compare each set of means separately. Student type (traditional/nontraditional) was used as the independent variable, with the final grade scores and ALEKS posttest being the dependent variables as shown in Table 6. The reason both outcomes were of interest was due to the course grade not being the only measure of success. Faculty teaching the sections with ALEKS require other measures of success such as homework.
completion and participation, in order to determine final grade whereas the ALEKS posttest is purely a measure of how well the student knows the math topic.

Table 6

*Question 3 Variables*

<table>
<thead>
<tr>
<th>Independent Variable-Student Type</th>
<th>Dependent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>Student outcomes</td>
</tr>
<tr>
<td></td>
<td>- ALEKS posttest</td>
</tr>
<tr>
<td></td>
<td>- final grade score</td>
</tr>
<tr>
<td>Nontraditional</td>
<td>Student outcomes</td>
</tr>
<tr>
<td></td>
<td>- ALEKS posttest</td>
</tr>
<tr>
<td></td>
<td>- final grade score</td>
</tr>
</tbody>
</table>

The researcher prepared questions to collect information regarding the students’ perception of the ALEKS tool. An End-of-Course survey (Appendix 3), was sent to the students that agreed to participate in the study. The researcher did not receive any responses from the student group. The survey was posed to the students in the ALEKS sections only. These questions were meant to collect information on how the students felt about using ALEKS within their math course. In addition, a question was presented to help determine if ALEKS was used outside of class. Results to these questions were to be compared to the student groups to determine if the use of adaptive technology aligns with the theories of adult learning and stereotype threat.

*Validity Reliability and Generalizability*

The use of quasi-experimental designs comes with some concern regarding internal validity. The researcher cannot control the characteristics or quantity of the students enrolled in the course sections. In addition to this apprehension is the realization that students who enroll in remedial courses drop or withdraw prior to the completion of the course (Bonham & Boylan,
To minimize these concerns, the researcher required at least six sections for each of the groups to be studied. The section enrollments ranged from 14-39 students in each, for a total student sample of 605. The number of students improved the probability of there being a sample size large enough to determine validity of the outcomes as well as the expected population of nontraditional students.

Reliability of the initial data collection is considered very strong. The ACCUPLACER placement test is commonly used to determine course assignment at two-year colleges. Its’ predictive validity has been questioned but studies have verified its ability to successfully predict placement (James, 2006). Likewise, reliability of both the pre and posttests is expected to be consistent as the collection of student responses is conducted using the ALEKS Math Placement tests for each of the groups. The probability of interference with these assessment methods is very low. Confidence in the reliability of the assessment results is very high.

To determine the extent of generalizability, characteristic data was collected on the participants in order to compare groups of students facing remedial math courses. Moreover, final grades were collected to determine differences between the outcomes of the student groups within the two different types of instructional method sections. This information is of particular interest considering the need to find a best practice to improve student achievement in the area of remedial math. Because of the importance stressed on determining a reliable instructional strategy for nontraditional learners, the number of nontraditional learners in this study needed to be more than half of the participant sample.

Protection of Human Subjects

Of concern with this quasi-experimental study, there may be problems if the students show major differences in the pretest results thus swaying the results of the posttest if they are
starting at noticeable differences in their prior knowledge. This possibility is known and was be
controlled for using a well-known statistical tool.

Other ethical considerations were similar to that of the physician’s oath to do no harm. Should one of the participant groups, either in the treatment or control groups do very poorly, besides the ethical implications, this researcher is also an educator and may feel a propensity to report this issue. However, since MATC has been using ALEKS within their remedial courses, this has not been an issue for the researcher. It is just something to be considered by the faculty, dean and associate deans of the college.

All faculty and students within the chosen courses and sections were asked to participate in this study, however no students under the age of eighteen were allowed to participate. Students were sent an agreement to participate that indicated this study was for educational research and had no bearing on their grade. Both students and faculty were informed their identity would be kept confidential. Because student information was de-identified, confidentiality was assured. MATC’s administration, the IR Department, faculty and students were reassured of the ethical nature of this study as well as its intent to use the information for research purposes only.
Chapter 4: Study Results

The purpose of this study was to determine if adaptive learning technologies, specifically the McGraw-Hill Education tool ALEKS, impacts math outcomes for nontraditional learners enrolled in remedial mathematics at two-year colleges and if so, is the performance level and completion rate equal to or higher than completion rates and performance levels of traditional students enrolled in the same course. This chapter will provide information on the participant sample, data collection process, data cleaning and data descriptions. In addition, the statistical analysis is presented to test the null hypotheses indicated in Chapter three. This study was guided by three research questions. The outcomes of the research questions are grouped, analyzed, and discussed.

Sample Description

This study was conducted during the fall term of the academic year 2018-2019 at a 2-year public college located in the Midwest. There were two remedial math courses taught at the site-college: Pre-Algebra (MATGEN-109) and Elementary Algebra with Applications (MATGEN-110). Both courses had multiple sections and used different instructional methods as determined by the math faculty. During the time when this study was conducted, 57 sections of the two remedial courses were offered. Faculty have a choice regarding the methods they use to teach the sections. The Associate Dean of Math provided the list of courses and sections that used either ALEKS or traditional instruction. The sections selected for this study used either traditional didactic methods or the McGraw Hill Education tool ALEKS. For this study, an academic term lasts for 16 weeks. Of the sections offered, 20 sections of two remedial math courses qualified for the study description.
Course and student characteristic data were collected from two remedial math courses. Each section had the capacity of twenty-five students, however not all sections were full. Also, many of the sections surpassed the 25-student per section maximum. Student capacity is at the discretion of the faculty. The course and section counts are shown in Table 7.

Table 7

Number of Course Sections and Enrollment Totals

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Sections</th>
<th>Enrollment Totals (non-duplicated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATGEN-109</td>
<td>11</td>
<td>329</td>
</tr>
<tr>
<td>MATGEN-110</td>
<td>9</td>
<td>276</td>
</tr>
</tbody>
</table>

Data Collection Process

This section describes the data collection process for the student surveys. An explanation of the problems that occurred related to survey response collection is depicted. Then the process for collecting the student characteristic data, the student outcomes, and the ALEKS pre and posttest results is described.

Since the instructional method for each section is determined by the faculty, I needed to determine which sections used which instructional method. An email request was sent to the Associate Dean of Math, asking for the final list of MATGEN sections that were taught using the ALEKS technology and for sections that were taught using traditional methods. Table 8 lists the quantity of sections for both MATGEN courses along with the section’s instructional method. To ensure the greatest sample size, all sections were used in this study.
Table 8

**Instructional Method Distribution**

<table>
<thead>
<tr>
<th>Course</th>
<th>Instructional Method</th>
<th>Section Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATGEN-109</td>
<td>ALEKS</td>
<td>3</td>
</tr>
<tr>
<td>MATGEN-109</td>
<td>Traditional</td>
<td>8</td>
</tr>
<tr>
<td>MATGEN-110</td>
<td>ALEKS</td>
<td>5</td>
</tr>
<tr>
<td>MATGEN-110</td>
<td>Traditional</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>ALEKS</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>Traditional</td>
<td>12</td>
</tr>
</tbody>
</table>

**Student Sample-Surveys**

The researcher requested from the Director of Institutional Research; a list of student email addresses of those enrolled in the MATGEN sections. After receiving the list of email addresses, the researcher sent an email to the entire list of students [N=826], identified by the Director of IR. The email contained basic information about the study along with a link to the informed consent document and the survey link. Within a week the researcher received 10 responses from the students. The low number of responses made the researcher question if the email contained spam language warnings. She then tested the email process to ensure the email from her Northeastern email account was not being blocked by a spam filter. Based on the test, it was determined the emails were not being blocked as spam. The researcher waited an additional two weeks and sent the research study email to the students a second time. An additional 10 responses were received from the student population. The researcher waited until the end of the semester but only received an additional two consent forms and completed surveys. Responses received from a total possible participant pool of 826, was 22. This sample
was not large enough to conduct an analysis however, because the college collects many data points, the researcher was able to conduct the study using institutional data.

