Effects of Intelligent Computer-Generated Interactive Mathematics Programs on Students’ Achievement and Affective Domain

by

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ABSTRACT

TITLE: Effects of Intelligent Computer-Generated Interactive Mathematics Programs on Students’ Achievement and Affective Domain

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The purpose of this study was to determine the relationship each of the mathematics web-based programs, MyMathLab and Assessments and Learning in Knowledge Spaces (ALEKS), has with students’ mathematics achievement. In addition, the study examined the relationship between students’ affective domain and the type of program as well as student achievement. The affective domain measures were students’ anxiety, self-efficacy as well as their attitudes towards mathematics. The study used a quasi-experimental nonrandomized pretest-posttest control group during the spring 2016 semester. The data were collected using several different instruments including: (a) a questionnaire, (b) a test of prerequisite skills, and (c) an end-of-semester comprehensive final examination.

Results from this study indicated that students’ affective domain and which web-based program is used in the course have an effect on student achievement. Students that completed their work in ALEKS had higher attitudes, higher self-efficacy, lower anxiety, and higher student achievement than students that completed their work in MyMathLab.

The results of this research inform the mathematics community about the effect choosing a web-based program has on student achievement in intermediate algebra and their affective domain. Also, the findings show the importance and place great emphasis of students using the web-based programs and completing the work within the program.
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Chapter 1
Introduction

Purpose of Study

The purpose of this study was to determine the relationship each of the mathematics web-based programs, MyMathLab and Assessments and Learning in Knowledge Spaces (ALEKS), has with students’ mathematics achievement. In addition, the study examined the relationship between students’ affective domain and the type of software as well as student achievement. The affective domain measures were students’ anxiety, self-efficacy as well as their attitudes towards mathematics. For the purpose of this study, mathematics achievement was defined as students’ intermediate algebra end-of-course comprehensive final exam score.

Background and Rationale

Traditionally, students spend their time in class listening to the instructor lecture. Instructors continue to strive to get and keep students engaged in the learning process as this is a fundamental process to the students’ success. Students are able to ask questions and receive the instructor’s feedback during class. The students may increase their understanding by receiving immediate feedback from the instructor. The process of being able to receive instruction, practice the concepts, ask questions, and reattempt the practice is helpful in the learning process; however, this is not the normal progression when students complete pencil
and paper homework outside of class. For these reasons, the introduction of technology has received an influx of support.

Over the past decade, technology has been on the rise in and outside the classroom. Not only are teachers able to provide lecture notes and extra resources like videos and tutorials, teachers using technology are able to offer an opportunity for students to complete their homework through software where they may receive immediate feedback even while outside of classroom. The advancement of technology has increasingly and forever changed the classroom. Systems are able to offer students feedback instantly while also freeing the instructor from the normally cumbersome procedure of grading the paper and pencil assignments. Schools should “give strong consideration to using web-based products for delivery of skill manipulation and application-related problems. As web-based software has improved, mathematics education has gained a tool which improves the delivery of mathematical manipulation and problem-solving skills (Hagerty & Smith, 2005).”

Since the increase of the use of technology in the classroom, many different web-based programs have been developed. For example, some of the programs that are currently being used in the mathematics classrooms include WebAssign, WeBWork, MyMathLab, and ALEKS. Two of programs, ALEKS and MyMathLab, are more commonly used (Hu et al., 2014; Nwaogu, 2012; Vezmar, 2011). For this reason, ALEKS and MyMathLab will be reviewed in this study.
MyMathLab was created by Addison Wessley. The creation of the program was brought about by making an extensive databank of algorithmically based problems available to students and teachers to provide them with randomly generated practice exercises that are tied directly to the content of their textbook. It does not appear that the creation of this program was based on a particular theory but mostly to provide teachers and students with a valuable resource.

ALEKS was created and based on theory. The theory that drove ALEKS into creation was the Knowledge Space Theory (KST). ALEKS is an adaptive, artificial intelligence, interactive, eLearning software created by cognitive scientists and software engineers at the University of California, Irvine, using the KST. Major funding for the development of the software was provided by the National Science Foundation and published by McGraw-Hill Education (ALEKS, 2015). The program uses the KST to assess each student on what they already know and what they are ready to learn.

KST is based on the concepts of Combinatorics and stochastic processes (Falmagne et al., 1990). The framework allows for the creation of algorithms to construct knowledge spaces that include the concepts students understand and those the student is ready to learn. In order to organize what the student can do and what the student is ready to learn, we have to understand that every concept in mathematics is tied to another or possibly many other concepts. For example, if a student knows how to write the equation of a line going through a given point and
perpendicular to a given line then one can assume the student knows how to find
the slope of a given line, how to find the reciprocal of a number, how to use the
point-slope formula, etc. Seeing that each concept is tied to another allows the use
of algorithms to create an exam that will assess the student in as few as 30
questions to determine each student’s current knowledge spaces. Because ALEKS
is based on this theory, it can be very beneficial in the learning process.

MyMathLab and ALEKS are very different in the way they were created. In
addition, they have many other major differences. Students enter a math classroom
with a set of skills which may be very different from other students in the same
course. In some courses, the instructor will administer an introductory exam to see
what the students understand and what they need to learn to catch up and be
prepared for the course material. Once the exam is reviewed, it is up to the
instructor to find a way to remediate. It can be difficult for an instructor to organize
the data for each student, find time to remediate students during class and even
more difficult to find time outside of class. However, Keup (1998) explains that a
plan must be devised and implemented for the success of the student and that
remediation is necessary for success. ALEKS and MyMathLab both have the
option to remediate students; however, implementing remediation in one program
is very different from the other.

ALEKS requires an initial assessment for any course. The initial assessment
is a chance to see what the student already knows how to do and what they are
ready to learn. The results of the assessment provide the necessary needs for remediation. There is nothing that the instructor will need to tabulate, organize, or set up for the student. The remediation needed for each student is created by the program after the student completes the initial assessment. ALEKS will start the student at the stage necessary to fill gaps they may have in the curriculum. In a course using MyMathLab, it is not an automatic feature for the course to be set up to remediate the students. The instructor would need to create the course that is conducive to remediation.

After students complete the initial assessment in ALEKS, they will begin work on objectives they are ready to learn. Once the students have completed a set of objectives, the program automatically assesses them with no more than 30 questions and provides the students and teachers immediate detailed feedback. Frequent testing can lead to improved learning (Martinez and Martinez, 1992). A meta-analysis of 40 studies showed that frequent testing will continue to increase performance until a certain level (more than 1 to 2 assessments per week) where it may start to decline (Bangert-Drowns et al., 1991). ALEKS is automatically set to test the students when necessary. The tests are given to the student within the ALEKS program automatically after they have completed a group of objectives. However, MyMathLab testing is set by the instructor. Instructors will create the assessment, assign it, and place a due date on the assignment. The instructor would
be responsible for knowing when each student is ready to test and will need to go into the program to schedule and assign the assessment.

As shown above, there are major differences in the two programs. ALEKS was created and based on the KST theory while MyMathLab was created for ease of use for instructors and students. ALEKS provides remediation techniques, frequent yet small automatic assessments, and immediate summarized feedback. While MyMathLab offers the option for instructors to create a course conducive to remediation, instructors are able to create assessments, and pull data from the program these features are not automatic. Many other differences are discussed in depth throughout the literature review in Chapter 2.

Even though MyMathLab and ALEKS are commonly used web-based programs in a mathematics course, there are few studies comparing the two. Oshima (2010) integrated ALEKS into one college algebra course and MyMathLab into another. There was a dramatic increase in students’ retention and success for students who used ALEKS. Although not statistically significant, the ALEKS group showed a slightly better course grade than the MyMathLab group. Stillson & Nag (2009) compared MathXL (early name of MyMathLab) to ALEKS. The research reported higher scores for students using MathXL; however, there were many outside factors that possibly affected the outcome of the study. For example, tutors and a lab were made available to MathXL students during the fall 2006 semester but they were not available during the fall 2005 semester for the students.
using ALEKS. Another informal study completed by Allen (2007) included the comparison of MyMathLab and ALEKS. Allen claims that ALEKS was able to assist less prepared students in reaching success because of the program’s emphasis on repetition and continuous assessment.

While few studies have compared the two programs to each other, there are a number of studies comparing each of the web-based programs to a traditional classroom. Many of the studies cited four main factors that were affected. The majority of the studies included different parts of the student’s affective domain. For example, they included attitudes towards mathematics, self-efficacy towards mathematics, and anxiety towards mathematics. Most commonly, when comparing a traditional pencil and paper classroom to a classroom using MyMathLab or ALEKS, many of the studies showed an effect on student achievement.

The Knowledge Space Theory, assessment theory, theory for self-efficacy, attitudes, and anxiety all clearly point to ALEKS as being the superior program. As no formal studies have been done, this study compares MyMathLab to ALEKS while looking at the effect on student achievement, the effects on different parts of the students’ affective domain, including any interactions they may have with student achievement.
Definition of Terms

Key terms pertinent to the study are operationally defined as follows:

1. *Achievement* is defined as the students’ score on the MAT 1033 comprehensive final exam.

2. *Affective domain* refers to the students’ emotions toward a learning experience and includes their feelings, values, enthusiasm, motivation, and attitudes. For the study, students’ affective domain was examined by looking at their attitude towards mathematics, self-efficacy towards mathematics, and their anxiety towards mathematics.

3. *Anxiety toward mathematics* is defined as a feeling of tension, apprehension, or fear that interferes with math performance. For this purpose of this study, Mathematics Self-Efficacy and Anxiety Questionnaire ([MSEAQ]; 2009) will be used to measure students’ anxiety.

4. *Attitude toward mathematics* is defined as students’ level of self-confidence, value, enjoyment, and motivation relative to mathematics. For the purpose of this study, Martha Tapia’s Attitudes Toward Mathematics Inventory ([ATMI], 1996) will be used to measure students’ attitudes towards mathematics.
5. *Intermediate algebra* is defined as the 3-credit-hour, 48-contact-hour course MAT 1033, which refers to a specific set of instructional objectives and content defined by Florida’s Division of Community College’s intermediate algebra curriculum. The major topics of this course includes linear equations and inequalities with one and two variables, polynomials, rational expressions, laws of exponents and radicals, properties and operations of complex numbers, non-linear equations, systems of equations and inequalities, and functions.

6. *Mathematics self-efficacy* is defined as a student’s beliefs, perceptions, or confidence of their abilities in mathematics. For the purpose of this study, Diana K. May’s Mathematics Self-Efficacy and Anxiety Questionnaire ([MSEAQ], 2009) will be used to measure students’ mathematics self-efficacy.

7. *Student attributes* is defined as students’ age, gender, and race/ethnicity.

**Research Questions and Hypotheses**

**Research Questions.** The overall research question for this study is “What is the relationship between the web-based programs and student achievement?”

This research examines the following questions:

1. Is there a significant difference between using one of the web-based programs, MyMathLab or ALEKS, and student achievement?
2. Is there a significant difference between using one of the web-based programs and students’ affective domain?
   a. Is there a significant difference between using one of the web-based programs and students’ attitude towards mathematics?
   b. Is there a significant difference between using one of the web-based programs and students’ self-efficacy towards mathematics?
   c. Is there a significant difference between using one of the web-based programs and students’ anxiety towards mathematics?

3. What is the interaction between using one of the web-based programs and students’ affective domain as they relate to student achievement?
   a. What is the interaction between using one of the web-based programs and students’ attitudes towards mathematics as they relate to student achievement?
   b. What is the interaction between using one of the web-based programs and students’ self-efficacy towards mathematics as they relate to student achievement?
   c. What is the interaction between using one of the web-based programs and students’ anxiety towards mathematics as they relate to student achievement?
Research Hypotheses. The research hypotheses that correspond to the above research questions are as follows:

**Hypothesis 1.** Students using the web-based program ALEKS will have higher student achievement than students using MyMathLab.

**Hypothesis 2.** The difference between the web-based program, MyMathLab or ALEKS and students’ affective domain is hypothesized as follows: (a) Students using ALEKS will have a greater increase in their attitudes towards mathematics than students using MyMathLab. (b) Students using ALEKS will have a greater increase in their self-efficacy than students using MyMathLab. (c) Students using ALEKS will have a greater decrease in their anxiety towards mathematics than students using MyMathLab.

**Hypothesis 3.** The interaction between the web-based program, MyMathLab or ALEKS and students’ affective domain as they relate to student achievement is hypothesized as follows: (a) Students using ALEKS will have a greater increase in student achievement with respect to attitude than students using MyMathLab. (b) Students using ALEKS will have a greater increase in student achievement with respect to self-efficacy than students using MyMathLab. (c) Students using ALEKS will have greater increase in student achievement with respect to anxiety than students using MyMathLab.
Study Design

This study was conducted using a quasi-experimental, nonrandomized control group, pretest-posttest design with intact groups. The target population was all students enrolled in intermediate algebra (MAT 1033) in public Florida colleges in the spring 2016, 16-week semester. The population was delimited to a smaller accessible population that consisted of students enrolled in MAT 1033 at Eastern Florida State College (EFSC). The convenient sample ($N = 81$) was made of students from four Palm Bay face-to-face classes. The four face-to-face classes were assigned to the researcher by the Palm Bay mathematics department chair.

Significance of the Study

There are many studies that compare traditional courses completing pencil and paper homework to courses using technology to complete their homework. However, there is little systematic research comparing the different types of technology in a mathematics course. This leaves a large gap in research that needs to be filled. This study attempts to inform colleges, instructors, and the mathematics research community about the effect of the two main web-based programs being used: MyMathLab and ALEKS.

Another significance of the study is that it examines the interactions between the web-based program used and the students’ affective domain. It is important to know the effects of web-based programs on the feelings and emotions of the students. Knowing that one program is more beneficial in lowering anxiety,
increasing attitudes towards math, and/or increasing math self-efficacy will not only allow the colleges and instructors to choose a program best fitted for the courses but also make publishers aware of these outcomes so they are able to adjust and better their programs to help students face higher achievements.