**Student Sample—Characteristics and Outcomes Data**

A data request of the student characteristics, final grades, and the ALEKS pre and posttest scores of the two courses was sent to the Director of Institutional Research. The list of requested data is shown in Table 9. The Director of IR de-identified the student information and assigned a numeric identifier (pseudo number), to each student record within the sample. The course and section information were included in the sample.

Table 9

*List of Student Data Requested from Institutional Research*

<table>
<thead>
<tr>
<th>Enrollment Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Credential Type</td>
</tr>
<tr>
<td>Last Year Attended HS</td>
</tr>
<tr>
<td>ACT Math Score</td>
</tr>
<tr>
<td>ACCUPLACER Arithmetic Score</td>
</tr>
<tr>
<td>Enrollment Current Status</td>
</tr>
<tr>
<td>Enrollment Status Date</td>
</tr>
<tr>
<td>Final Course Grade</td>
</tr>
<tr>
<td>Student Gender</td>
</tr>
<tr>
<td>Student Race/Ethnicity</td>
</tr>
<tr>
<td>Student Age</td>
</tr>
<tr>
<td>Credits Attempted</td>
</tr>
</tbody>
</table>
In addition to the student characteristic and grade data, the researcher requested student outcomes data (pre and posttest scores), for the ALEKS sections. Initially the researcher only received ALEKS data for seven of the eight sections. The researcher then contacted the Director of IR indicating that ALEKS data for one of the sections was missing. After the Director of IR confirmed the section did use the ALEKS tool, the remainder of the data was sent for the final ALEKS section.

**Data Cleaning**

First the researcher scanned the data for consistency. She then added an identifier to discern the independent variable-instructional method: AL represented the ALEKS sections and TI for traditional sections. This prefix was then joined to the student numeric identifier (pseudo number), supplied by the Director of IR. This resulted in a student identification number of instructional method and a number. This method increased the anonymity of the student data records. The file contained 919 records. It was reviewed numerous times to ensure data validity. It was clear that there were many duplicates in the data file. Record duplication occurred each time a student changed sections or their status. The duplicates were reviewed and culled which resulted in a final sample of 605 records.

**Data Descriptions and Explanation**

As shown in Table 9, there were eleven sections of the Pre-Algebra (MATGEN-109) course included in the study and nine sections of the Elementary Algebra with Applications (MATGEN-110) course. The section sizes ranged from 14 to 39 students, for a total sample of 605 unduplicated student records. The data was then reviewed and aligned in preparation for the analysis.
Scores and grades. Students that apply to the site college are encouraged to complete the ACT ACCUPLACER placement test. These scores were collected as part of the data request for both courses. The scores were used to establish a baseline knowledge level. Out of the total sample of 605, 508 ACCUPLACER scores were provided. Final grades were collected for both groups. Out of the 605 sample, only 344 students had a final grade. The ALEKS final assessment scores were collected from the participants that enrolled and completed the math course sections that used ALEKS. From the ALEKS sections, the sample totaled 230. Among this sample, 110 ALEKS posttest scores were available as indicated in Table 10.

Table 10

Scores and Grade Samples

<table>
<thead>
<tr>
<th>Student Outcomes</th>
<th>Total Sample</th>
<th>Sample (with data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCUPLACER</td>
<td>605</td>
<td>508</td>
</tr>
<tr>
<td>ALEKS</td>
<td>230</td>
<td>110</td>
</tr>
<tr>
<td>Final Grade Score</td>
<td>605</td>
<td>344</td>
</tr>
</tbody>
</table>

Traditional and nontraditional student descriptors. To conduct the analysis, the researcher had to first differentiate traditional students from nontraditional with the data available. As previously noted, age alone does not fairly define nontraditional students (Choy, 2002; Horn & Carroll, 1996). The researcher was able to collect several data that align with those identified by prior research as part of the nontraditional definition: age, secondary credential type, duration between secondary completion and enrollment in college, and full or part-time enrollment status. The researcher categorized the data elements as indicated in Table 11.
Table 11

*Traditional and Nontraditional Data Definitions*

<table>
<thead>
<tr>
<th>Data Element</th>
<th>Traditional</th>
<th>Nontraditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>&lt;=24</td>
<td>&gt;24</td>
</tr>
<tr>
<td>Secondary Credential Type</td>
<td>High School Diploma</td>
<td>High School Diploma Equivalent or; General Education Degree</td>
</tr>
<tr>
<td>Secondary to Post Secondary Enrollment Duration</td>
<td>&lt;=2 years</td>
<td>&gt;2 years</td>
</tr>
<tr>
<td>Enrollment Status</td>
<td>&gt;=12 credits</td>
<td>&lt;12 credits</td>
</tr>
</tbody>
</table>

Prior research identifies nontraditional students as those identifying with one or more of these data elements (Horn & Carroll, 1996). Others have defined nontraditional students using student background characteristics or at-risk behaviors, (Kim, 2002). For this study, a student was defined as nontraditional when they aligned with two or more of the previously defined characteristics. According to Horn and Carroll, this would mean these students are moderately nontraditional (1996). Student characteristic data was then further categorized as traditional or nontraditional according to the study definitions. The researcher used zero (0) to represent the traditional students and one (1) to identify the nontraditional students.

The student data was sorted and aligned for each of the traditional and nontraditional characteristic definitions. Table 12 lists the characteristic along with the distribution of each.
Table 12

*Student Sample Characteristics*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Traditional (0)</th>
<th>Nontraditional (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>373</td>
<td>232</td>
</tr>
<tr>
<td>Enrollment Status</td>
<td>147</td>
<td>458</td>
</tr>
<tr>
<td>High School Credential(^a)</td>
<td>509</td>
<td>58</td>
</tr>
<tr>
<td>Years Since Completing HS Credential(^a)</td>
<td>240</td>
<td>327</td>
</tr>
</tbody>
</table>

\(^a\)38 participants did not report this information.

Based on this study’s definition of identifying with at least two nontraditional characteristics, there were 277 traditional students and 328 nontraditional students.

**Student Groups**

The data was further examined to determine how many students enrolled in the course sections that were either taught with the ALEKS adaptive learning tool or with traditional methods. The allocation in quantity as well as percentage is listed in Table 13.

Table 13

*Research Study Groups*

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive Traditional (AT)</td>
<td>100</td>
<td>16.5</td>
<td>16.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Adaptive Nontraditional (AN)</td>
<td>130</td>
<td>21.5</td>
<td>21.5</td>
<td>38.0</td>
</tr>
<tr>
<td>Non-Adaptive Traditional (NT)</td>
<td>177</td>
<td>29.3</td>
<td>29.3</td>
<td>67.3</td>
</tr>
<tr>
<td>Non-Adaptive Nontraditional (NN)</td>
<td>198</td>
<td>32.7</td>
<td>32.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>605</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
Enrollments and Drops

Student enrollment and drop data was collected to compare completion rates between students enrolled in the ALEKS sections to those in the traditional sections. This information is important in order to investigate research question number two, which examines completion rates of nontraditional learners. Table 14 provides enrollment and drop information from the student sample.

Table 14

Enrollment Status of Student Sample

<table>
<thead>
<tr>
<th>Enrollment Status</th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added after course started</td>
<td>34</td>
<td>5.6</td>
<td>5.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Dropped</td>
<td>191</td>
<td>31.6</td>
<td>31.6</td>
<td>37.2</td>
</tr>
<tr>
<td>Instructor Dropped</td>
<td>68</td>
<td>11.2</td>
<td>11.2</td>
<td>48.4</td>
</tr>
<tr>
<td>Enrolled</td>
<td>312</td>
<td>51.6</td>
<td>51.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>605(^{a})</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) Of note, there was one student that received an incomplete and one student that was auditing the course. While these two students were not included in the total of those who dropped, they did not receive a final grade score.

Of the 605 students that enrolled into the remedial math courses, 346 or 57.2% completed the math course with 259 or 42.8% dropping out or being dropped by their instructor from the math course prior to the completion of the course. Those students who were dropped by the instructor, were dropped because the student stopped attending the course. This occurred with 68 students or 11.2%.
Student Sample Demographics

In addition to student characteristic data that defined students as traditional or nontraditional, other relevant data was collected. Student gender and racial or ethnicity data was collected to determine if there was an impact on outcomes as related to Stereotype Threat Theory. Distribution of these data are displayed in Tables 15 and 16.

Table 15

*Student Gender Distribution*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>398</td>
</tr>
<tr>
<td>Male</td>
<td>207</td>
</tr>
</tbody>
</table>

Table 16

*Student Ethnicity Distribution*

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Indian</td>
<td>5</td>
</tr>
<tr>
<td>Asian</td>
<td>43</td>
</tr>
<tr>
<td>Black or African-American</td>
<td>224</td>
</tr>
<tr>
<td>Hispanic</td>
<td>126</td>
</tr>
<tr>
<td>Two or More Races</td>
<td>24</td>
</tr>
<tr>
<td>White</td>
<td>156</td>
</tr>
<tr>
<td>Unknown</td>
<td>27</td>
</tr>
</tbody>
</table>

Using the institutional data provided, the researcher then conducted the analysis to determine if the results could support the hypothesis.
**Research Hypothesis and Question Analysis**

The study’s overall null hypothesis is stated as, $H_0$ - There is no difference in performance between traditional and nontraditional students in remedial math when using ALT. The researcher investigated three questions to determine if the null hypothesis could be accepted or rejected. The tool used to conduct the analysis was IBM’s Statistical Program Social Sciences (SPSS), Version 25. This study’s research questions refer to groups within the formulas. The groups have been previously labeled (Table 1), in Chapter 3 and are shown again (for the readers convenience).

Table 1  
*Study Groups by Instructional Method*

<table>
<thead>
<tr>
<th>Instructional Method</th>
<th>Type of student</th>
<th>Groups (#)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive</td>
<td>Traditional</td>
<td>AT (1)</td>
</tr>
<tr>
<td>Adaptive</td>
<td>Nontraditional</td>
<td>AN (2)</td>
</tr>
<tr>
<td>Non-adaptive</td>
<td>Traditional</td>
<td>NT (3)</td>
</tr>
<tr>
<td>Non-adaptive</td>
<td>Nontraditional</td>
<td>NN (4)</td>
</tr>
</tbody>
</table>

**Research Questions and Results**

Research Question 1-Does the integration of adaptive learning technology (ALEKS), within remedial math courses result in different outcomes for remedial math learners?

The hypothesis can be stated as:

$H_0$: $\mu_{12}=\mu_{34}$

$H_A$: $\mu_{12}\neq\mu_{34}$.
Instructional method was the independent variable with the final Grade Score as the dependent variable. The grade score values were identified by the Associate Dean of the Math Department and are shown in Table 17.

Table 17

Grade Score Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.00</td>
</tr>
<tr>
<td>A-</td>
<td>3.75</td>
</tr>
<tr>
<td>B+</td>
<td>3.25</td>
</tr>
<tr>
<td>B</td>
<td>3.00</td>
</tr>
<tr>
<td>B-</td>
<td>2.75</td>
</tr>
<tr>
<td>C+</td>
<td>2.25</td>
</tr>
<tr>
<td>C</td>
<td>2.00</td>
</tr>
<tr>
<td>C-</td>
<td>1.75</td>
</tr>
<tr>
<td>D+</td>
<td>1.25</td>
</tr>
<tr>
<td>D</td>
<td>1.00</td>
</tr>
<tr>
<td>D-</td>
<td>.75</td>
</tr>
<tr>
<td>U</td>
<td>0.00</td>
</tr>
</tbody>
</table>

To answer this question, an Independent Samples $t$-test was utilized to test the null hypothesis. The $t$-test helps determine if the differences between the means are significant or if the difference is due to chance (Hoy, 2010, p. 53). A comparison of the final grade scores from the ALEKS (AL) sections were compared to the final grade scores of the traditional instruction (TI) sections.
The student groups were not differentiated between traditional and nontraditional since we were comparing the results of all students by instructional method. There were 137 student final grade scores within the adaptive learning or ALEKS sections and 207 student final grade scores within the sections taught using a traditional method. The mean scores were very close with only a .1594 difference, as shown in Table 18.

Table 18

*Group Statistics-Comparison of Instructional Methods*

<table>
<thead>
<tr>
<th>Instr. Method</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional Instruction</td>
<td>207</td>
<td>2.1618</td>
<td>1.18461</td>
<td>.08234</td>
</tr>
<tr>
<td>ALEKS</td>
<td>137</td>
<td>2.3212</td>
<td>1.22247</td>
<td>.10444</td>
</tr>
</tbody>
</table>

Based on the Sig. being .322 in Levene’s Test (Table 20), the assumption of homogeneity of variance for the variables AL and TI is not violated. We used the results in the Equal variances assumed row in Table 19 to answer Research Question 1.

Table 19

*Independent Samples t-Test-Grade Score*

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>Grade Score</td>
<td>.984</td>
<td>.322</td>
</tr>
</tbody>
</table>
The results illustrated in Table 19 indicate we cannot reject the null hypothesis ($H_0: \mu_{12}=\mu_{34}$). The $t$-value equals 1.206 and has a p-value of .229, greater than 0.05. We cannot conclude there is a difference in student outcomes when integrating ALEKS with remedial math course instruction.

Research Question 2-Does the integration of adaptive learning technologies within remedial math courses impact the completion rates of nontraditional learners at two-year colleges? The hypotheses were stated as:

$$H_0: \mu_2=\mu_4$$

$$H_A: \mu_2 \neq \mu_4.$$  

This analysis compares only the nontraditional student completion outcomes within both the ALEKS and traditional instruction sections. For this research question, completion was defined by the student earning a final grade (regardless of the final grade score). A category was added to the data file, named Completed, with values assigned as, (0=non-completion, 1=completion). The data was then filtered to only include the completion outcomes for the nontraditional students. This resulted in a total sample of $n=328$ with the ALEKS section nontraditional students equal to 130 and the traditional instruction students equal to 198. To determine if the difference was significant, a 2x2 Crosstab analysis with Chi-Square test was used. Instructional method was the independent variable and completion outcome as the dependent variable. Table 20 shows the crosstab comparison of the ALEKS and Traditional sections.
Table 20

*Crosstabulation-Instruction Method by Completion Rates and Percentage*

<table>
<thead>
<tr>
<th>Instructional Method</th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>56</td>
<td>74</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>(43%)</td>
<td>(57%)</td>
<td></td>
</tr>
<tr>
<td>Traditional Instruction</td>
<td>108</td>
<td>90</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>(55%)</td>
<td>(45%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>164</td>
<td>328</td>
</tr>
</tbody>
</table>

Table 21

*Chi-Square Test-Instructional Method and Completion*

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance</th>
<th>Exact Sig. (2-sided)</th>
<th>Exact Sig. (1-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>4.129</td>
<td>1</td>
<td>.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuity Correction</td>
<td>3.683</td>
<td>1</td>
<td>.055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>4.139</td>
<td>1</td>
<td>.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher's Exact Test</td>
<td></td>
<td></td>
<td>.055</td>
<td>.027</td>
<td></td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>328</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 65.00.
b. Computed only for a 2x2 table

The Pearson Chi-Square statistic is 4.129 with a *p*-value of .042 shown in Table 21.