**Study Limitations and Delimitations**

**Limitations.** The generalizability of this study is limited by the following:

1. *Experience of the student.* At EFSC, both MyMathLab and ALEKS are used in different math courses. In other words, it is likely that some students may have used ALEKS or MyMathLab prior to taking MAT 1033 in the Spring 2016 semester. This may have affected the student’s achievement as they have already learned to use the program where for others it may be new to them. If conducted at a school where students have never used one or both of the programs, the study may yield different results.

2. *Curriculum.* Instructors using MyMathLab or ALEKS at different colleges may choose different objectives for intermediate algebra. Choosing different objectives for this course may change the outcome of the study.

3. *Program setup.* MyMathLab and ALEKS both have many options on how the course is setup. Both programs have additional resources for students that instructors may require as part of the student’s grade.
Because there are so many different ways to create a course in either
program, studies completed with different setups may develop different
results.

4. *Resources.* Some campuses require lab time and provide convenient
tutoring services while others do not. Studies completed with different
resources available to the students may yield different results.

5. *Sample demographics.* Studies conducted with different sample
demographics may not produce the same results. The sample
demographics are provided in both Chapters 3 and 4 to compare and for
generalizability purposes.

6. *Add-drop period.* EFSC provides a week for students to switch courses.
It is possible that a student dropped a course using ALEKS and took the
course using MyMathLab (or vice versa). Similar studies that do not
have an add-drop week may produce different results.

7. *Group assignment.* This experiment will be quasi-experimental because
the courses that were selected for the research were already intact.
Randomly selecting the sample of students was not possible for this
study. The registrar’s office randomly assigns freshmen to each course.
Transfer and continuing students select their own schedule. If the
sample of students are randomly assigned, then the results of the study
may yield different results.
**Delimitations.** This study is further limited to the following:

1. *Target population.* The ideal population would be all mathematics students in the U.S. but it was delimited to Eastern Florida State College students as the target population and the Palm Bay and eLearning campus students as the accessible population.

2. *Participating courses and instructors.* The targeted courses were selected for this study because they were assigned to the instructor of this study (convenience sampling). This study looked specifically at MAT 1033 – Intermediate Algebra students as opposed to all math students currently enrolled at EFSC. Studies using different courses or more than one instructor may yield different results.

3. *Time.* The study was completed in the spring semester. The sample of students during the spring semester may yield different results than students from the fall semester. The fall semester normally consists of first time students where the spring semester normally has much fewer first time students. Studies conducting a similar study in the fall may produce different results.

4. *Students’ anxiety towards mathematics.* Students’ anxiety toward mathematics was measured using Mathematics Self-Efficacy and Anxiety Questionnaire ([MSEAQ]; May, 2009). Similar studies using a different anxiety instrument may produce different results.
5. **Students’ attitudes toward mathematics.** Students’ attitudes toward mathematics was measured using Attitudes Toward Mathematics Inventory ([ATMI]; Tapia, 1996). Similar studies using a different instrument to measure students’ attitudes toward mathematics may get different results.

6. **Students’ mathematics self-efficacy.** Students’ mathematics self-efficacy was measured using Mathematics Self-Efficacy and Anxiety Questionnaire ([MSEAQ]; May, 2009). Studies using a different instrument to measure students’ mathematics self-efficacy may present different results.

7. **Student achievement.** Student achievement was measured using the MAT 1033 prerequisite examination and the MAT 1033 comprehensive final examination. Other studies using different exams may yield different results.
Chapter 2
Review of Related Literature

Introduction

This chapter is organized into four sections. The first section provides associated theory in which this study is grounded; remediation, mastery learning, and self-efficacy. The second section includes a discussion of technology and its importance. For the third section, an introduction of each of the two main web-based instructional programs that are used in many mathematics courses around the world. This section includes studies conducted with each program and their outcomes. Lastly, the forth section includes a more in-depth comparison of the two web-based programs.

Assessment, Mastery Learning, and Self-Efficacy Theory

Assessment theory. Elton and Laurillard (1979) stated that the quickest way to change student learning is to change the assessment system. Bangert-Drowns, Kulik, and Kulick (1991) agreed by stating that teachers can increase the affective results of instruction by testing students more often. Bangert-Drowns et al. summarized the results of 31 studies. Results showed that the students who were frequently tested showed greater gains in examination performance. “More frequent classroom testing stimulates practice and review, gives students more opportunities for feedback on their work, and has a positive influence on student study time (Bangert-Drowns et al., 1991)” Additional testing provides an opportunity for
instructors to correct student errors and reward good performance. It allows the teachers to show the students what they are expected to learn. Turney (1931) and Kulp (1933) both divided their classes into two groups based on their performance. Students who had lower performance were given weekly tests in addition to regular examinations while the stronger students only completed the regular examinations. By the end of the course, both studies showed equal performance in the two groups.

Crooks (1988) summarizes the results from 14 specific fields of research that look at the relationship between assessment and student outcomes. The in-depth study found that student evaluations have powerful direct and indirect impacts which can be positive. Frequent assessments can increase student’s motivation, self-efficacy, and achievement as well as decrease test anxiety. Four of the studies within the Bangert-Drowns et al. (1991) meta-analysis showed students’ attitudes higher in courses with more assessment than students who were tested less frequently.

As explained by Crooks (1988), in order to see positive results, there are certain requirements. One major influence is feedback. It is necessary to show students a confirmation of the correct answers but more importantly to identify the errors of knowledge and understanding. Timing of the feedback and assistance in correcting the errors is vital. “Students should be given regular opportunities to practice and use the skills and knowledge that are the goals of the program, and to obtain feedback on their performance. Such evaluation fosters active learning,
consolidation of learning, and if appropriately arranged can also provide the retention benefits associated with spaced practice (Crooks, 1988, p. 470).”

When the assessment theory is applied to the study, students using ALEKS should have higher motivation, self-efficacy, attitudes, and achievement as well as lower anxiety than students using MyMathLab. ALEKS students will see these benefits because ALEKS assesses the students not only frequently but also when each individual student is ready to be tested. ALEKS also provides the student with immediate, detailed feedback that is summarized for each student to know their individual understanding and knowledge of the concepts.

**Mastery learning theory.** Bloom (1968) introduced the idea of “learning for mastery.” Later, it was shortened to “mastery learning” (Bloom, 1971). With Bloom’s strategy, the material is first taught, assessed, corrections made, and then students are reassessed. Teachers chunk the material from the course into sections, teach a portion of the material, and then assess the students over that section of material. Once assessed, valuable feedback is given to each student so they are able to better understand what they know and what objectives need more practice. Students are able to correct the misunderstandings, reassess to make sure they have mastered the material previously missed, and move forward to the next section of material. Some courses introduce the material, assess, and then move onto a new topic without a chance for students to reflect. This takes away the ability for the student to look at their mistakes and go back to fix these mistakes before moving.
on to more advanced topics. Being able to correct the mistakes can provide
motivation to each student and empower them to move forward through the course.

When applied to the context of the study, mastery learning is more readily
used in the ALEKS program. The program automatically assesses each student
after they have completed so many objectives, after they have spent so much time
in the program, or once the instructor has initiated an assessment. Each of these
major assessments covers the same topics but composed of slightly different
problems, as Bloom suggests. Thus, when looking at the theory, students using
ALEKS should have a higher achievement than students using MyMathLab as
ALEKS more readily supports mastery learning.

**Self-efficacy theory.** Bandura explains that self-efficacy is built and/or
destroyed through performance accomplishments, vicarious experiences, social
persuasion, and physiological feedback. In 1986, Bandura coined the term self-
efficacy as “people’s judgments of their capabilities to organize and execute the
courses of action required to attain designated types of performance.” With a strong
self-efficacy, students are able to set goals, uphold a strong commitment, and face
difficult tasks with determination. It enriches accomplishment and personal well-
being.

**Tying Theories Together.** Performance accomplishment is one of the main
ways and actually the most effective way of increasing self-efficacy. Therefore,
mastery learning and self-efficacy have a strong connection. As Bandura (1986)
and Bloom (1971) assert, providing mastery experiences for students is a way to increase self-efficacy. In the study by Hagerty, Smith, & Goodwin (2010) mentioned earlier, Black Hills State University mathematics department put ALEKS to the test. The department agreed that ALEKS easily survives Bandura and Bloom's theory. As applied to this study, mastery learning experiences are readily made available for teachers to provide and continually possible for students to face throughout a course using ALEKS. The software occasionally assesses the students while they are working on their homework and also during proctored assessments given by the instructor. ALEKS provides a chance for students to put their knowledge and understanding to the test. They are able to increase their self-efficacy by watching their overall pie grow as they learn more objectives. Therefore, students using ALEKS should have higher achievement than students using MyMathLab because the former promotes mastery learning and, consequently, increases self-efficacy.

Technology

Traditionally, in a lecture-based course, students spend their time in class listening to the instructor. Instructors continue to strive to get and keep students engaged in the learning process. This is a fundamental process to the students’ success. Students are able to ask questions and receive the instructor’s feedback during class. The student may increase their understanding by receiving the immediate feedback from the instructor. The process of being able to receive
instruction, practice the concepts, ask questions, and reattempt the practice is helpful in the learning process; however, this unfortunately is not the normal progression when the student completes pencil and paper homework outside of class. For these reasons, the introduction of technology has received a wealth of support.

Over the past decade, technology has been on the rise in and outside the classroom. Not only are teachers able to provide lecture notes and extra resources like videos and tutorials, teachers using technology are able to offer an opportunity for students to complete their homework through software where they may receive immediate feedback even while outside of classroom. The advancement of technology has increasingly and forever changed the classroom. Systems are able to offer students feedback instantly while also freeing the instructor from the normally cumbersome procedure of grading the paper and pencil assignments. Schools should “give strong consideration to using web-based products for delivery of skill manipulation and application-related problems. As web-based software has improved, mathematics education has gained a tool which improves the delivery of mathematical manipulation and problem-solving skills (Hagerty & Smith, 2005).”

As the use of technology in the classroom has increased over the years, many studies have been completed to measure the benefits. For example, research has been conducted to see if technology has the potential to increase student achievement. Several studies compare student achievement in a traditional
instruction (TI) course compared to a computer-assisted instruction (CAI) course. Many have found an increase in student achievement, students’ attitudes, attendance, and self-efficacy while reporting a decrease of anxiety towards mathematics (Bonham, Beichner, and Deardorff, 2001; Brothen & Wamback, 2000; Butzin, 2000; Dillard-Eggers et al., 2008; Hirsch and Weibel, 2003; Holton et al., 2009; McSweeny, 2003; Nguyen, 2002; Olusi, 2008; Schwartz, 2007; Zerr, 2007). Even though many have found a plethora of positive outcomes, others have found statistically insignificant difference or no difference at all (Hauk and Segalla, 2005). How can this be? After many different outcomes, researchers have learned that it depends how the technology is actually used in the classroom (Kerrigan, 2002; Tempelaar et al., 2005; Wenglinsky, 1998; Wright, 1999). For technology to reap its true benefits, there are three main features that should be considered: accessible & available 24/7, adaptive, and provide rapid feedback (Moore, Walsh, & Risquez, 2008; Glaser, Chudowsky, & Pellegrino, 2001; Tempelaar et al, 2006).

The technology that will be offered to students should be, first of all, accessible & available 24/7. It should be easy for students to access and available to students at any period of the day so that they are able to work from anywhere at any time. This will help to eliminate educational barriers (Vrasidas & Zembylas, 2013). The second important aspect to consider is for the technology to be adaptive. As Tempelaar et al. (2005) discussed, it is important for the technology to be adaptive as every student is different. Each student has a different set of skills when they
enter the classroom. Technology should adapt to these set of skills and build upon them. It should allow for a learning path that is individualized for each student knowing the student’s prior knowledge and learning style (Falmange et al., 2006, Abdullah, 2003). One other main feature for technology to be beneficial to students is for the software to provide rapid feedback. It is necessary for the student and teacher to gauge the current knowledge and understanding which will allow them to work as a team to plan for growth. Immediate feedback can help the student realize what topics they are struggling with so they are able to quickly address the issue and gain better understanding of the topics. Rapid feedback is also valuable to the instructor as they will be able to quickly identify students who are struggling, pinpoint the issue, and help them with their understanding in that topic (Palocsay & Stevens, 2008). Having the feedback quickly will allow the instructor to know what material the students already know, what they are struggling with, and what they are ready to learn (Draaijer, 2004). This allows the instructor to prepare lesson plans that are formed for the group of students that will be receiving the lecture.

As Bonham & Boylan (2011) state, when technology is utilized it fosters greater student engagement. Schwartz (2007) explains that technology helps to force students to be more precise. The software helps to control for sloppy math errors that are not always caught in paper and pencil homework. Epper & Baker (2009, p. 3) state that “technology can be used to expand, strengthen, and create efficiencies in the delivery of math.” Knowing that technology is beneficial for the
students, many policies and grants have been formed to include technology as part of the learning process. For example, The Institute for Higher Education Policy includes utilization of technology as one of the 3 strategies for improving the effectiveness and enhancing the teacher-learning process (Aycaster, 2001).

Technology is part of the standards for both American Mathematical Association of Two-Year Colleges (AMATYC) and the National Council of Teachers of Mathematics (NCTM). For example, AMATYC provides guiding principles in the standards for college-level math prep. One principle that AMATYC has established is the “use of technology as an essential part of an up-to-date curriculum” (AMATYC, 2006). Also, NCTM makes it very clear that teachers should use technology to enhance the learning opportunities of their students. Technology is essential in teaching and learning mathematics as it effects the mathematics that is taught and improves students’ learning (NCTM, 2000). Not only are major mathematics associations including technology as a necessity in the classroom, but there is also support at the federal and state level. They have joined the force to improve performance of the nation’s students by supporting educational technology. Major steps began when President Clinton and Vice President Gore announced the Technology Literacy Challenge in 1996. The goal of the challenge was to ensure that all students have access to educational technology so they are able to improve student achievement (Wenglinsky, 1998).
From many directions, such as several research outcomes, math associations and councils, support at the federal and state level, many have joined together in agreeance that technology in the classroom is valuable. Because technology is beneficial, it is important to research different types that are available and review their features before selecting which resource to actually use in the classroom. Some examples of programs used for math courses include WebAssign, WeBWorks and two common programs Assessment of Learning in Knowledge Space (ALEKS) and MyMathLab (Hu et al., 2014; Nwaogu, 2012; Vezmar, 2011). Both are interactive, web-based instructional programs used around the world and at many different grade levels; K-12 schools, colleges, and universities. The next section takes a look at these two programs in depth to see what they have to offer and review some research that has been conducted with each software.