Since the *p*-value is less than the .05 cutoff, we can reject the null hypothesis (H0: μ2=μ4). The result is significant indicating that completion rates differ based on instructional method.
ALEKS instructional method resulted in a completion rate of 57% compared to 45% for traditional instruction.

Research Question 3-Do nontraditional learners perform at an equal to, or higher level than traditional learners in remedial math when adaptive learning technology is integrated within remedial math instruction? The hypothesis can be stated as:

\[ H_0: \mu_1=\mu_2 \]
\[ H_A: \mu_1 \neq \mu_2. \]

To test this null hypothesis, the independent variable used was instructional method, where instructional method equals adaptive technology (ALEKS). The researcher reviewed both, the students’ final grade score as well as their ALEKS posttest score to test the null hypothesis. To conduct the analysis, a grade value was applied to the alphabetical grades. This scale was provided by the Associate Dean of Math at MATC. The values used were previously shown in Table 17.

The researcher was able to use the Independent Samples \( t \)-test to answer the null hypothesis. Reviewing the Group Statistics (Table 22), the Adaptive Traditional group had a sample size of 63 with a 2.1429 mean grade score, while the Adaptive Nontraditional group had 74 students with a mean grade score of 2.4730.

<table>
<thead>
<tr>
<th>Group Statistics-Dependent Variable-Grade Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Study Group</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Grade Score</td>
</tr>
<tr>
<td>Adaptive Traditional</td>
</tr>
<tr>
<td>Adaptive Nontraditional</td>
</tr>
</tbody>
</table>
Levene’s Test for Equality of Variances was applied to determine if the assumption of equal variance could be assumed between the traditional and nontraditional student groups (Table 23). Since the Sig. = .441 is greater than .050, we can assume homogeneity of variance for the variable Grade Score and use information in the top row of Table 23.

Table 23

*Independent Samples t-Test-Dependent Variable-Grade Score*

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variances assumed</td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td></td>
<td>.598</td>
<td>.441</td>
</tr>
</tbody>
</table>

Using the Independent Samples t-test, we found there was no significant difference in traditional student or nontraditional student outcomes from the adaptive sections when using Grade Scores as the dependent variable (t = 1.584, df = 135, p > 0.05).

The ALEKS posttest score was then used as the dependent variable. Since the student participants were enrolled in multiple sections, taught by different faculty, there could be some variation in their grade scores. By using the scores from a software testing instrument (ALEKS), some degree of assumed human bias can be removed, thus increasing the reliability of the analysis.

When the final Grade Score was the dependent variable, there were a total of 137 in the sample, however not all students completed the ALEKS posttest which explained the lower
sample number of 110. Again, the Adaptive Nontraditional student sample scored higher with a mean ALEKS posttest score of 57.1061 whereas the Adaptive Traditional group had a mean ALEKS posttest score of 51.7955 as shown in Table 24.

Table 24

*Group Statistics-Dependent Variable-ALEKS Posttest*

<table>
<thead>
<tr>
<th>Research Study Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS Posttest score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adaptive Traditional</td>
<td>44</td>
<td>51.7955</td>
<td>22.90585</td>
<td>3.45319</td>
</tr>
<tr>
<td>Adaptive Nontraditional</td>
<td>66</td>
<td>57.1061</td>
<td>26.58000</td>
<td>3.27177</td>
</tr>
</tbody>
</table>

Levene’s Test for Equality of Variances resulted in an F-value of 2.099 and a *p*-value of .150 indicating that the assumption of equal variances was not violated.

Table 25

*Independent Samples Test-Dependent Variable-ALEKS Posttest*

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
<td>T</td>
</tr>
<tr>
<td>ALEKS PostTest Score Equal variances assumed</td>
<td>2.099</td>
<td>.150</td>
</tr>
</tbody>
</table>

Using the *t*-test for Independent Samples, there was no statistical significance between the adaptive traditional and adaptive nontraditional student outcomes when using ALEKS posttest scores (*t* = -1.084, df = 108, *p* > 0.05). Based on the statistical analysis, we cannot reject the null hypothesis (*H₀*: µ₁=µ₂). Thus, we cannot conclude the integration of ALT within remedial math
instruction results in different performance levels for nontraditional students when compared to traditional students at two-year colleges.

The t-tests allowed the researcher to compare means, but the researcher wanted to look a deeper to determine if any of the categorical variables predicted student outcomes. To determine if any of the characteristics impacted student outcomes, a univariate analysis of variance (ANOVA) was performed. This test is a bit more robust and allowed the researcher to determine if there were any relationships that predict student outcomes. Table 26 provides the results of this test.

Table 26

ANOVA with Dependent Variable of Grade Score

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>88.343a</td>
<td>44</td>
<td>2.008</td>
<td>1.432</td>
<td>.048</td>
</tr>
<tr>
<td>Intercept</td>
<td>100.541</td>
<td>1</td>
<td>100.541</td>
<td>71.702</td>
<td>.000</td>
</tr>
<tr>
<td>AccuplacerArithmeticScores</td>
<td>6.479</td>
<td>1</td>
<td>6.479</td>
<td>4.620</td>
<td>.033</td>
</tr>
<tr>
<td>InstrMethod</td>
<td>.001</td>
<td>1</td>
<td>.001</td>
<td>.001</td>
<td>.975</td>
</tr>
<tr>
<td>StatusFinal</td>
<td>.668</td>
<td>1</td>
<td>.668</td>
<td>.477</td>
<td>.491</td>
</tr>
<tr>
<td>StudentGender</td>
<td>4.024</td>
<td>1</td>
<td>4.024</td>
<td>2.870</td>
<td>.092</td>
</tr>
<tr>
<td>StudentRaceEthnic</td>
<td>17.297</td>
<td>6</td>
<td>2.883</td>
<td>2.056</td>
<td>.059</td>
</tr>
<tr>
<td>InstrMethod * StatusFinal</td>
<td>.014</td>
<td>1</td>
<td>.014</td>
<td>.010</td>
<td>.921</td>
</tr>
<tr>
<td>InstrMethod * StudentGender</td>
<td>2.030</td>
<td>1</td>
<td>2.030</td>
<td>1.448</td>
<td>.230</td>
</tr>
<tr>
<td>InstrMethod * StudentRaceEthnic</td>
<td>1.074</td>
<td>5</td>
<td>.215</td>
<td>.153</td>
<td>.979</td>
</tr>
<tr>
<td>StatusFinal * StudentGender</td>
<td>1.516</td>
<td>1</td>
<td>1.516</td>
<td>1.081</td>
<td>.299</td>
</tr>
<tr>
<td>StatusFinal * StudentRaceEthnic</td>
<td>10.894</td>
<td>5</td>
<td>2.179</td>
<td>1.554</td>
<td>.174</td>
</tr>
</tbody>
</table>
Based on the ANOVA, only the ACCUPLACER Arithmetic Score was statistically significant (Sig. = .033) in explaining the Grade Score. However, with an R Squared = .207, almost 79% of the variance in Grade Score was unexplained. No other variables were found to be significant predictors of the Grade Score.