**MyMathLab**

In 1994, Addison Wessley and publisher Pearson Education launched an extensive databank of algorithmically based problems that provide students and teachers randomly generated practice exercises that are tied directly to the content of their textbook. In 1998, colleges and universities began the use of MyMathLab. The program started on a floppy disk with practice problems and other simple features that most students could only access while on campus. Now, the program has grown to provide much more; eBook, videos, student solution manuals, audio tapes, answer books, practice tests, and other supplemental resources. These
resources are now available to teachers and students from any location at any time where the internet is available. MyMathLab is one of “the world’s leading collection of online homework, tutorial, and assessment products designed with a single purpose in mind: to improve the results of all higher education students, one student at a time” (Pearson, 2015).

MyMathLab provides many beneficial features. To set up a course, the instructor selects a textbook that will be used for the course. Each textbook has a set of questions that instructors may use to create homework assignments. MyMathLab also provides example homework assignments, quizzes, and tests that teachers may copy and assign to their students. Once the assignments are assigned, the student can begin working. Each student will have similar, but not identical problems. This is helpful to ensure students are doing their own work (Vezmar, 2011). The student can complete the question on a piece of paper and type in the answer. If the question is answered correctly, they will receive points for that question and may choose to move onto any question in the assignment or even move onto a different assignment. If the student answers the questions wrong, for most questions, they are allowed two more tries on the same exact problem. If they miss the question after three attempts, the question will be marked with a red X and the computer program will provide the student with a hint based on their answer. The student may then choose to complete a “similar exercise” to regain points for that question, move onto another question, or open a different assignment. If the
student selects “similar exercise,” they will be given a similar problem with different numerical values. Students can select “similar exercise” as many times as they want to make sure they understand the concept. If the instructor allows the similar example feature, it is possible for a student to earn a perfect score on nearly all homework assignments.

Within each assignment, the student has many tools to assist them through each question. As seen in the screenshot below, some questions have Help Me Solve This, View an Example, Video, Textbook, and Ask My Instructor. Help Me Solve This provides a step-by-step explanation of how to complete the current question in the student’s homework. Students may view the steps and return back to the homework question; however, the homework question values have changed. The student will be required to complete the work for a new question on their own and type the answer to receive the points for that question. View an Example is a feature that many students use. When students click View an Example, they will be given a step-by-step explanation of how to solve a problem that is the same problem in their homework with different numerical values. A screenshot of View an Example is shown below. After viewing the steps, the student may go back to the original question. The Video feature provides a recording of an instructor solving similar problems on the board. Unfortunately, videos are only available for about 50% of the questions (depending which textbook is chosen by the instructor). The Textbook feature provides the pages that the current question
relates to in the eBook. Ask My Instructor is a chance for the student to send the
current question they are working on to the instructor’s email. They can add an
explanation, question, or work before sending the email. Each of the features
explained above may be turned on or off by the instructor for each type of
assignment. An entire example assignment is shown in Appendix D as a printable
version.

Figure 2.1 MyMathLab Homework Question
Some parts of MyMathLab that students and instructors value are the ability for students to complete their homework wherever and whenever they want and still have help via Help Me Solve This. Also, students appreciate the ability to make multiple attempts on homework, quizzes, and tests and be able to save the best score. Another positive feature is the data the program provides (Burch & Kuo, 2010).

Major flaws of MyMathLab exist and should be considered. First, the program provides a number of multiple choice questions which allows the student to successfully answer the question by guessing without actually understanding the concept (Burch & Kuo, 2010). Secondly, the number of algorithmically generated questions is not infinite. Because the questions are on a loop, a student is able to press “similar exercise” several times until their original question comes around. In
other words, students can purposefully get a question wrong until they are given the correct answer, write down the question with its associated answer, and repeatedly press “similar exercise” until that same original question comes up again so they can put in the correct answer. This can be tasking, but makes cheating obtainable. Lastly, because students are doing their work online, it is difficult for teachers to know who is actually completing the online homework (Burch & Kuo, 2010).

After looking at several beneficial features and flaws of MyMathLab, several studies that have been completed will be reviewed. Each of the following studies have put MyMathLab to the test for comparison to a traditional paper-pencil class, to evaluate student achievement, student attitudes, and to increase the overall structure and results of a math course.

White (2006) compared students in a traditional course to students completing the course using online homework through MyMathLab. In the fall 2004 and spring 2005 semesters, Saint Leo University found students who utilized MyMathLab in their Finite Mathematics course scored significantly higher on the final exam than students who did not use MyMathLab. As White (2006, p. 241) explained, “the utilization of learning resources does have a significant effect on final exam scores.”

Jacobson (2006) at Weber State University, Utah conducted a study to compare a course with paper homework to a course with computer homework. A majority of the students had positive feelings towards MyMathLab and believed it
helped them to understand the material. Student evaluations showed positive results but exam scores collected through the entire semester showed a different outcome. Although the results were not statistically significant, exam scores for students using MyMathLab were lower than students doing pencil and paper homework.

In the fall 2006 and spring 2007 semesters Ramapo College, New Jersey implemented an entirely-online developmental mathematics course using MyMathLab and compared the results to traditional courses. The instructors saw an increase in scores for online students compared to the scores of the students completing the traditional course. Although they noticed the students having a hard time with written communication in math because the course was entirely online, the instructors felt the benefits of the online course outweighed those of the traditional course (Potocka, 2010).

In the fall of 2007, Florida Atlantic University (FAU) formed a committee to help solve issues of increasing drop-fail-withdraw (DFW) rates for students in college algebra. The committee investigated the problems and added MyMathLab homework, iClickers, ALEKS placement test at the beginning of each semester, seven common exams formed by the faculty, as well as other changes. The data showed a decrease in the DFW rates but it is unknown if the decrease is because of their actions (Gonzalez-Muniz et al., 2012).

During the 2007-2008 academic school year, a study was conducted in college algebra courses at Indiana University of Pennsylvania. Traditional courses
in the fall 2007 were compared to courses using MyMathLab in the spring 2008. Data was collected to see if using the web-based program would help students with understanding and retention of material. Exam scores through the semester and final exams were reported. The results showed that MyMathLab students performed better on exams and demonstrated higher retention (Burch & Kuo, 2010).

University of Maryland Eastern Shore (UMES) implemented MyMathLab into remedial math courses in the fall and spring of 2007-2008. Course data and surveys were collected to measure student satisfaction, persistence, and achievement. Students thought the system was easy to use and helped them to better understand the material. The data was compared to previous semesters of the course and showed a statistically significant decrease in withdrawal and a significant increase in pass rates (Buzzetto-More & Ukoh, 2009).

Fayetteville State University, North Carolina implemented MyMathLab in college algebra for two courses and compared the exam results and end of course grades to two traditional college algebra courses. While students using MyMathLab performed slightly better, the results were not statistically significant; however, students using MyMathLab had a course success rate of 70% while students in the traditional classes had a 49% success rate (Kodippili & Senaratne, 2008).

In the fall 2010 semester, the Owens campus of Delaware Technical & Community College implemented MyMathLab in Elementary Algebra to test the
effectiveness of increasing student achievement. Not only did the instructors report an increase in quiz and test scores, but also an improvement in the attitudes towards math. Following these results, MyMathLab was implemented in every course (Vezmar, 2011).

Norwich University, Vermont one group students in the spring of 2010 completed college algebra in a traditional paper and pencil homework course. This group was compared to students that completed their homework online using MyMathLab in the spring of 2011. After collecting the data, Mathai & Olsen (2013) noticed that higher-skilled students using MyMathLab showed gains while lower-skilled students using MyMathLab did not show improvements. In this study, the sample was very small and nonrandom which may have caused the results to not be definitive (Mathai & Olsen, 2013). In summary, MyMathLab studies have shown an increase in student achievement in some studies while others had no significant difference or no difference at all.

**ALEKS**

ALEKS is an adaptive, artificial intelligence, interactive, eLearning software created by cognitive scientists and software engineers at the University of California, Irvine, using the Knowledge Space Theory. Major funding for the development of the software was provided by the National Science Foundation and published by McGraw-Hill Education (ALEKS, 2015). The program uses the
Knowledge Space Theory (KST) to assess each student on what they already know and what they are ready to learn.

The Knowledge Space Theory is based on the concepts of Combinatorics and stochastic processes. Falmagne et al., 1990 provides an in-depth explanation with associated mathematical formulas used for the development of ALEKS. For the purpose of this study, a simplified explanation of the theory is explained. If a course requires the knowledge and understanding of certain concepts, we will call the set of all topics the universal set K. Set K contains the subsets A, B, and C. Set A contains all topics the student already knows. Set B contains the set of topics the student does not know. Set C contains the objectives the student does not currently know but is ready to learn, which means C is a subset of K and a subset of set B. A diagram of the sets is provided below.

![Diagram of Sets for ALEKS program](image)

*Figure 2.3 Diagram of Sets for ALEKS program.*

The objectives, especially in a math course, are tied to each other in one fashion or another. For example, if a student knows how to simplify a rational
expression involving polynomials, then we may assume they know how to factor polynomials. Here is another example: if a student is able to solve a word problem such as: “Gwendolyn is \( \frac{3}{4} \) as old as Rebecca. Rebecca is \( \frac{2}{5} \) as old as Edwin. Edwin is 20 years old. How old is Gwendolyn?”, then we are able to assume they know how to multiply whole numbers and fractions. Similarly, if a student is unable to solve \( 378 \times 605 \), then we may assume it would be a waste of time to ask them the word problem given earlier. Because the concepts in the course (set \( K \)) are related, we are able to ask only 20 to 30 questions to determine what topics are in each set \( A, B, \) or \( C \) for that individual student. The set of objectives the student has shown proficiency in, is called the knowledge state.

Once all the objectives are selected for a course, ALEKS uses the Knowledge Space Theory to determine what topics belong in each set for the individual student. At the beginning of each course, this is found by requiring each student to complete an initial assessment containing no more than 30 questions. The initial assessment is different for each student. The student begins the exam with all objectives in set \( B \) (the set of topics the student does not know). No topics are in set \( A \) (set of objectives the student knows) or \( C \) (set of objectives the student is ready to learn).

The student is asked an initial question. If the student correctly answers the question, then the objectives that are tied to the current objective (skills needed to answer that question correctly) are placed in set \( A \) with a likely probability. If the
student answers the question incorrectly, then the objectives remain in set B with a low probability of the student understanding that concept and each topic tied to that question. The software also looks at the way the student is answering the question. For example, if the student provides the answer as 3 when the correct answer is negative 3, then the software is able to pick up on the mistake and decide how to ask future questions to investigate a possible misunderstanding of an objective related to negatives instead of an issue of understanding all other objectives tied to the question.

The next question on the initial assessment is determined by the answer the student provides on the previous question. The software determines the next question using multidimensional connections; there are many links between objectives and many paths to find each student’s knowledge state. The system will continue asking questions until each objective has a very high or very low probability. Once there are no more useful questions, the student’s individual knowledge state is determined. Because of the random nature of the assessment, it is possible that some topics in each set are placed incorrectly. By the end of the assessment, the student’s knowledge of the objectives for the course are listed and represented by a multicolor pie as seen below.
Figure 2.4 Example of ALEKS Pie

The pie chart shows what the student knows, what they are ready to learn, and shadows the topics the student does not know and is not ready to learn. After the initial assessment is completed in the Assessment Mode, the student will begin in the Learning Mode where they are able to pick a topic from the pie that they are ready to learn. Based on the initial assessment, these are the topics that the student has the prerequisite knowledge to be able to learn the new objective. Once the student selects the new objective, they are given a question pertaining to that objective. On the page with the current question, the student is provided with material that will help them complete the question. For example, they can click “Explain,” view the online dictionary, or view resources that the instructor has posted. When they click the “Explain” button, the software will exit the current question and provide them with a step-by-step process of solving the problem with
specific instructions. The screenshot below shows an example of the “Explain” feature. Appendix E contains example questions from the ALEKS program. After they view the steps, they can return to a similar question to practice. Some of the questions also provide alternative or more detailed explanation of the problem. The ALEKS online dictionary is organized for the student to quickly find information tied to the current question. As mentioned, the students are able to review any materials that the instructor has posted. Instructors are able to add resources to each objective in the course so that the students are able to review the material when they are in the questions tied to that objective.
Figure 2.5 ALEKS Example of “Explain” Feature

Once the student answers the current question, they are provided immediate feedback. If the question is answered incorrectly, the feedback is provided with suggestions of how to correct the mistakes and definitions of topics associated with the question. Depending on the answer provided by the student, ALEKS may suggest the student exit the current topic and work on a related topic that is less advanced. The system is based on mastery learning so the student will be required to show understanding of each topic before moving on to the next objective. Therefore, if the student answers the question correctly, the system will require the
student attempt two or three more similar questions to make sure the student clearly understands the topic. If the student shows understanding, then the topic is added to the portion of the pie as a topic the student knows. Later through the course, ALEKS will periodically ask a similar type of question to make sure the student has retained the information. If the student later answers the question incorrectly, it will be subtracted from their pie until they are successful at the question two or three more times. Periodic reassessment of each objective will continue until the end of the course to ensure the student is retaining the material. Another available resource provided to students is the ability to make an individualized practice worksheet. Students are able to create and print a practice worksheet by the click of a button. ALEKS formulates a worksheet of problems that the student needs to practice with a few challenging ‘ready to learn’ questions towards the end.

Some of the features that ALEKS provides make the software very beneficial to students and instructors. ALEKS is well-known for targeted and individualized assistance, deliverance that encourages self-pacing, on-going assessment, and prompt feedback (Nwaogu, 2012). One very useful feature of ALEKS is the initial assessment which is adaptive; it is able to see what the student already knows and build upon that knowledge. Many students enter a course with a different set of skills. They start college in a remediation stage. By far, the group of students that have the most skill deficiencies suffer the lowest rate of achievement (Bahr, 2012). For the software to be adaptive to each student’s current knowledge
state, it is able to assist the instructor and student in filling those gaps so the student can increase understanding throughout the course.

Another key feature of ALEKS is that the system does not ask multiple choice questions. In other words, each question requires the student to produce an authentic input (Tempelaar et al., 2006). This prevents students from guessing the correct answer. With ALEKS, there are no lucky guesses since all questions have a large number of possible responses. The probability of lucky guesses is trivial (Falmagne et al., 2007). The questions that are given to students are of higher caliber which entices instructors and institutions to integrate ALEKS into their classroom (Hagerty, Smith, & Goodwin, 2010)

Another benefit, as mentioned earlier, is the fact that ALEKS uses the mastery learning approach; students are required to show understanding of the current objectives before they are allowed to move onto the next topic. Even once the student has shown mastery, the students will periodically be asked similar questions that are tied to that objective just to make sure the student is retaining the material. Bonham & Boylan (2011) explain that mastery learning is a promising practice especially for remediation in mathematics. ALEKS’ expectation for mastery is helpful in reducing the need for frequent reviewing and aids the student in progressing through the material faster (Nwaogu, 2012). ALEKS will require the student to complete an assessment after so much time is spent in the system, after the student has mastered so many topics, after the student has been signed out of
the program for a long period of time, or even when the instructor initiates an assessment. This is extremely beneficial as it will allow the instructor to check for understanding and retention at any point in time. (Nwaogu, 2012).

The last major valuable feature of ALEKS is the feedback the software provides. Instead of giving each student a numerical measurement of their current understanding in the course, ALEKS provides a summary of the topics each student has mastered and what they are ready to learn. Looking at the difference between what the student can do and what the student is ready to learn is similar to the ‘Zone of proximal development’ (ZPD) which is a concept introduced by psychologist Vygotsky (Vygotsky, 1978). As Falmagne et al. (2006), explained learning as multidimensional. There should not be a simple numerical value that summarizes the knowledge of each student. For example, if a test was given to Michael Jordan, Tiger Woods, and Pete Sampras that computes the numerical athletic ability it would be negligible to order the numerical values from least to greatest and say one is a better athlete than another. Their abilities are multidimensional similar to the mathematical abilities of our students.

The multidimensional feedback that ALEKS provides is beneficial to the instructors, administrators, and even the students. The organization and ease of use that ALEKS provides is very useful. It is easy to gather data that explains the student’s current progress in the course. The system provides a pie chart which offers an immediate visual each time a student or instructor logs into the program.
The student is able to graphically see their progress. The instructor can see the progress of the entire class or click on a student’s name to see their individual progress. Both the instructor and student may click at any time to see a current list of objectives they have mastered and the topics that they are ready to learn. The instructor is able to see the percentage of students that have mastered or are ready to learn each objective. Both the student and teacher are able to see how much time was spent in the system at any given time with a list of topics that were attempted, mastered, and added to their pie during that time.

The above features show the many benefits of the program, but there are some flaws to ALEKS. Because ALEKS is individualized, it does not pair perfectly with a lecture based course. When a teacher is covering a certain topic during class, it is unlikely that students are currently working on the same topic in ALEKS. The student may have already completed that objective, are therefore ahead of the instructor, and possibly become bored during the lecture. It is also possible that a student has not reached that topic in their pie. This can cause the student to become frustrated. Even with these issues, research has shown ALEKS leads to great success (Hagerty, Smith, & Goodwin, 2010).

There have been several studies completed to test the benefits of ALEKS. Many studies compare ALEKS to the traditional classroom with pencil and paper homework and result in higher student achievement for students using ALEKS. Some studies show a slight increase in student achievement but not a statistically
significant increase. However, those same studies show an increase in student attitudes, retention, attendance, and even a reduction in anxiety. There are studies that show no difference between the traditional classroom and ALEKS, but each of the studies explained issues that were caused by outside factors.

Canfield (2001) reported surveys that were completed by students after using ALEKS for part of the semester. The most prominent results captivated the instructor: Students reported that they would recommend the use of ALEKS and would prefer to take their next course using the online program. The students said that they liked the detailed explanations and feedback, the tailored practice problems the system provided by the simple click of a button, and many reported the decrease in stress due to the self-paced nature of the online work.

In 2001, Black Hills State University (BHSU), South Dakota redesigned their college algebra course. Some changes included far fewer lectures, cooperative activities, and whole class discussions. In addition, a major modification to the course was the addition of ALEKS. With the changes, the university saw a 21% increase in passing rate, 300% increase in enrollment in the next mathematics course in the program, 25% improvement in attendance, and a statistically significant increase in scores of the nationally normed Collegiate Assessment of Academic Proficiency (CAAP). Data showed an increase in self-efficacy as well. After these reports, the college decided to use ALEKS in all sections of college algebra. While there have been positive outcomes from the changes of the college
algebra course, they cannot all be contributed only to ALEKS (Hagerty, Smith, & Goodwin, 2010).

Stillson & Alsup (2003) compared a group of students who used ALEKS to a group of students that completed a traditional course. The data showed an increase in student averages for the students who actually used and spent time in the program. Again, technology can be useful in the classroom if it is used correctly. The research recommends that schools should teach the instructors and students how to use the program so its benefits may be optimized (Stillson & Alsup, 2003).

In the 2003 fall semester, ALEKS was put to the test against a traditional format course. 4 college algebra courses used ALEKS (n = 132) and four sections completed paper and pencil homework (n = 119). The ACT was used as the pretest and posttest to measure gains in student achievement. The most recent ACT score for each student was recorded prior to completing the college algebra course. After the students completed the course, students retook the ACT. The ACT scores for each student were compared. The results showed that students using ALEKS outperformed the traditional format course. In fact, ALEKS increased the students’ growth approximately 11%. Not only did the students using ALEKS increase their ACT scores, but they also showed that they retained the information much better than students who did not use ALEKS 14 months after the end of the class (Hagerty & Smith, 2005).
Carpenter (2006) looked at the total amount of time spent using ALEKS and noticed a strong, positive correlation with student retention and success. The students were encouraged to spend at least 3 hours and make 6% progress on their pie outside of class throughout each week of the course. As explained earlier and as this research reports, technology can be beneficial when it is used correctly. The software can only benefit the student if they actually use the software (Carpenter, 2006).

Taylor (2008) compared 54 ALEKS users to 39 traditional lecture students in an intermediate algebra course from three colleges and two universities. The data collected showed no statistically significant difference in performance between the two groups. However, ALEKS users showed a decrease in anxiety and an increase in attitudes toward mathematics more than reported for traditional students.

ALEKS was used and shown to remove remediation and improve student’s math skills (Fine, Duggan, & Braddy, 2009; Fullmer, 2009). East Central University, Oklahoma inaugurated a program called ATLAS (Accessible-on-demand, Technology-based, Learning-for-mastery, Assessment-driven, Student-Centered system) to help students better prepare for college level math courses. The program was successful in helping the students remove remediation (Fine, Duggan, & Braddy, 2009).

Lincoln University, Pennsylvania introduced ALEKS to increase the usefulness of their program, SWOT (Strengths, Weaknesses, Opportunities, and
Threats). They also found that ALEKS was effective in increasing students’ math skills (Fullmer, 2009).

Nwaogu (2012) wanted to investigate what effects ALEKS shows on students’ achievement by looking at the gains between a pre- and post-test. ALEKS users showed a significant difference between pretest and posttest scores. The results showed a strong positive correlation between mastery of concepts and their assessments. The best regression equation includes the time each student spent within the program.

In summary, ALEKS provides many beneficial features but also comes with a few flaws. As noted with several of the studies mentioned, the majority of research has shown that ALEKS users perform equally or better in mathematics than those who do not use the online program (Oshima, 2010).

**Comparison of MyMathLab and ALEKS**

There have been a few studies completed comparing MyMathLab to ALEKS. Oshima (2010) integrated ALEKS into one college algebra course and MyMathLab into another. There was a dramatic increase in students’ retention and success for students who used ALEKS. Although not statistically significant, the ALEKS group showed a slightly better course grade than the MyMathLab group. Stillson & Nag (2009) compared MathXL (early name of MyMathLab) to ALEKS. The research reported higher scores for students using MathXL; however, there were many outside factors that possibly affected the outcome of the study. For
example, tutors and a lab were made available to MathXL students during the fall 2006 semester but they were not available during the fall 2005 semester for the students using ALEKS. Another study completed with the comparison of MyMathLab and ALEKS was reported by Allen (2007). Allen claims that ALEKS was able to assist less prepared students in reaching success because of the program’s emphasis on repetition and continuous assessment.

As explained, MyMathLab and ALEKS each have features beneficial in the classroom. Now, a closer look at the comparison between the two is important. The main topics discussed are the issues aligning course coverage to homework, data reports, and assessments dealing with mastery learning and cheating.

Instructors normally assign homework that coincides with the current topic in the course. For example, if the instructor teaches how to factor polynomials, students will normally expect that the homework assigned will cover factoring polynomials. Homework checks the student’s knowledge and understanding of the day or week’s lecture. This is the case for MyMathLab. Instructors are able to select each and every single question on each and every assignment. They will select the due date which is normally around the time the instructor covers that material. This all seems simple. However, ALEKS does not work this way. As discussed earlier, ALEKS is individualized; the upcoming assignment questions and exams are based upon what the student has already learned. Instructors are not able to select individual questions. They are only able to select objectives for the
course at the beginning of the semester and the program will create the assignments and assessments based off the student’s information. Instructors are able to set goals for completion dates for each objective. Each student will possibly be at a different objective than the teacher but the goal completion date can help keep the students on schedule. The student’s pace may be slower or faster than the instructor.

ALEKS provides a large amount of data summarized in very user-friendly forms. As an instructor, it is easy to find what students are struggling with overall. Instructors are able to see which objectives students are attempting, which ones they have mastered, how many attempts each student tried per objective before mastering the topic, how many attempts they completed even after mastering a concept, how much time each student has spent in the program down to the second and even down to the question, and so much more. All information is easily accessed by the instructor and also by the individual student. Not only are the reports easy to access but they are summarized to make it easy to see any issues by just glancing at the report. MyMathLab, unfortunately, does not have many of the options as easily accessible as ALEKS. MyMathLab recently introduced a new reporting feature; however, it does not provide easy to use features. For example, when the instructor opens the reports the students from every course are grouped together in one long list. The names of the students are not alphabetized or sectioned off by which course they are enrolled. For some reason, student’s names
appear in the list more than one time. The lists are sectioned through many pages which make it harder to access. In addition, several of the pages in the list are blank. Some of the data provided is not useful to the instructor either because it is not summarized in a way that the instructor can make an overall deduction or because the values provided by the report mean nothing. MyMathLab is improving their reports feature and may eventually have similar features to ALEKS.

Another major difference between the two programs deals with mastery learning. MyMathLab and ALEKS both allow for mastery learning. The big difference is the way they are initiated. Mastery learning is already built into ALEKS. All assessments and assignments are automatically tied to the student’s pie with each objective required to complete the course. In order for MyMathLab to use mastery learning, the instructor must set up this feature on their own. It is possible, but instructor time is involved.

It can be difficult for teachers to think about the possibility of their students cheating on homework. For example, a student may have someone else complete their homework for them or, as explained earlier on MyMathLab, may continually press “similar exercise” until they get a perfect score. For this reason, many instructors may count homework as a very small percentage of their grade or even not count the work for credit at all. Because of ALEKS’ built in mastery learning technique, teachers are able to check for retention and cheating at any point in time. ALEKS assessments are tied to each and every assignment they complete in the
course automatically so the teacher can assign a proctored test to a student at any
time and when the student completes the assessment (which is set to test over every
objective in the course) ALEKS will automatically update the pie with the
objectives the student has shown mastery. In other words, if someone else did their
homework for them the night before then the proctored assessment in class will
remove any objectives that the student did not learn. As Burch and Kuo (2010)
point out, MyMathLab does not prevent cheating. The assessments and mastery
learning are not tied together as well to make it easy for an instructor to reassign
homework, tests, and quizzes when a student does not show understanding on an
assessment.

In summary, both programs have valuable features but ALEKS’ benefits
seem to outweigh those of MyMathLab. Although ALEKS does not follow the
course schedule, it is easy to use for instructors and students, mastery learning is
already built into the system, and it prohibits cheating. From the theory stated
earlier, students using ALEKS will have higher student achievement, better
attitudes towards mathematics, higher self-efficacy towards mathematics, and a
decrease in anxiety towards mathematics.
Chapter 3
Methodology

The focus of the study was to determine the relationship each of the mathematics web-based programs, MyMathLab and Assessments and Learning in Knowledge Spaces (ALEKS), has with students’ mathematics achievement. In addition, the study examined the interaction between students’ affective domain and the type of software on student achievement. The affective domain measures are students’ anxiety, self-efficacy as well as their attitudes towards mathematics. For the purpose of this study, mathematics achievement is defined as students’ intermediate algebra end-of-course comprehensive final exam score.

In this chapter a description of the population and sample is given. Then, a description of how the data was collected using instruments to assess attitude, self-efficacy, and attitudes towards mathematics as well as the student achievement assessment is delivered. Lastly, how the data was analyzed is described.