Research Question 4-Does the student’s comfort level with technology impact the students’ successful completion in remedial math when the course utilizes adaptive learning technology? While the researcher sent out an email request to the student sample, only a minimal amount (22), of students agreed to the survey. The researcher sent emails to the 22 students that agreed to participate in this study on three different occasions. No responses were received. This question was not able to be researched. The inability to collect this information significantly impacted the researcher’s ability to use this information to substantiate the use of
adaptive learning technology with Adult Learning Theory. Survey questions were written qualitatively so that the researcher could have learned more of the student’s experience and comfort with the technology. Due to the failure to collect this information, little data can be identified to support Adult Learning Theory and the researcher relied on the data collected to substantiate alignment to Stereotype Threat Theory.

**Data Related to Stereotype Threat Theory**

The researcher reviewed the data to determine if there was any significance regarding student outcomes that supported Stereotype Threat Theory. The theory claims that females, African-Americans and Hispanics do worse in math courses due to anxiety (Aronson, 2004). Regarding females, other studies found that even high-performing women were impacted by high-stakes math exams (Good, Aronson, & Harder, 2008). Because ALEKS tests the student as part of the learning, high stakes testing anxiety may be reduced. A comparison of the means of the final grade scores for gender and ethnicity were grouped by traditional instruction sections and ALEKS sections. The means were grouped by gender for the ALEKS sections and traditional instruction sections are listed in Table 27. The females in the ALEKS sections had a higher Grade Score Mean (2.5194), than those in the Traditional Instruction sections (2.1393). Results for the male groups were just the opposite. The Grade Score Mean for the males in the ALEKS sections was 1.9415 whereas the Grade Score Mean for males in the Traditional Instruction sections was 2.2007.

Table 27

<table>
<thead>
<tr>
<th>Gender/Instructional Method</th>
<th>N</th>
<th>Grade Score Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female-ALEKS</td>
<td>90</td>
<td>2.5194</td>
</tr>
</tbody>
</table>
Independent Samples $t$-tests was conducted for the student samples, comparing the Grade Score of the females in the two section types (ALEKS and traditional instruction). The results did show a statistical significance for the female students with a $t$-value of 2.337 and $p$-value of .020. Using the same grouping for the male sample, there was no statistical significance between the Grade score means of the students in the ALEKS sections or Traditional Instruction sections ($t = 1.169$, $df = 121$, $p$-value = .245). The same analysis was applied to the ethnic groups as shown in Table 28.

Table 28

**Ethnicity Mean Score Comparison**

<table>
<thead>
<tr>
<th>Ethnicity/Instructional Method</th>
<th>N</th>
<th>Grade Score Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American-ALEKS</td>
<td>48</td>
<td>2.3750</td>
</tr>
<tr>
<td>African American-TI</td>
<td>67</td>
<td>2.0224</td>
</tr>
<tr>
<td>Hispanic-ALEKS</td>
<td>29</td>
<td>2.1293</td>
</tr>
<tr>
<td>Hispanic-TI</td>
<td>40</td>
<td>1.8563</td>
</tr>
<tr>
<td>American Indian-ALEKS</td>
<td>1</td>
<td>3.0000</td>
</tr>
<tr>
<td>American Indian-TI</td>
<td>3</td>
<td>3.7500</td>
</tr>
<tr>
<td>Asian-ALEKS</td>
<td>12</td>
<td>2.5000</td>
</tr>
<tr>
<td>Asian-TI</td>
<td>17</td>
<td>2.3824</td>
</tr>
<tr>
<td>Two+ Races-ALEKS</td>
<td>7</td>
<td>2.7143</td>
</tr>
<tr>
<td>Two+ Races-TI</td>
<td>6</td>
<td>2.1250</td>
</tr>
<tr>
<td>White-ALEKS</td>
<td>35</td>
<td>2.1571</td>
</tr>
<tr>
<td>White-TI</td>
<td>64</td>
<td>2.3086</td>
</tr>
</tbody>
</table>
Independent Samples $t$-tests was ran for each of the ethnic groups, comparing the ALEKS sections to the Traditional Instruction sections. Of each of the groups analyzed, none resulted in statistical significance. It is interesting to note that all of the ethnic group’s Grade Score means were higher in the ALEKS sections with the exception of the American Indian group, however that sample was very small. The opposite was true for the White students.

**Conclusion**

The researcher primarily used Independent Samples $t$-tests to analyze the data and answer the three research questions. Analysis of the Grade Scores (DV) using instructional method as the independent variable were reviewed. Results affirmed there was no significant difference in the final grade scores (outcomes) for remedial math learners when the ALEKS tool was included in the instructional method.

Next, the researcher reviewed completion rates for only the nontraditional students to determine if ALEKS had any effect when compared to the sections taught with traditional instruction methods. The analysis resulted in a statistically significant difference in completion rates for the nontraditional students enrolled in the ALEKS sections when compared to the traditional instruction sections.

To analyze the third question, the researcher applied the Independent Samples $t$-tests twice using the means from the Grade Scores and the ALEKS posttest scores. This strategy was applied to determine if nontraditional learners perform at a higher level than traditional students in remedial math when ALT (ALEKS), is incorporated into the instruction. Students final grade scores and ALEKS posttest scores were assigned to the dependent variable and the independent variable used was instructional method=AL (ALEKS).
Using a $t$-test to analyze the student’s final grade scores resulted in no statistical
difference. In addition, when the researcher used the ALEKS posttest scores as the DV, there
was no statistical difference. Based on these results, the researcher concluded there is no
statistical significant difference in the outcomes of nontraditional students when compared to
traditional students in remedial math courses that include an ALT.

The researcher attempted to collect information from the student groups related to their
comfort and use of the ALEKS tool by sending a survey to the sample. After several attempts
without any response, the researcher considered this attempt unsuccessful. This information
would have helped the researcher answer research question 4 and to compare the results to the
principles of Adult Learning Theory. The researcher was able to conduct some analysis to
support Stereotype Threat Theory.

Results from Independent Samples $t$-test by gender and ethnicity were conducted. The
results did show a statistical significance of Grade Scores between the females in the ALEKS
sections when compared to the females in the Traditional Instruction sections. The results from
the same test conducted on the ethnic groups did not show any statistical significance.
Chapter 5: Discussion of Results and Findings

For decades remedial courses have significantly contributed to incomplete attainment of a college degree (Bailey, 2009). This issue has been felt the greatest at 2-year colleges where the percentage of those placed into remedial education ranges from 40-98% depending on the source or study (Bailey, 2009; Levin & Calcagno, 2008; Pretlow & Wathington, 2013; Tierney & Garcia, 2008). Despite many attempts to address this problem, there has not been any one strategy that consistently improves remedial course outcomes (Bailey, 2009; Hodara & Jaggars, 2014). Another complexity at 2-year colleges is the student body diversity.

Two-year colleges enroll both traditional, (direct from high school) students but also enroll a significant number of adult or non-traditional students. These students have different needs and challenges when compared to traditional students (Miglietti & Strange, 1998). One thing in common between the two student groups is failures in remedial education, especially in math. As previously noted, there has not been any consistent method to improve the outcomes of students in remedial education however, advances in artificial intelligence and technology may provide some improvement.

McGraw-Hill Education has worked to develop an adaptive technology, Assessment LEarning in Knowledge Spaces (ALEKS) that may improve student outcomes in remedial math. There have been some research studies using ALEKS in both secondary and post-secondary math courses with mixed results (Craig et al., 2013; Hagerty & Smith, 2005; Taylor, J., 2008). A thorough review did not produce any studies comparing remedial math outcomes of traditional students to nontraditional students at two-year colleges.