Population and Sample

Population. The target population for the study was all students enrolled in intermediate algebra, MAT 1033, at a public state college in Florida during the spring 2016, 16-week semester. A smaller accessible population was delimited from the target population. It consisted of students enrolled at the Palm Bay campus in Brevard County at Eastern Florida State College (EFSC). EFSC has four campuses located in Titusville, Cocoa, Melbourne, and Palm Bay. The
demographics of the college during the spring 2016 semester are provided in Table 3.1. As a summary: the mean age of all EFSC is 25 years old, 59% of the students are female, and the race/ethnicity enrollment percentages were as follows: White 68.39%, Hispanic 11.84%, Black 11.39%, unknown 1.46%, American Indian 0.43%, Pacific Islander 0.37%, and 3.66% as two or more races.

Table 3.1

<table>
<thead>
<tr>
<th>Campus</th>
<th>Headcount*</th>
<th>Ethnicityb</th>
<th>Age</th>
<th>Genderc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FT</td>
<td>PT</td>
<td>W</td>
<td>B</td>
</tr>
<tr>
<td>Cocoa (N = 4170)</td>
<td>1379</td>
<td>2791</td>
<td>2958</td>
<td>448</td>
</tr>
<tr>
<td>Melbourne (N = 5380)</td>
<td>1972</td>
<td>3408</td>
<td>3931</td>
<td>357</td>
</tr>
<tr>
<td>Palm Bay (N = 3392)</td>
<td>1065</td>
<td>2327</td>
<td>1901</td>
<td>652</td>
</tr>
<tr>
<td>Titusville (N = 1942)</td>
<td>566</td>
<td>1376</td>
<td>1389</td>
<td>239</td>
</tr>
<tr>
<td>Total (N = 14884)</td>
<td>4982</td>
<td>9902</td>
<td>10179</td>
<td>1696</td>
</tr>
</tbody>
</table>

*Note. All data are from the end of the add/drop period report.

*FT = Full-time and PT = Part-time, bW = White, B = Black, H = Hispanic, A = Asian, and O = Other (American Indian, Pacific Islander, Multi-Race, and unknown). cstudents college-wide declined to specify gender.

Sample. The sample was created using convenience sampling. From the accessible population, four courses were selected from the spring 2016, 16-week semester and included 81 students. The four courses were face-to-face on the Palm Bay campus. Two of the face-to-face courses were assigned the MyMathLab program and the other two were assigned ALEKS. The Monday/Wednesday 10:50
AM class used ALEKS, while the Tuesday/Thursday 10:50 AM class used MyMathLab. For the 1:30 courses, the Monday/Wednesday class used MyMathLab and the Tuesday/Thursday used ALEKS. This information is summarized in Table 3.2 below. The sample sizes for the groups were MyMathLab \( n = 37 \) and ALEKS \( n = 44 \).

Table 3.2

Class Schedules for ALEKS and MyMathLab Groups

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday/Wednesday</th>
<th>Tuesday/Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:50 A.M.-12:05 P.M.</td>
<td>ALEKS</td>
<td>MyMathLab</td>
</tr>
<tr>
<td>1:40 P.M.-2:55 P.M.</td>
<td>MyMathLab</td>
<td>ALEKS</td>
</tr>
</tbody>
</table>

The sample characteristics were self-reported by the students. The mean age was \( M = 22 \) years old and 42% of the sample was female. 65.8% of the sample was White/Caucasian, 19.8% were Black, 12.3% were Hispanic, 2.1% were Asian, and 16% were Other. When comparing the demographics of the accessible population to the sample, the sample was representative.

Instrumentation

Three instruments were used to collect data including students’ affective domain and demographics, achievement, and a survey of the programs. The affective domain questionnaire contained measurements for students’ anxiety.
towards mathematics, students’ attitudes towards mathematics, students’ self-efficacy towards mathematics, as well as a section for demographics.

**Affective domain questionnaire.** The affective domain questionnaire contains three sections. The first section consisted of Mathematics Self-Efficacy and Anxiety Questionnaire ([MSEAQ]; May, 2009). The second section consisted of Attitudes Toward Mathematics Inventory ([ATMI]; Tapia and Marsh, 1996). Lastly, the third section contained a questionnaire to collect student demographics. The questionnaire was administered after the add-drop week through an online Learning Management System, Canvas. A copy of each instrument is given in Appendix A.

**Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ).** This questionnaire was developed by Diana K. May (2009) and consists of 29 questions using a 5-point scale where 1 = Never, 2 = Seldom, 3 = Sometimes, 4 = Often, and 5 = Usually. Items pertaining to anxiety have a reverse scale. Students also have the option of NR = No Response. The MSEAQ has an overall Cronbach alpha of .94 which measured the internal consistency. Cronbach’s coefficient alpha for mathematics self-efficacy of .91 and mathematics anxiety subscales of .91. Therefore, in terms of internal consistency, MSEAQ is highly reliable.

**Attitudes Toward Mathematics Inventory (ATMI).** Developed by Martha Tapia (1996), the ATMI consists of 40 questions rated on a 5-point Likert-type scale with 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 =
Strongly Agree. Scores range from 40 to 200, with higher scores showing positive attitude towards mathematics. After examining the responses of 545 students, the reliability coefficient alpha was .97. A retest was completed and the results showed consistency.

**Student Demographics.** Student gender, age, and race/ethnicity were collected in the final section of the affective domain questionnaire. This information was self-reported and used to show group equivalency.

**Mathematics Achievement.** Student achievement was measured using the MAT 1033 prerequisite examination scores and the comprehensive MAT 1033 final examination scores. The topics covered in the examination are decided upon the course plan objectives. The course objectives can be seen in Appendix C. The MAT 1033 prerequisite examination was a modified version of a developmental mathematics comprehensive final examination developed by EFSC faculty. It was used to assess students’ mathematical background. The examination consisted of 43 dichotomously scored questions with 40 multiple choice questions and three graphing questions. Each question was equally weighted and scores could have ranged from zero to 43. The comprehensive final exam included 25 dichotomously scored multiple-choice questions. Students were given two hours to complete the exam. Scores can range from zero to 25. The comprehensive post-assessment was created by the Palm Bay Mathematics Department at Eastern Florida State College during the Spring and Fall semesters of 2015. The test covers the main concepts of
MAT 1033. Students completed the prerequisite exam as a pretest at the beginning of the semester and the comprehensive final exam as a posttest at the end of the semester. Both exams are included in Appendix B. The exams were graded by the researcher.

Course Description

Intermediate algebra (MAT 1033) is a 3-credit-hour 48-contact hour-course at EFSC. This course is a prerequisite course for college algebra (MAC 1105). The course objectives are listed in Appendix C. The catalog description for MAT 1033 is as follows:

Prerequisites: MATV 0028 or MATV 0022 with a grade of “S”, or MATV 0057 with a grade of “C” or higher, or appropriate placement scores.

Prepares students for MAC 1105. Includes vocabulary, symbolism, basic operations with algebraic expressions, polynomials, linear equations and inequalities in two variables and their graphs, exponents, radicals and radical equations and complex numbers, introduction to functions (MAT 1033 – Intermediate Algebra,” 2015).

Procedures

Research methodology/design. This study employed a quasi-experimental methodology pretest-posttest design. The convenience sample consisted of students from four courses that were selected from the spring 2016, 16-week semester. The four courses were face-to-face on the Palm Bay campus. Two of the face-to-face
courses were assigned the MyMathLab program and the other two were assigned ALEKS. The Monday/Wednesday 10:50 AM class used ALEKS, while the Tuesday/Thursday 10:50 AM class used MyMathLab. For the 1:30 courses, the Monday/Wednesday class used MyMathLab and the Tuesday/Thursday used ALEKS. This information was summarized in Table 3.2. This research methodology was employed because the researcher studied the effects of group membership on a dependent measure. The group memberships consist of students enrolled in a course using MyMathLab or ALEKS and the dependent measure calculated from the MAT 1033 final exam.

**Human subjects research.** An Internal Review Board (IRB) application was completed for both Florida Institute of Technology (FIT) and Eastern Florida State College (EFSC). The application and approval #15-188 from FIT is provided in Appendix F. The EFSC IRB approval is included in Appendix G. As indicated in the applications, the study was conducted in an education setting and under normal teaching conditions. There are no known physical or mental risks to the students. The data was collected and stored in a secure location by the researcher. The aggregated data was shared with the dissertation committee. During the study, students used their student identification number.

**Description of independent and dependent variables.** The variables were dummy coded. The independent variables were group membership with ALEKS as the reference group, gender with male as the reference group, students’ age in
years, students’ affective domain with MSEAQ scores for self-efficacy, MSEAQ scores for anxiety, and ATMI scores. Lastly, the dependent variable was students’ final examination scores.

**Study implementation.** During the spring 2016 16-week semester, the study was implemented at EFSC. Four MAT 1033 courses were included in the sample. The four courses all taught by the same instructor were face-to-face and met two times per week for 1 hour and 15 minutes. Two of the face-to-face courses used MyMathLab and the other two used ALEKS. A timeline of the events is shown below.

![Timeline of Study Implementation](image)

*Figure 3.1 Timeline of Study Implementation*

In each of the classes, the students were given a syllabus on the first day with an outline of all assignments on MyMathLab or ALEKS that were required for the course. On the first day of class, the students were made aware of the research study and the expectations of the course were explained with an introduction of their assigned web-based program. On the second day of class, the students completed the pretest and were instructed to complete the questionnaires on the LMS Canvas course homepage over the weekend. All assignments were due the day before the following week’s class meeting. In other words, the homework was
due at 11:59 Sunday night for classes meeting on Monday, Wednesday. Classes meeting on Tuesday, Thursday had their homework due at 11:59 Monday night.

MyMathLab is the current EFSC math department preferred web-based program. However, the Palm Bay provost and math department chair approved using ALEKS for the two spring 2016 semester courses. Also, the math cluster (all mathematics faculty from all four EFSC campuses) voted and approved the use of ALEKS for the two spring 2016 courses. The approval letters from the department chair and the mathematics cluster are included in Appendix H.

Data Analysis

As mentioned above, students’ group membership, attributes, affective domain values, and their final exam scores were recorded. Data were reviewed for incomplete data, linearity between two variables by inspection of bivariate scatterplots, and the assumptions of multivariate analysis.

The research question for this study is “What is the relationship between the web-based programs and student achievement?” The following is a description of how the data was analyzed to test each hypothesis in attempt to answer each research question.

Research question 1. Is there a significant difference between using one of the web-based programs, MyMathLab or ALEKS, to student achievement? The hypothesis for this question was that students using the web-based program ALEKS will have higher achievement than students using MyMathLab. $H_0$: There
will be no difference between the students’ pretest posttest scores whether they are using MyMathLab or ALEKS.

For this research question, an analysis of covariance (ANCOVA) was conducted to test the hypothesis. ANCOVA evaluated the mean of the continuous dependent variable comprehensive final exam scores for each categorical independent variable, students using MyMathLab or ALEKS, while controlling for the continuous variable of the pretest scores.

Research question 2. Is there a significant difference between using one of the web-based programs and students’ affective domain? The hypothesis for this question was that the (a) students using ALEKS will have a greater increase in their attitudes towards mathematics than students using MyMathLab. $H_0$: There will be no significant difference between students’ attitudes towards mathematics whether they use MyMathLab or ALEKS. (b) students using ALEKS will have a greater increase in their self-efficacy than students using MyMathLab, $H_0$: There will be no significant difference between students’ self-efficacy towards mathematics whether they use MyMathLab or ALEKS. (c) students using ALEKS will have a greater decrease in anxiety towards mathematics than students using MyMathLab. $H_0$: There will be no significant difference between students’ anxiety towards mathematics whether they use MyMathLab or ALEKS.

(a) For this research question, a $t$-test was completed to compare the mean difference of the students’ attitudes towards mathematics for the ALEKS group to
the mean difference of the students’ attitudes towards mathematics for the MyMathLab group. An alpha level of 0.05 will be set.

(b) \( H_0: \) The mean of the differences for students’ self-efficacy towards mathematics for students using ALEKS will be equal to the mean of the differences for students’ self-efficacy towards mathematics for students using MyMathLab. \( H_1: \) mean of ALEKS higher than mean of MyMathLab.

For this research question, a \( t \)-test was completed to compare the mean difference of the students’ self-efficacy towards mathematics for the ALEKS group to the mean difference of the students’ self-efficacy towards mathematics for the MyMathLab group. An alpha level of 0.05 will be set.

(c) \( H_0: \) The mean of the differences for students’ anxiety towards mathematics for students using ALEKS will be equal to the mean of the differences for students’ anxiety towards mathematics for students using MyMathLab. \( H_1: \) mean of ALEKS less than mean of MyMathLab.

For this research question, a \( t \)-test was completed to compare the mean difference of the students’ anxiety towards mathematics for the ALEKS group to the mean difference of the students’ anxiety towards mathematics for the MyMathLab group. The alpha level was set at 0.05.

**Research question 3.** What is the interaction between using one of the web-based programs and students’ affective domain as they relate to student achievement? The hypothesis for this question was that (a) students using ALEKS
will have a greater increase in student achievement with respect to attitude than students using MyMathLab. \( H_0 \): There will be no interaction between which web-based program is being used and students’ attitudes towards mathematics as they relate to student achievement. **(b)** Students using ALEKS will have a greater increase in student achievement with respect to self-efficacy than students using MyMathLab. \( H_0 \): There will be no interaction between which web-based program is being used and students’ self-efficacy towards mathematics as they relate to student achievement. **(c)** Students using ALEKS will have a greater increase in achievement with respect to anxiety than students using MyMathLab. \( H_0 \): There will be no interaction between which web-based program is being used and students’ anxiety towards mathematics as they relate to student achievement.

**(a)** For this research question, a multiple regression analysis was conducted with student achievement as the criterion variable and students’ attitudes towards mathematics and whether they used MyMathLab or ALEKS as the predictor variables. Additionally, the predictor variables were centered with the product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003).

**(b)** For this research question, a multiple regression analysis was conducted with student achievement as the criterion variable and students’ self-efficacy towards mathematics and whether they used MyMathLab or ALEKS as the predictor variables. Additionally, the predictor variables were centered with the
product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003).