This study was developed to determine if there was a difference in outcomes for nontraditional students when compared to traditional students in remedial math when an adaptive
learning tool was used. The purpose was to determine if nontraditional students would experience improved outcomes in remedial math courses where ALEKS was integrated with the instruction. The study was based on the principles of Adult Learning Theory and Stereotype Threat Theory. One hypothesis guided this study along with four research questions adding to the details of the study.

In general, the findings reported in Chapter 4 indicate that there was little difference in the final grade scores for the nontraditional students compared to the final grade scores of traditional students. However, there were some findings that did result in positive completion rates in the adaptive (ALEKS) sections. This chapter provides a summary of the study along with the following sections: presentation and findings implications, contribution to local knowledge and application of the findings, implications and suggestions for further research and a personal reflection of the research experience.

Presentation of the Findings

This study was conducted at a 2-year urban minority-majority college in the Midwest. The study took place during the fall semester of 2018, with data collected from two similar remedial math courses. The sample contained 605 student records from 21 sections of the two courses. The primary analysis method used was Independent Samples t-test. A crosstabulation and Pearson’s Chi-square along with an ANOVA were also used. From the student sample, gender and ethnicity were reviewed as well, to determine if there was a statistical difference to support Stereotype Threat Theory.

Research Question 1: Does the integration of adaptive learning technology (ALEKS), within remedial math courses result in different outcomes for remedial math learners? The independent variable used was instructional method and the dependent variable was final grade
score. The independent variable had two groups of students, those enrolled in the Traditional Instruction sections (control group), and the other group enrolled in the ALEKS sections (test group). An Independent Samples $t$-test was conducted to compare the means of the groups. There was no statistical difference in the final grade score between the two groups.

This result could be perceived as both positive and negative. On one hand academic leaders, faculty, and students can feel some assuredness that student learning outcomes are not significantly impacted by the two teaching methods. On the other hand, ALEKS did not prove to be a successful interventional method to significantly improve overall remedial math outcomes. With ALEKS being an added cost, remedial education stakeholders may need to weigh the benefits against the costs of the tool.

Research Question 2: Does the integration of adaptive learning technologies within remedial math courses impact the completion rates of nontraditional learners at two-year colleges? Research question 2 focused on the completion rates of nontraditional students in the ALEKS (AL) and Traditional Instruction (TI) sections. This analysis compared the completion rates regardless of grade for only the nontraditional students. Completion means were compared between the AL and TI sections. The results showed a statistical significance with the nontraditional students in the ALEKS sections completing at a higher rate. This information is important because completion of remedial math has been shown to result in improved credential completion rates (Bahr, 2013). While this is a positive result, more research needs to be conducted because this is one group at one college. In addition, this researcher only looked at completions without determining if the completion grade was at the level of passing. Future research should review completion results.
Research Question 3: Do nontraditional learners perform at an equal to, or higher level than traditional learners in remedial math when adaptive learning technology is integrated within remedial math instruction? The IV was instructional method using only the ALEKS sections. Two dependent variables were analyzed: final grade score and the ALEKS posttest scores. The means comparison for both the final grade score and the ALEKS posttest scores were slightly higher but the analysis did not show any statistical significance for either dependent variable. An ANOVA was conducted to determine if any one variable or combination of variables resulted in any statistical significance on the grade score. The only variable that resulted in significance was the ACCUPLACER score. Interesting enough, the ACCUPLACER placement test has been questioned in other research as a valid placement tool (Medhanie et al., 2012). Research on remedial placement resulted in findings that indicate students can be placed either too low or too high with underprepared students feeling the impact of misplacement (Rodríguez, Bowden, Scott-Clayton, & Belfield, 2014).

In addition to conducting research to answer the hypothesis and research questions, the student demographic data was reviewed to determine if there was any significance in student outcomes based on gender or ethnicity. Results for the females enrolled in either the AL or TI sections were compared. There was a statistical difference for females having a higher mean score in the AL sections. Results for the male groups was insignificant.

Comparison of mean scores was reviewed for the reported ethnic groups. There was no statistical difference between the AL or TI sections for any of the ethnic groups however most of the minority populations did slightly better in the AL sections whereas the white students did slightly poorer in the AL sections. These findings show some level of increased equity in remedial math since the minority students did slightly better in the AL sections than their white
peers. This information is relevant because other studies have resulted in white students with higher success rates when compared to their ethnic peers (Wolfle, 2012).

Review of this information is important due to prior research indicating that females, black and Hispanic students experience greater math anxiety than their white peers, (Aronson, Fried & Good, 2002; Woodard, 2004). Specific to women, studies have found that not only does STT hinder the individuals’ capacity to perform, it also impairs the behaviors that develop the skills to perform, (Appel, Kronberger, & Aronson, 2011). This is significant because students should be informed of tools that may increase their success rates. Any information that guides students to improved performance and outcomes should be shared with those students.

**Interpretation of the Findings**

This study examined nontraditional remedial math outcomes to determine if there was a difference when ALT is included in the instructional delivery. The analysis revealed the ACCUPLACER test to be the only predictor of student outcomes. This information is important because many post-secondary entities are discontinuing the use of a placement test, specifically ACCUPLACER (Kowski, 2013). Colleges are modifying their admissions and placement processes in favor of multiple measure strategies including high school grade point average, grade on last math course, and even the socioeconomic status of the students’ high school (Kowski, 2013). Applying the multiple measures strategy to traditional student applicants may work well but since many two-year colleges have a majority population of nontraditional students, this information may not be accessible. Two-year colleges may need to consider multiple strategies based on their student applicants.
**Theoretical Frameworks**

There were two theoretical frameworks that guided this study, the principles of Adult Learning Theory and Stereotype Threat Theory. Many of the tests in this study compared nontraditional students to traditional. Most resulted in slightly higher mean scores for the nontraditional students but not to a difference that is significant. This effect is demonstrated again in Table 29 where the traditional students had a higher ALEKS pretest mean score (24.0455) when compared to the nontraditional students (22.0). The nontraditional students had a higher posttest score (57.1061) when compared to the traditional students, (51.7955). And while there was no statistical difference between the two groups when comparing the final grade scores, the traditional students scored closer to a C grade whereas the nontraditional students scored closer to a C+.

Table 29

*Group Statistics-Comparison of Traditional and Nontraditional students in ALEKS math course*

<table>
<thead>
<tr>
<th>Research Study Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS PreTest Percent</td>
<td>Adaptive Traditional</td>
<td>44</td>
<td>24.0455</td>
<td>16.96776</td>
</tr>
<tr>
<td></td>
<td>Adaptive Nontraditional</td>
<td>66</td>
<td>22.0000</td>
<td>20.20206</td>
</tr>
<tr>
<td>ALEKS PostTest Percent</td>
<td>Adaptive Traditional</td>
<td>44</td>
<td>51.7955</td>
<td>22.90585</td>
</tr>
<tr>
<td></td>
<td>Adaptive Nontraditional</td>
<td>66</td>
<td>57.1061</td>
<td>26.58000</td>
</tr>
</tbody>
</table>

These results demonstrate that there is some difference between the two groups but I needed additional information to support or reject the hypothesis. When this study was designed, I expected to collect qualitative information from the students that would have either supported
the hypothesis or rejected it. Due to the inability to collect survey information (Appendix F),
from the students regarding use of the tool, comfort level, and where/how they used the tool the
researcher was not able to align results to Adult Learning Theory. Because of this roadblock
with the study, I focused on the data I was able to collect and reviewed the results related to the
theory of Stereotype Threat. The results related to Stereotype Threat Theory for gender and
ethnicity are reflected in the Presentation of the Findings section.

Other Interesting Findings

Frequency tables provided information on each nontraditional characteristic. This study
defined nontraditional students as those who identify with two or more characteristics
(Previously listed). The percent of nontraditional students at community colleges can be as large
as 73% (Clark, 2012), however it is important to determine what defines a student as
“nontraditional”. This is important in order to determine what types of support are needed to
increase student success. Age alone should not define a student as nontraditional, the
characteristics that impact learning are of greater importance, such as the numbers of hours a
student has to work or if they have dependents. Of interest is the amount of students that would
have not identified as nontraditional, if the definition were solely based on age. The total amount
of students (24 years old or younger), was 373 or around 61.65% however, after applying this
studies definition, the total traditional students decreased 181 or about 30%. Out of the total
sample (N=605), 458 student identified as part-time which is important when supporting
students. If we only counted age as a determining factor, many students would not receive the
supports needed that pertain to other nontraditional characteristics.

One other result from the data was the amount of students that dropped remedial math.
From this study, 260 or 42.9% of students dropped from the remedial math courses. For the
most part, we don’t know the reasons why they dropped and will not be able to address this problem unless more research is conducted (Bombardieri, 2017). This data is similar to other research and is concerning because little is known about what happens to these students (Jimenez, Sangard, Morales, & Thompson, 2016).

**Implications of Findings**

The implications are favorable for remedial math administrators, faculty and students. Since there was no significance with the student outcomes based on student group as related to instructional method, there is no need to differentiate teaching methods to students based on their nontraditional characteristics. Students of all backgrounds can be admitted to the remedial courses.

Important information became evident based on the review of gender and ethnicity and outcomes of those in the AL sections as opposed to the TI sections. There are several for-profit vendors developing adaptive learning technologies to address the remedial math problems. The algorithms that have allowed these systems to evolve from machine tutors to actual adaptive tools based on artificial intelligent calculations now need to look at other student information in order to continue to improve and refine the adaptive intelligence. The vendors need to invest in the research of student profiles to further develop the algorithms and truly make these systems personalized to each learner.

**Faculty Use of ALEKS**

In addition to the failures of the researcher to acquire qualitative information from the students and faculty, the researcher could not identify how the adaptive technology was applied in each of the math sections. ALEKS could have been used as a supportive tool, a homework tool, or as a large percentage of instructional delivery. This information could have added perspective to the student outcomes and additional validity to the study. Focus on what goes on
in the remedial math class is extremely important for research (Cox, 2015). Another question that was not able to be answered was, did the faculty support the use of ALEKS? Students can perceive if an instructor is engaged and supportive of the institutional methods and tools (George, 2012). If faculty are not supportive of the tool, this will impact student outcomes. As such faculty may not apply ALEKS in an optimal practice (Mesa, 2012).

**Future Directions of Research**

Research on remedial education needs to continue because remedial education remains a problematic and costly barrier to college credential attainment for many unprepared students. Of the strategies being implemented, there are two major directions remedial education seems to be heading that will need research. Some colleges are completely discontinuing to offer remedial education and other are creating co-requisite models with added support (Mangan, 2019).

In recent educational articles, many four-year colleges are deciding to remove remedial education courses as an option to those students who test low on placement exams and cannot be admitted into a major or program. There has been legislation enacted that has or will remove remedial education from colleges in Colorado, Florida and the entire California State University System (Mangan, 2019; Wingerter, 2019).

**Personal Reflection**

This reflection is meant to explain some of the challenges I had as a scholarly researcher. There were a couple components that I planned to include in my study but was challenged to complete and include in the findings. In addition, I wanted to add information on how this process has changed me as a practitioner of scholarly research.

**Study Challenges**

As part of the original design of this study, were two survey components that I was unable to conduct and collect data. I created a follow-up survey (Appendix F), with three open-
ended questions regarding the student’s perception of the adaptive technology’s usefulness. This information could have provided insight as to the students experience with the technology and if this impacted their use of the tool. In addition, I intended to interview the math faculty (Appendix G), to gain insight related to their experience and comfort-level of the tool as well as the faculty perspective towards the tool’s value. Again, there was no response from faculty when asked to participate in this study.

These failures could have been due to technology (spam filters), or the lack of interest in responding to surveys. I did send two requests to the student sample but only received a few responses, not enough to apply statistical analysis. Students receive many requests to complete surveys and may have been overwhelmed by these types of requests. Regarding the faculty’s lack of response, I am a bit remiss to understand why they would not want to share their thoughts.

One final thought regarding the challenges of surveying students and faculty. I feel that I was not as well-versed in the rules regarding contact with the two groups and was a bit apprehensive in order to keep the study as un-biased as possible. As a recommendation, I believe doctoral students could benefit from a guidebook on how (methods of best practice) and how much (attempts to collect survey data), works best in higher education. Doctoral students sometimes have one chance to get this correct or it could affect data collection and findings.

**Developing as a Scholar-practitioner**

This experience has contributed to my growth as a scholar-practitioner more than I ever imagined. Prior to the deep-dive into peer-reviewed research, I erroneously assumed many opinions for fact because they were published in higher education publications. I now have a
discerning eye and the knowledge to determine when articles are based on empirical research as opposed to personal conjecture.

This experience has taught me that research has no end. I heard this statement from someone (that I am unable to recall), “research rarely answers a question, it prompts more questions”. As I have become more passionate about research, I have found this to be true. I find myself not only searching for more studies related to topics I’m interested in, but also sharing articles with colleagues for which they have interest. Developing my skills as a scholar-practitioner has impacted my professional work as it has allowed me to become a better grant writer and investigator. The work that I have conducted analyzing data has increased my knowledge of interpreting results. I now understand that just because the results show a difference, does not mean it is significant. This process has been long and sometimes very difficult, but all worth the development and growth I have experienced. I plan to continue my research with remedial math and have plans to contact McGraw Hill Education to inquire about the direction of the ALEKS tool.
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Appendix A: Informed Consent to Participate in educational Research-Student

I would appreciate your assistance with a research project on Adaptive Learning Technology for Remedial Math: Instructional Change to Improve Nontraditional Student Success at Two-Year Colleges. The results will be used as part of my dissertation to complete my Doctorate of Education from Northeastern University. This research may help colleges better understand the ALEKS tool for math learning.

All you need to do is complete 1-2 short questionnaires, which will take approximately 10 to 15 minutes each. You will be asked to complete the first survey after you agree to participate. You will be asked to complete the second questionnaire at the end of this semester. Both questionnaires will be accessible online but if you prefer paper, that will be provided. If you do not wish to participate, simply discard the questionnaire.

Responses will be completely anonymous; your name will not appear anywhere on the survey. Completing and submitting the questionnaires constitutes your consent to participate. The questionnaires can be completed on paper or online.

Keep this letter for your records. If you have any questions regarding the research, contact Kate Skophammer, (617) 390-3450, Northeastern University, Human Subject Research Protection, 360 Huntington Avenue, Mail Stop: 560-177, Boston, MA 02115. Research supervisor’s contact information: Dr. Michael Dean, Dissertation Chair, (646)-404-2433. If you have any questions regarding your rights as a research participant, please contact the Institutional Review Board, Milwaukee Area Technical College, 700 W. State St., Milwaukee, WI 53233, (414) 297-8509. Thank you for your help.
Appendix B-Informed Consent to Participate in Educational Research-Faculty

I would appreciate your assistance with a research project on Adaptive Learning Technology for Remedial Math: Instructional Change to Improve Nontraditional Student Success at Two-Year Colleges. The results will be used as part of my dissertation to complete my Doctorate of Education from Northeastern University. This research may help colleges better understand the use of adaptive learning technology for math learning.