(c) For this research question, a multiple regression analysis was conducted with student achievement as the criterion variable and students’ anxiety towards mathematics and whether they used MyMathLab or ALEKS as the predictor variables. Additionally, the predictor variables were centered with the product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003).

In summary, this chapter provided a description of the population and sample. Then, a description of how the data was collected using instruments to assess attitude, self-efficacy, and attitudes towards mathematics as well as the student achievement assessment. Lastly, how the data was analyzed was described.
Chapter 4
Results

Introduction

This chapter includes the descriptive statistics, inferential statistics, and the results of the hypotheses for each research question. The descriptive statistics include a summary and description of the data collected for each research question. The inferential statistics give an analysis of the data to provide a description and make inferences about the population. Lastly, the results from testing each of the hypotheses are provided.

Preliminary Analyses

Prior to testing the study’s hypotheses, preliminary data screening was completed. The data set was modified with simple adjustments. In addition, missing data and outlier analysis was completed.

Data set modifications. The first preliminary data screening that was completed transferred each response in the Attitudes Toward Mathematics Inventory to a numerical equivalent value. In other words, Strongly Disagree was represented with 1, Disagree with 2, Neutral with 3, Agree with 4, and Strongly Agree with 5. In addition, each of the negatively worded questions were reverse coded. Each of the nominal variables were switched to a numerical value using a dummy code as explained in Chapter 3. Lastly, the names of each student were removed and replaced with a row number.
Next, the data were reviewed to check for any missing values. The original sample included 81 students. After accounting for each of the students that were dropped from the course, 45 students remained (44% decrease). Since the 36 students that dropped the course did not take the comprehensive MAT 1033 Intermediate Algebra final exam and because the exam score is the dependent variable for this study, it was necessary to exclude those students from the data set. Looking at each group individually, the original sample contained 81 students with 44 in the ALEKS group and 37 in MyMathLab. The ALEKS group lost 20 (pre-N = 44, post-N = 24) which is a reduction by 45%. The MyMathLab group lost 16 students (pre-N = 37, post-N = 21) which is a reduction by 43%. With the smaller data set, power analysis was completed and found to be 0.804.

**Outlier analysis.** Outliers are data points that lie abnormally far from the other values in the data set. Outliers can occur in many ways. For example, the data value could have been incorrectly measured, incorrectly recorded, or the value could just deviate from the norm. Issues may arise when outliers are present and should be reviewed for possible removal. If the outliers are not removed, they can skew the distribution, inflate errors, distort estimates, disguise significance, or even harvest a false significance (type 1 and type 2 error).

For this study, the Jackknife distance method was performed using the JMP statistical software. The Jackknife distance method uses estimates of the mean, standard deviation, and correlation matrix (Efron, 1982). The distances are
calculated, values are plotted, and a reference line shown to see which data points are outliers. Jackknife distance method helps to minimize false positives by identifying the outliers so they can be removed.

After completing the Jackknife distance method using JMP, 2 outliers were detected and excluded from the data set. Before removing them from the sample, \( N = 45 \). After removing the outliers, \( N = 43 \) where ALEKS \( N = 22 \) and the MyMathLab \( N = 21 \).

**Effect on Student Achievement (RQ1)**

For the first question, is there a significant difference between using one of the web-based programs, MyMathLab or ALEKS, to student achievement, a pretest and posttest were assessed to each group after the add-drop week. The pretest was given to measure the preexisting knowledge of each student and the scores were used as a control variable.

**Descriptive Statistics.** The MAT 1033 prerequisite examination was a modified version of a developmental mathematics comprehensive final examination developed by EFSC faculty. It was used to assess students’ mathematical background. The examination consisted of 43 dichotomously scored questions with 40 multiple choice questions and 3 graphing questions. Each question was equally weighted and scores could have ranged from 0 to 43.

Table 4.1 shows the summary of the data collected from the sample for the prerequisite exam. The means for each group only vary by less than half a point.
Scores ranged from 5 to 33 with $M = 20.40$ ($SD = 6.2$). The MyMathLab scores ranged from 5 to 31 with a mean $M = 19.86$ ($SD = 6.3$) while the ALEKS scores ranged from 11 to 33 with a mean $M = 20.91$ ($SD = 6.2$). The difference in the scores for each group is not statistically significant, $R^2 = 0.00005$, $F(1, 42) = 0.004$, $p = .950$. This information shows the groups started the course with similar prerequisite knowledge.

**Table 4.1**

**Summary of Means and Standard Deviations for Scores on the Test of Prerequisite Skills**

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>22</td>
<td>20.91</td>
<td>6.2</td>
<td>11-33</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>19.86</td>
<td>6.3</td>
<td>5-31</td>
</tr>
<tr>
<td>Overall</td>
<td>43</td>
<td>20.40</td>
<td>6.2</td>
<td>5-33</td>
</tr>
</tbody>
</table>

*Note.* Exam was used to assess students’ mathematical background.

The posttest for MAT 1033 was a comprehensive final exam that included 25 dichotomously scored multiple-choice questions. The exam was administered during the last week of the semester during finals week. Below, Table 4.2 contains a summarized analysis of the scores. The scores ranged from seven to 25 with an overall mean $M = 18.8$ ($SD = 4.87$). The MyMathLab group had a higher overall mean, $M = 19.29$ and the ALEKS group had a mean $M = 18.41$. The MyMathLab group had the greater mean while the ALEKS group had greater variability with a
standard deviation of 5.30 and range 7-25 (MyMathLab having $SD = 4.46$ and a range of 9-25).

**Table 4.2**

*Summary of Means and Standard Deviations for Scores on the Comprehensive Final Exam*

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>22</td>
<td>18.41</td>
<td>5.30</td>
<td>7-25</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>19.29</td>
<td>4.46</td>
<td>9-25</td>
</tr>
<tr>
<td>Overall</td>
<td>43</td>
<td>18.8</td>
<td>4.87</td>
<td>7-25</td>
</tr>
</tbody>
</table>

*Note.* Scores could have ranged from 0 to 25.

**Inferential Statistics.** Before testing the hypothesis using an analysis of covariance (ANCOVA), the assumptions normality, homogeneity of variance, and linear relationships were checked. Normality was checked by analyzing the distribution and the normal quantile plot of the residuals. Homogeneity of variance was checked by comparing the variances and checking the $F$ statistic. In addition to normality and homogeneity of variance, a linear relationship for each independent variable with the dependent variable must be checked. There was a statistically significant linear relationship between the pretest and posttest with $p = 0.0057$. $R^2$ showed that 18.9% of the posttest score was explained by the pretest. Lastly, homogeneity regression was checked. To do this, the factorial fit model was
completed between the pretest and groups, MyMathLab and ALEKS. No evidence was shown that the slopes were different ($p = 0.2803$).

After each assumption was checked, the analysis of covariance was performed. ANCOVA evaluated the mean of the continuous dependent variable comprehensive final exam scores for each categorical independent variable, students using MyMathLab or ALEKS, while controlling for the continuous variable of the pretest scores. The analysis showed that there was no statistically significant difference with $p = 0.3424$.

**Results of Hypothesis Testing.** The hypothesis for this question was that students using the web-based program ALEKS will have higher achievement than students using MyMathLab. $H_0$: There will be no difference between the students’ pretest posttest scores whether they are using MyMathLab or ALEKS. There was insufficient evidence to reject the null hypothesis. Therefore, there is not enough information to show that ALEKS students will have a higher achievement than students using MyMathLab ($p = 0.3424$).

**Effect on Affective Domain (RQ2)**

The next research question was “is there a significant difference between using one of the web-based programs and students’ affective domain?” This question was broken into the domains of (a) attitudes, (b) self-efficacy, and (c) anxiety. A questionnaire was given to the students to measure each.
Attitude Descriptive Statistics (RQ2a). To measure the students’ attitude toward mathematics, the ATMI questionnaire was used (Tapia, 1996). Three students did not complete the initial questionnaire and were therefore dropped from the sample. Below, Table 4.3 shows a summary of the initial (pre) and end of the semester (post) ATMI scores for each group and for the overall sample.

For the initial ATMI scores, the sample scores ranged from 51 to 193 with a mean score $M = 132.70$ ($SD = 27.52$) for students’ attitudes towards mathematics. The MyMathLab group scores ranged from 85 to 193 and started with a higher initial attitude towards math with $M = 140.9$ ($SD = 26.8$) while ALEKS students’ scores ranged from 59 to 167 and had a mean $M = 123.63$ ($SD = 26.04$).

For the post ATMI scores, both group means decreased. MyMathLab scores ranged from 71 to 194 and had a loss of 6 points in the mean from the initial to the final ATMI questionnaire (pre-$M = 140.90$, $SD = 26.80$, and post-$M = 134.90$, $SD = 34.57$). The ALEKS scores ranged from 62 to 153 and had a drop in the overall mean of the group of 4.16 points (pre-$M = 123.62$, $SD = 26.40$, post-$M = 119.47$, $SD = 27.00$). This can be seen in both Table 4.3 and 4.4. Table 4.4 shows a summary of differences of the students’ pre and post-ATMI scores.
Table 4.3

Summary of Students’ Scores on the Attitudes toward Mathematics Inventory (ATMI)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pre M</th>
<th>Pre SD</th>
<th>Post M</th>
<th>Post SD</th>
<th>Range Pre</th>
<th>Range Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>19</td>
<td>123.63</td>
<td>26.04</td>
<td>119.47</td>
<td>27.00</td>
<td>59-167</td>
<td>62-153</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>140.90</td>
<td>26.80</td>
<td>134.90</td>
<td>34.57</td>
<td>85-193</td>
<td>71-194</td>
</tr>
<tr>
<td>Overall</td>
<td>40</td>
<td>132.70</td>
<td>27.52</td>
<td>127.58</td>
<td>31.78</td>
<td>59-193</td>
<td>62-194</td>
</tr>
</tbody>
</table>

Note. Attitudes were measured using Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI). Attitude scores could have ranged from 40 to 200 where higher scores reflect more positive attitudes.

Table 4.4

Summary of Differences of Students’ Scores on the Attitudes toward Mathematics Inventory (ATMI)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>19</td>
<td>-4.16</td>
<td>14.54</td>
<td>-29 to 23</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>-6.00</td>
<td>17.41</td>
<td>-39 to 23</td>
</tr>
<tr>
<td>Overall</td>
<td>40</td>
<td>-5.13</td>
<td>15.94</td>
<td>-39 to 23</td>
</tr>
</tbody>
</table>

Note. Difference in scores from the initial ATMI questionnaire at the beginning of the semester to the final ATMI score at the end of the semester.
Attitude Inferential Statistics (RQ2a). For this research question, an independent-samples $t$-test was completed to compare the mean difference of the students’ attitudes towards mathematics for the ALEKS group to the mean difference of the students’ attitudes towards mathematics for the MyMathLab group.

Results of Hypothesis Testing (RQ2a). The hypothesis for this question was that students using ALEKS will have a greater increase in their attitudes towards mathematics than students using MyMathLab. $H_0$: There will be no significant difference between students’ attitudes towards mathematics whether they use MyMathLab or ALEKS. There was insufficient evidence to reject the null, $t(37) = 0.4, p = 0.72$. Therefore, there is not enough information to show that ALEKS will have a greater increase in their attitudes towards mathematics than students using MyMathLab.

Self-Efficacy Descriptive Statistics (RQ2b). MSEAQ questionnaire (May, 2009) was used to measure the students’ self-efficacy towards mathematics. As stated previously, 3 students did not complete the initial questionnaire and were therefore dropped from the sample. Below, Table 4.5 shows a summary of the initial (pre) and end of the semester (post) MSEAQ self-efficacy scores for each group and for the overall sample.

For the initial MSEAQ scores, the sample ranged from 17 to 70 with a mean score $M = 44.7 (SD = 11.55)$ for students’ self-efficacy towards mathematics. The
MyMathLab group started with a higher initial self-efficacy towards math where scores ranged from 28 to 70 and mean $M = 48.48$ ($SD = 10.94$) while ALEKS students’ scores ranged from 19 to 61 and a mean $M = 40.53$ ($SD = 11.00$).

For the post MSEAQ self-efficacy scores, both group means decreased. MyMathLab scores ranged from 26 to 70 and had a loss of 1.86 in the mean from the initial to the final MSEAQ questionnaire (pre-M = 48.48, SD = 10.94 and post-M = 46.62, SD = 13.22). The ALEKS scores ranged from 17 to 58 and had a drop in the overall mean of the group of 0.79 (pre-M = 40.53, SD = 11.00, post-M = 39.74, SD = 12.21). This can be seen in both Table 4.5 and 4.6. Table 4.6 shows a summary of differences of the students’ pre and post-MSEAQ self-efficacy scores.

**Table 4.5**

**Summary of Students’ Self-Efficacy Scores on the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pre M</th>
<th>Post M</th>
<th>Pre SD</th>
<th>Post SD</th>
<th>Pre Range</th>
<th>Post Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>19</td>
<td>40.53</td>
<td>39.74</td>
<td>11.00</td>
<td>12.21</td>
<td>19-61</td>
<td>17-58</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>48.48</td>
<td>46.62</td>
<td>10.94</td>
<td>13.22</td>
<td>28-70</td>
<td>26-70</td>
</tr>
<tr>
<td>Overall</td>
<td>40</td>
<td>44.70</td>
<td>43.35</td>
<td>11.55</td>
<td>13.06</td>
<td>19-70</td>
<td>17-70</td>
</tr>
</tbody>
</table>

*Note.* Self-efficacy was measured using May’s (2009) Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). Self-efficacy scores could have ranged from 14 to 70.
Table 4.6

Summary of Differences of Students’ Self-Efficacy Scores on the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>19</td>
<td>-0.79</td>
<td>8.00</td>
<td>-11 to 18</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>-1.86</td>
<td>7.27</td>
<td>-14 to 9</td>
</tr>
<tr>
<td>Overall</td>
<td>40</td>
<td>-1.35</td>
<td>7.55</td>
<td>-14 to 18</td>
</tr>
</tbody>
</table>

Note. Difference in scores from the initial self-efficacy score from the MSEAQ questionnaire completed at the beginning of the semester and the final MSEAQ score at the end of the semester.