All you need to do is participate in a focus group discussion, which will take approximately 30-45 minutes. You will be asked to provide your personal experience and opinion of the use of ALEKS within MATGEN-109. This activity will be conducted as a facilitated group discussion, however if you feel uncomfortable sharing your insight in a group, a one-on-one session can be set-up upon request. The session will be recorded however, the only person having access to the recording will be this researcher. Responses will be completely anonymous; your name will not appear anywhere on the transcription. Completing and submitting the questionnaires constitutes your consent to participate. The questionnaires can be completed on online or on paper by request.

Keep this letter for your records. If you have any questions regarding the research, contact Kate Skophammer, (617) 390-3450, Northeastern University, Human Subject Research Protection, 360 Huntington Avenue, Mail Stop: 560-177, Boston, MA 02115. Research supervisor’s contact information: Dr. Michael Dean, Dissertation Chair, (646) 404-2433. If you have any questions regarding your rights as a research participant, please contact the Institutional Review Board, Milwaukee Area Technical College, 700 W. State St., Milwaukee, WI 53233, (414) 297-8509.

Thank you for your help.
Appendix C: Permission Letter to Conduct Research to/from the College President

January 18, 2018

Dear Dr. Martin,

As you know, I am the Director of Curriculum and Instructional Support at MATC. I am also a student researcher through Northeastern University (NEU). Currently I am working on a thesis proposal to study the impact of adaptive learning technology on non-traditional students in remedial math. The purpose of this letter is to request permission to conduct a research study at Milwaukee Area Technical College (MATC). I have spoken to both the Dean of Liberal Arts and the Associate Dean of Mathematics. Both have consented to work with me on the study.

My plan is to focus on remedial math student learning outcomes when an adaptive learning technology is used as an instructional tool. Data will be collected to determine if the adaptive learning tool ALEKS (from McGraw Hill Education), has a positive impact on traditional, nontraditional or both types of students.

The study will classify nontraditional students based on several student characteristics as opposed to age alone. Student demographics and outcomes data will be collected from Institutional Research along with two surveys posed to the student groups in MATGEN-109. In addition, a faculty focus group will provide insight regarding their opinion of adaptive learning tools. The voluntary participants will be a combination of students and faculty. The information collected from this study may offer insight as to appropriate teaching methods based on the type of student learner.

Following your approval, I will apply to the NEU Internal Review Board for further approval to conduct research with human subjects. Please contact me directly at 414-297-7613 if you have additional questions, or the chairperson of my committee, Dr. Michael Dean, at Northeastern University, can be contacted at (646) 404-2433.

Thank you in advance for your time and consideration. I look forward to hearing from you regarding this request.

Respectfully,

P. Pamela Holt
Doctoral Candidate 2018, College of Professional Studies
Northeastern University, Boston
Appendix D: Faculty Informational and Participation Letter

Dear MATGEN-109 Faculty:

My name is P. Pamela Holt, you may know me as the Director of Curriculum and Instructional Support at MATC but I am a doctoral student at Northeastern University (NEU). I have received permission from President Martin and approval from both MATC Internal Review Board and NEU Internal Review Board to conduct my research study at MATC from March – June 2018. Your course section(s) have meet the criteria to participate in this study.

This study will provide data to determine if nontraditional students perform as well as traditional students in remedial math when using adaptive learning technology. The title of the research study is *Remedial Math Instruction Using Adaptive Learning Technologies: Better Suited for Traditional, Nontraditional or Both types of Learners?* The purpose of the study is to determine if adaptive technology impacts learning outcomes for nontraditional students in remedial math when compared to traditional student learning outcomes. The research process includes four steps: collection of student characteristics from both database retrieval and a student survey, collection of student outcomes (completion data and grades), an end-of-course student survey, and a faculty focus group discussion.

During the faculty focus group discussion, I will, ask questions that center on how you used ALEKS in your instruction and what are the most/least beneficial parts of ALEKS. The focus group discussion will take about 45 minutes and includes only faculty using the ALEKS tool in MATGEN-109. The focus group will be held during non-school work time and held at a mutually decided upon location (the option of participating remotely will be offered).

The discussion will be recorded for the purpose of creating a transcript specifically for the requirements of the dissertation. The recording will not be shared with anyone at MATC and will be destroyed upon completion of my doctorate degree. Faculty will not be identified by name. All responses will be kept confidential—identifying information will never be published. Any discussions I conduct will be under stringent university protocols, which protect the interviewee’s confidentiality and right to withdraw from the study at any time.

Your participation is meaningful to the success of the research study, as we will have the opportunity to reflect upon the benefits and challenges of using ALEKS in remedial math, and by having the opportunity to contribute to the literature to share best practices that may be helpful to your peers and other schools. Your participation in the faculty focus group is entirely voluntary. I want you to know that confidentiality will be strictly adhered to, and I will use pseudonyms to protect you. In addition, the data collected will primarily be used for the student researcher’s doctoral thesis project, and potentially for future journal articles.

Thank you for your attention and consideration.

P. Pamela Holt
Doctoral Candidate 2015
College of Professional Studies-Northeastern University
Appendix E: Student Demographics Survey-Determination of Nontraditional status

Please select the I Agree button to confirm that you wish to participate in this research and are willing to complete a 6-question survey.

Please complete the following questions.

Enter your Student ID

1. What is your current age?
2. Are you currently working?
   Yes/No
3. If so, approximately how many total hours a week do you work? (select one)
   - Less than 10
   - Between 10-20
   - Between 21-30
   - More than 30 hours a week
4. Can someone besides you claim you as a dependent on their Income Taxes? (select one)
   - Yes
   - No
   - Don’t know
5. What year did you complete high school or earn your GED?
6. Do you have dependents that rely on you for financial support? (select all that apply)
   - Wife or husband
   - Child
   - Parent
   - Other family member
   - Other non-family member
Appendix F: End-Of-Course Survey Questions

1. Please indicate your level of comfort in the use of technology (e.g., computer software programs) at the beginning of this course?

2. Please indicate your current (i.e., at the end of this course) level of comfort in the use of technology (e.g., computer software programs) at the beginning of this course?

3. Please indicate the degree to which the ALEKS software was helpful to you in this course?
   a. Not at all helpful
   b. Not very helpful
   c. Somewhat helpful
   d. Very helpful

4. Did you feel comfortable using the ALEKS software?
   a. I did not use it.
   b. I did not feel comfortable using the software
   c. Not at first, but became comfortable with it during the semester.
   d. I felt comfortable using ALEKS throughout the course.

5. Would you recommend ALEKS to your friends/peers?
   a. Yes
   b. No
   c. Not sure

6. Did you use the ALEKS software outside of class/lab?
   a. Yes (secondary question--select all that apply)
      i. Using a mobile device
      ii. Using a Smartphone
      iii. Using at home/work computer
      iv. Using campus computer
   b. I tried but had difficulty
   c. No

7. Please share your thoughts on what made ALEKS software most useful to you in understanding the material in this course?
   a. Open-end question

8. Please share your thoughts on what aspects of the ALEKS software were least useful to you in understanding the material in this course?
   a. Open-end question

9. In general, please share any other thoughts you have on the use of the ALEKS software in this course?
   a. Open-end question
Appendix G: Faculty perspective on the use of ALEKS-Faculty Focus Discussion

1. Did you volunteer to include ALEKS in your math course(s)?
2. How did you use/incorporate ALEKS within the MATGEN-109 course?
3. What do you consider to be the most beneficial part of using ALEKS in MATGEN-109?
4. What do you consider to be the least beneficial part of using ALEKS in MATGEN-109?
5. Will you use ALEKS again in math instruction? Why/why not?