Self-Efficacy Inferential Statistics (RQ2b). For this research question, an independent-samples *t*-test was completed to compare the mean difference of the students’ self-efficacy towards mathematics for the ALEKS group to the mean difference of the students’ self-efficacy towards mathematics for the MyMathLab group.

Results of Hypothesis Testing (RQ2b). The hypothesis for this question was that students using ALEKS will have a greater increase in their self-efficacy than students using MyMathLab, H₀: There will be no significant difference between students’ self-efficacy towards mathematics whether they use MyMathLab or ALEKS. There was insufficient evidence to reject the null, *t*(37) = 0.4, *p* = 0.66. Therefore, there is not enough information to show that ALEKS will have a greater
increase in their self-efficacy towards mathematics than students using MyMathLab.

**Anxiety Descriptive Statistics (RQ2c).** MSEAQ questionnaire (May, 2009) was used to measure the students’ anxiety towards mathematics. As stated previously, 3 students did not complete the initial questionnaire and were therefore dropped from the sample. Below, Table 4.7 shows a summary of the initial (pre) and end of the semester (post) MSEAQ anxiety scores for each group and for the overall sample.

For the initial MSEAQ scores, the sample scores ranged from 18 to 73 with a mean score $M = 41.80$ ($SD = 12.39$) for students’ anxiety towards mathematics. The ALEKS group scores ranged from 31 to 68 and started with higher initial anxiety towards mathematics with $M = 45.16$ ($SD = 11.82$) while MyMathLab students’ scores ranged from 16 to 62 and had a mean $M = 38.76$ ($SD = 12.39$).

For the post MSEAQ anxiety scores, the mean of the ALEKS group decreased while MyMathLab saw an increase. ALEKS scores ranged from 25 to 73 with a mean $M = 35.16$ ($SD = 13.10$). MyMathLab scores ranged from 18 to 61 and had an increase of 1.29 in the mean from the initial to the final MSEAQ questionnaire (pre-$M = 38.76$, SD = 12.39 and post-$M = 40.05$, SD = 11.98). This can be seen in both Table 4.7 and 4.8. Table 4.8 shows a summary of differences of the students’ pre and post-MSEAQ anxiety scores.
Table 4.7

Summary of Students’ Anxiety Scores on the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre N</th>
<th>Post N</th>
<th>Pre M</th>
<th>Post M</th>
<th>Pre SD</th>
<th>Post SD</th>
<th>Pre Range</th>
<th>Post Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>19</td>
<td>45.16</td>
<td>45.16</td>
<td>11.81</td>
<td>13.10</td>
<td>31-68</td>
<td>25-73</td>
<td></td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>38.76</td>
<td>40.05</td>
<td>12.39</td>
<td>11.98</td>
<td>16-62</td>
<td>18-62</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>40</td>
<td>41.80</td>
<td>42.75</td>
<td>12.39</td>
<td>12.63</td>
<td>16-68</td>
<td>18-73</td>
<td></td>
</tr>
</tbody>
</table>

Note. Anxiety was measured using May’s (2009) Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). Anxiety scores could have ranged from 15 to 75.

Table 4.8

Summary of Differences of Students’ Anxiety Scores on the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>19</td>
<td>0.00</td>
<td>7.81</td>
<td>-13 to 19</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>1.29</td>
<td>7.36</td>
<td>-9 to 19</td>
</tr>
<tr>
<td>Overall</td>
<td>40</td>
<td>0.68</td>
<td>7.51</td>
<td>-13 to 19</td>
</tr>
</tbody>
</table>

Note. Difference in scores from the initial anxiety score from the MSEAQ questionnaire completed at the beginning of the semester and the final MSEAQ score at the end of the semester.
**Anxiety Inferential Statistics (RQ2c).** For this research question, an independent-samples *t*-test was completed to compare the mean difference of the students’ anxiety towards mathematics for the ALEKS group to the mean difference of the students’ anxiety towards mathematics for the MyMathLab group. Although MyMathLab did see an increase in anxiety, the change was not statistically significant *t*(37) = 0.5, *p* = 0.60.

**Results of Hypothesis Testing (RQ2c).** The hypothesis for this question was that students using ALEKS will have a greater decrease in anxiety towards mathematics than students using MyMathLab. *H*<sub>0</sub>: There will be no significant difference between students’ anxiety towards mathematics whether they use MyMathLab or ALEKS. The results from the independent-samples *t*-test show that there is insufficient evidence to support this claim (*p* = 0.60).

**Effect of Affective Domain Relating to Student Achievement (RQ3)**

This research question asked “what is the interaction between using one of the web-based programs and students’ affective domain as they relate to student achievement?” The question was broken into each of the domains of *(a)* attitudes, *(b)* self-efficacy, and *(c)* anxiety. The question was answered by examining students in each group (MyMathLab or ALEKS) and the domains and preforming multiple regression analyses. In addition, the correlation between group membership and each domain with the addition of the posttest results is reported.
**Attitude Descriptive and Inferential Statistics (RQ3a).** ATMI questionnaire (Tapia, 1996) was used to measure the students’ attitude toward mathematics. Three students did not complete the initial questionnaire and were therefore dropped from the sample. An outlier analyses was completed earlier and noted above. The descriptive statistics for the questionnaire are included above in Tables 4.3 and 4.4.

**Relationship Between the Variables.** A scatterplot of each variable (posttest, group - MyMathLab vs ALEKS, and the attitude) were examined. After observing the data, no outliers or nonlinear relationships occurred. The correlation coefficient, $r$, and the probability for each are noted in Table 4.9. Between group and the posttest, the correlation $r = .09$ was not significant ($p = 0.5771$). There existed a significant correlation between attitude and the posttest $r = .36$ ($p = 0.0230$). Lastly, there was a significant relationship between group and attitude with $r = .3022$ ($p = 0.0500$).
Table 4.9

*Correlations between Posttest, Group, and Attitude*

<table>
<thead>
<tr>
<th></th>
<th>Posttest</th>
<th>Group</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.0921</td>
<td>1.0</td>
<td>0.3634</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3022</td>
</tr>
<tr>
<td>Attitude</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Multiple Regression.* A multiple regression analysis requires a linear relationship between the variables, homoscedasticity (homogeneity of variance), and normal distribution of residuals (predicted minus observed values). As mentioned above, a linear relationship was found between each variable. Homoscedasticity was examined by plotting the residuals with the predicted values. The fit mean line was located at zero meaning the variances were constant among the different values of the predicted posttest and no patterns were found in the data. The distribution of the residuals was also examined for normalcy. After checking the assumptions, it was appropriate to continue with the multiple regression analysis.

Predicting the posttest scores from the predictor variables, group and attitude using multiple regression gave an $R^2$ of 0.132. This suggests that 13% of the variance in posttest scores is accounted for by the predictors, group and attitude.
The Cohen’s (1992) effect size, \( f^2 = \frac{R^2}{1-R^2} \), was calculated to be .15. Using Cohen’s rough guidelines for multiple regression (.02 small, .15 medium, .35 large), this showed a medium effect. This indicated that the \( R^2 = .132 \) was of practical significance and explained how statistical significance was achieved even with the small sample size used in this study.

The regression coefficient for attitude was statistically significant (\( t = 2.27, p = 0.0294 \)), while the regression coefficient for group was not statistically significant (\( t = 0.12, p = 0.9054 \)). The prediction equation was:

\[
\text{Posttest} = 43.18 + .3654(\text{group}) + .2540(\text{attitude})
\]

This equation shows that if the group and attitude were both zero, then the posttest score would be 43.18. The equation also shows that the posttest score would increase .37 if the group is increased by one while attitude remains constant. Additionally, the posttest will increase .25 if the student’s ATMI score is increased by one point with the group remains constant.

**Interaction.** As discussed in Chapter 3, a multiple regression was also calculated with an interaction variable. The predictor variables were centered with the product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003). The adjusted \( R^2 \) was found to be .145, suggesting that about 15% of the variance in the posttest scores was accounted for by the predictor variables group, attitude, and the interaction of group.
and attitude. The adjusted $R^2$ increased by .013 from the multiple regression analysis without the interaction variable.

Cohen’s (1992) effect size, $f^2 = R^2/(1-R^2)$, was calculated to be .17 which can be interpreted as a medium effect size using Cohen’s rough guidelines (.02 small, .15 medium, .35 large). This indicated that the results may have some practical significance to mathematics educators.

The regression coefficient for attitudes remained statistically significant ($t = 2.19, p = .0349$), the regression coefficient for group remained not significant ($t = 0.10, p = .9227$), and the interaction variable was not significant ($t = -.72, p = 0.4787$). The prediction equation was:

$$\text{Posttest} = 43.28 + .30(\text{group}) + .11(\text{attitude}) + -.08(\text{G*A})$$

The strength of the interaction effect was computed by finding the difference between the $R^2$ values with and without the interaction variable in the regression analyses. With an original $R^2$ of 0.132 and the interaction $R^2$ of 0.145, this yields .013, meaning 1.3% of the variance in the posttest scores. To give a better sense of how student achievement changed depending on which web-based program was used was calculated from three different values of the students’ change in attitude: the lowest (ALEKS -29, MyMathLab -39), the mean (ALEKS -4.16, MyMathLab -6), and highest (ALEKS 23, and MyMathLab 23). See Figure 4.1.
As seen in Figure 4.1, the students with a lower attitude towards mathematics in the ALEKS group had a lower achievement score than the MyMathLab group. When the students showed a higher attitude towards mathematics, the ALEKS group scored higher on student achievement than the MyMathLab group.

**Results of Hypothesis Testing (RQ3a).** The hypothesis for this question was that students using ALEKS will have a greater increase in student achievement with respect to attitude than students using MyMathLab. $H_0$: There will be no interaction between which web-based program is being used and students’ attitudes towards mathematics as they relate to student achievement. The results from the
multiple regression analysis with an interaction showed that there is insufficient
evidence to support this claim.

**Self-Efficacy Descriptive and Inferential Statistics (RQ3b).** The MSEAQ
questionnaire (May’s, 2009) was used to measure the students’ self-efficacy toward
mathematics. Three students did not complete the initial questionnaire and were
therefore dropped from the sample. An outlier analyses was completed earlier and
noted above. The descriptive statistics for the questionnaire are included above in
Table 4.5 and 4.6.

**Relationship Between the Variables.** A scatterplot of each variable
(posttest, group - MyMathLab vs ALEKS, and the self-efficacy) were examined.
After observing the data, there were no outliers or nonlinear relationships. The
correlation coefficient, \( r \), and the probability for each are noted in Table 4.10. As
noted earlier, the correlation between group and posttest \( r = .09 \) was not significant
(\( p = 0.5771 \)). There existed a significant correlation between self-efficacy and the
posttest with \( r = .34 \) (\( p = 0.0348 \)). Lastly, there was a significant relationship
between group and self-efficacy with \( r = .34 \) (\( p = 0.0342 \)).
Table 4.10

Correlations between Posttest, Group, and Self-Efficacy

<table>
<thead>
<tr>
<th></th>
<th>Posttest</th>
<th>Group</th>
<th>Self-Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.0921</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>p = .5771</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>0.3389</td>
<td>0.3399</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>p = .0348</td>
<td>p = .0342</td>
<td></td>
</tr>
</tbody>
</table>

**Multiple Regression.** A multiple regression analysis requires a linear relationship between the variables, homoscedasticity (homogeneity of variance), and normal distribution of residuals (predicted minus observed values). As mentioned above, a linear relationship was found between each variable. Homoscedasticity was examined by plotting the residuals with the predicted values. The fit mean line was located at zero meaning the variances were constant among the different values of the predicted posttest and no patterns were found in the data. The distribution of the residuals was also examined for normalcy. After checking the assumptions, it was appropriate to continue with the multiple regression analysis.

Predicting the posttest scores from the predictor variables, group and self-efficacy using multiple regression gave an $R^2$ of 0.115. This suggests that 12% of the variance in posttest scores is accounted for by the predictors, group and self-efficacy.
The Cohen’s (1992) effect size, $f^2 = \frac{R^2}{1-R^2}$, was calculated to be .13. Using Cohen’s rough guidelines for multiple regression (.02 small, .15 medium, .35 large), the effect size is close to medium. This indicated that the $R^2 = .115$ was of practical significance and explained how statistical significance was achieved even with the small sample size used in this study.

The regression coefficient for self-efficacy was statistically significant ($t = 2.09$, $p = 0.0441$), while the regression coefficient for group was not statistically significant ($t = -0.16$, $p = 0.8764$). The prediction equation was:

$$\text{Posttest} = 51.99 + -0.98(\text{group}) + 0.5664(\text{self-efficacy})$$

This equation shows that if the group and self-efficacy were both zero, then the posttest score would be 51.99. The equation also shows that the posttest score would decrease by .98 if the group is increased by one while self-efficacy remains constant. Additionally, the posttest will increase .57 if the student’s MSEAQ self-efficacy score is increased by one point with the group remains constant.

**Interaction.** As discussed in Chapter 3, a multiple regression was also calculated with an interaction variable. The predictor variables were centered with the product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003). The adjusted $R^2$ was found to be .132, suggesting that about 13% of the variance in the posttest scores was accounted for by the predictor variables group, self-efficacy, and the interaction of
group and self-efficacy. The adjusted $R^2$ increased by .017 from the multiple regression analysis without the interaction variable.

Cohen’s (1992) effect size, $f^2 = R^2/(1-R^2)$, was calculated to be .15 which can be interpreted as a medium effect size using Cohen’s rough guidelines (.02 small, .15 medium, .35 large). This indicated that the results may have some practical significance to mathematics educators.

The regression coefficient for self-efficacy remained statistically significant ($t = 2.04, p = .0492$), the regression coefficient for group remained not significant ($t = 0.14, p = .8926$), and the regression coefficient of the interaction variable was not statistically significant ($t = -.82, p = 0.4163$). The prediction equation was:

$$\text{Posttest} = 51.08 + .43(\text{group}) + .57(\text{self-efficacy}) + -.22(G*S)$$

The strength of the interaction effect was computed by finding the difference between the $R^2$ values with and without the interaction variable in the regression analyses. With an original $R^2$ of 0.115 and the interaction $R^2$ of 0.132, this yields .017, meaning 1.7% of the variance in the posttest scores. To give a better sense of how student achievement changed depending on which web-based program was used was calculated from three different values of the students’ change in self-efficacy: the lowest (ALEKS -11, MyMathLab -14), the mean (ALEKS -0.79, MyMathLab -1.86), and highest (ALEKS 18, and MyMathLab 9). See Figure 4.2.
Figure 4.2 Slopes of how student achievement changed depending on self-efficacy and the web-based program MyMathLab or ALEKS.

As seen in Figure 4.2, ALEKS students scored higher on the posttest with respect to self-efficacy than students using MyMathLab. ALEKS students that increased their self-efficacy throughout the semester had higher student achievement than students who increased their self-efficacy while using MyMathLab. However, the results were not statistically significant.

Results of Hypothesis Testing (RQ3b). The hypothesis for this question was that students using ALEKS will have a greater increase in student achievement with respect to self-efficacy than students using MyMathLab. $H_0$: There will be no interaction between which web-based program is being used and students’ self-efficacy towards mathematics as they relate to student achievement. The results were not statistically significant. Therefore, the results from the multiple regression
analysis with an interaction showed that there is insufficient evidence to support this claim.

**Anxiety Descriptive and Inferential Statistics (RQ3c).** MSEAQ questionnaire (May’s, 2009) was used to measure the students’ anxiety toward mathematics. Three students did not complete the initial questionnaire and were therefore dropped from the sample. An outlier analyses was completed earlier and noted above. The descriptive statistics for the questionnaire are included above in Table 4.7 and 4.8.

**Relationship Between the Variables.** A scatterplot of each variable (posttest, group - MyMathLab vs ALEKS, and anxiety) were examined. After observing the data, no outliers or nonlinear relationships occurred. The correlation coefficient, \( r \), and the probability for each are noted in Table 4.11. As noted earlier, the correlation between group and posttest \( r = .09 \) was not significant \( (p = 0.5771) \). There existed a significant correlation between anxiety and the posttest with \( r = -0.34 \) \( (p = 0.0342) \). Lastly, there was not a significant relationship between group and anxiety with \( r = -0.29 \) \( (p = 0.0762) \).
Table 4.11

Correlations between Posttest, Group, and Anxiety

<table>
<thead>
<tr>
<th></th>
<th>Posttest</th>
<th>Group</th>
<th>Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.0921</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p = .5771</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>-0.3400</td>
<td>-0.2873</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>p = .0342</td>
<td>p = .0762</td>
<td></td>
</tr>
</tbody>
</table>

Multiple Regression. A multiple regression analysis requires a linear relationship between the variables, homoscedasticity (homogeneity of variance), and normal distribution of residuals (predicted minus observed values). As mentioned above, a linear relationship was found between each variable. Homoscedasticity was examined by plotting the residuals with the predicted values. The fit mean line was located at zero meaning the variances were constant among the different values of the predicted posttest and no patterns were found in the data. The distribution of the residuals was also examined for normalcy. After checking the assumptions, it was appropriate to continue with the multiple regression analysis.

Predicting the posttest scores from the predictor variables, group and anxiety using multiple regression gave an $R^2$ of 0.116. This suggests that 12% of the variance in posttest scores is accounted for by the predictors, group and anxiety.
The Cohen’s (1992) effect size, $f^2 = \frac{R^2}{1-R^2}$, was calculated to be .13. Using Cohen’s rough guidelines for multiple regression (.02 small, .15 medium, .35 large), the effect size is close to medium. This indicated that the $R^2 = .116$ was of practical significance and explained how statistical significance was achieved even with the small sample size used in this study.

The regression coefficient for anxiety was statistically significant ($t = -2.09$, $p = 0.0439$), while the regression coefficient for group was not statistically significant ($t = -0.04$, $p = 0.9706$). The prediction equation was:

$$\text{Posttest} = 98.49 + -0.23(\text{group}) + -0.52(\text{anxiety})$$

This equation shows that if the group and anxiety were both zero, then the posttest score would be 98.49. The equation also shows that the posttest score would decrease by .23 if the group is increased by one while anxiety remains constant. Additionally, the posttest will decrease .52 if the student’s MSEAQ anxiety score is increased by one point with the group remains constant.

**Interaction.** As discussed in Chapter 3, a multiple regression was also calculated with an interaction variable. The predictor variables were centered with the product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003). The adjusted $R^2$ was found to be .123, suggesting that about 12% of the variance in the posttest scores was accounted for by the predictor variables group, anxiety, and the interaction of group
and anxiety. The adjusted $R^2$ increased by .007 from the multiple regression analysis without the interaction variable.

Cohen’s (1992) effect size, $f^2 = \frac{R^2}{1-R^2}$, was calculated to be .14 which can be interpreted as a close to medium effect size using Cohen’s rough guidelines (.02 small, .15 medium, .35 large). This indicated that the results may have some practical significance to mathematics educators.

The regression coefficient for anxiety remained statistically significant ($t = -2.10, p = .0430$), the regression coefficient for group remained not significant ($t = 0.05, p = .9593$), and the regression coefficient of the interaction variable was not statistically significant ($t = -.53, p = .5983$). The prediction equation was:

$$
\text{Posttest} = 99.25 + .16(\text{group}) + -.53(\text{anxiety}) + -.13(\text{G*Anx})
$$

The strength of the interaction effect was computed by finding the difference between the $R^2$ values with and without the interaction variable in the regression analyses. With an original $R^2$ of 0.116 and the interaction $R^2$ of 0.123, this yields .007, meaning 0.7% of the variance in the posttest scores. To give a better sense of how student achievement changed depending on which web-based program was used was calculated from three different values of the students’ change in self-efficacy: the lowest (ALEKS -13, MyMathLab -9), the mean (ALEKS 0, MyMathLab 1.29), and highest (ALEKS 19, and MyMathLab 19). See Figure 4.3.
As seen in Figure 4.3, students using ALEKS had higher student achievement with respect to anxiety than students using MyMathLab. ALEKS students that decreased their anxiety throughout the semester had a higher posttest score than students that decreased their anxiety using MyMathLab. However, the difference was not statistically significant.

**Results of Hypothesis Testing (RQ3c).** The hypothesis for this question was that students using ALEKS will have higher achievement with respect to anxiety than students using MyMathLab. $H_0$: There will be no interaction between which web-based program is being used and students’ anxiety towards mathematics as they relate to student achievement. The results from the multiple regression
analysis with an interaction showed that there is insufficient evidence to support this claim.

**Additional Analyses**

**Homework Completion and Group.** In the original analyses, data were examined to test whether simply being in the group of students that used MyMathLab or ALEKS had an effect on student achievement. To take this study a step further, the data were examined to see if students who worked within the programs to complete the homework had an effect on student achievement. Homework completion and groups were examined to see if they had an effect on student achievement. The descriptive statistics for homework completion are shown below in Table 4.12.

**Table 4.12**

*Summary of Means and Standard Deviations for Percent of Homework Completion*

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEKS</td>
<td>22</td>
<td>77.95</td>
<td>24.8</td>
<td>27-100</td>
</tr>
<tr>
<td>MyMathLab</td>
<td>21</td>
<td>91.85</td>
<td>8.2</td>
<td>72-100</td>
</tr>
<tr>
<td>Overall</td>
<td>43</td>
<td>85.08</td>
<td>19.3</td>
<td>27-100</td>
</tr>
</tbody>
</table>

**Relationship Between the Variables.** A scatterplot of each variable (posttest, group - MyMathLab vs ALEKS, and homework completion) were
examined. After observing the data, 6 outliers were found and removed. The correlation coefficient, $r$, and the probability for each are noted in Table 4.13. As noted earlier, the correlation between group and posttest $r = .09$ was not significant ($p = 0.5771$). There existed a strong, significant correlation between homework and the posttest with $r = 0.73$ ($p < .0001$). There was a significant relationship between group and homework with $r = 0.36$ ($p = 0.0227$).

**Table 4.13**

*Correlations between Posttest, Group, and Homework*

<table>
<thead>
<tr>
<th></th>
<th>Posttest</th>
<th>Group</th>
<th>Homework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.0921</td>
<td>1.0</td>
<td>0.3641</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$p = .5771$</td>
<td>$p = .0227$</td>
</tr>
<tr>
<td>Homework</td>
<td>0.7284</td>
<td>0.3641</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>$p &lt; .0001$</td>
<td></td>
<td>$p = .0227$</td>
</tr>
</tbody>
</table>

**Multiple Regression.** A multiple regression analysis requires a linear relationship between the variables, homoscedascity (homogeneity of variance), and normal distribution of residuals (predicted minus observed values). A linear relationship was found between each variable. Homoscedasticity was examined by plotting the residuals with the predicted values. The fit mean line was located at zero meaning the variances were constant among the different values of the predicted posttest and no patterns were found in the data. The distribution of the
residuals was also examined for normalcy. After checking the assumptions, it was appropriate to continue with the multiple regression analysis.

Predicting the posttest scores from the predictor variables, group and homework completion using multiple regression gave an $R^2$ of 0.565. This suggests that 56.5% of the variance in posttest scores is accounted for by the predictors, group and homework completion.

The Cohen’s (1992) effect size, $f^2 = R^2/(1-R^2)$, was calculated to be 1.30. Using Cohen’s rough guidelines for multiple regression (.02 small, .15 medium, .35 large), the effect size was large. This indicated that the $R^2 = .565$ was of practical significance and explained how statistical significance was achieved even with the small sample size used in this study.

The regression coefficient for homework was statistically significant ($t = 6.79$, $p < .0001$). The regression coefficient for group was not statistically significant ($t = 1.69$, $p = 0.0995$). The prediction equation was:

$$\text{Posttest} = 9.9 + 3.74(\text{group}) + 0.79(\text{homework completion})$$

This equation shows that if the group and homework completion were both zero, then the posttest score would be 9.9. The equation also shows that the posttest score would increase by 3.74 if the group is increased by one while homework completion remains constant. Additionally, the posttest will increase 0.79 if the student’s homework completion is increased by one point while the group remains constant.
**Interaction.** A multiple regression was also calculated with an interaction variable. The predictor variables were centered with the product of the two variables as a third variable in order to analyze the interaction between the two (Jaccard & Turrisi, 2003). The adjusted R$^2$ was found to be .592, suggesting that about 59.2% of the variance in the posttest scores was accounted for by the predictor variables group, homework completion, and the interaction of group and homework completion. The adjusted R$^2$ increased by .027 from the multiple regression analysis without the interaction variable.

Cohen’s (1992) effect size, $f^2 = R^2/(1-R^2)$, was calculated to be 1.45 which can be interpreted as a large effect size using Cohen’s rough guidelines (.02 small, .15 medium, .35 large). This indicated that the results may have some practical significance to mathematics educators.

The regression coefficient for homework completion remained statistically significant ($t = 5.43, p < .0001$), the regression coefficient for group was significant ($t = 2.20, p = .0342$), and the regression coefficient of the interaction variable was not statistically significant ($t = -1.53, p = 0.1340$). The prediction equation was:

$$\text{Posttest} = -11.31 + 5.26\text{ (group)} + 1.01\text{ (homework completion)} + -.13\text{ (G*H)}$$

The strength of the interaction effect was computed by finding the difference between the R$^2$ values with and without the interaction variable in the
regression analyses. With an original R² of 0.565 and the interaction R² of 0.592, this yields .027, meaning 2.7% of the variance in the posttest scores.

*Figure 4.4* Slopes of how student achievement changed depending on homework completion and the web-based program MyMathLab or ALEKS.

As seen in Figure 4.4, students that completed the homework scored higher on the posttest. The results from the multiple regression analysis with an interaction showed that students who complete their work in ALEKS are more likely to score higher on the posttest than students that complete their work in MyMathLab.

**Pretest, Homework Completion, and Group.** Additionally, the pretest scores, homework completion, and groups were examined to see if they had an effect on student achievement. The descriptive statistics for pretest scores are shown in Table 4.1 and homework completion are shown in Table 4.12.
Relationship Between the Variables. A scatterplot of each variable (posttest, pretest, group - MyMathLab vs ALEKS, and homework completion) were examined. After observing the data, 6 outliers were found and removed. The correlation coefficient, \( r \), and the probability for each are noted in Table 4.14. As noted earlier, the correlation between group and posttest \( r = .09 \) was not significant \( (p = 0.5771) \), the correlation between homework and the posttest was significant with \( r = 0.73 \) \( (p < .0001) \), and the relationship between group and homework was not significant with \( r = 0.36 \) \( (p = 0.0227) \). The correlation between group and pretest was not significant with \( r = -0.06 \) \( (p = 0.7291) \). The correlation between pretest and homework was also not significant with \( r = 0.25 \) \( (p = 0.1220) \) There was a significant relationship between the pretest and posttest with \( r = 0.43 \) \( (p = 0.0063) \).
Table 4.14

Correlations between Posttest, Group, Homework, and Pretest

<table>
<thead>
<tr>
<th></th>
<th>Posttest</th>
<th>Group</th>
<th>Homework</th>
<th>Pretest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posttest</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>0.0921</td>
<td>1.0</td>
<td></td>
<td>p = 0.5771</td>
</tr>
<tr>
<td>Homework</td>
<td>0.7284</td>
<td>0.3641</td>
<td>1.0</td>
<td>p &lt; 0.0001 p = 0.0227</td>
</tr>
<tr>
<td>Pretest</td>
<td>0.4302</td>
<td>-0.0573</td>
<td>0.2518</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>p = 0.0063 p = 0.7291 p = 0.1220</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Multiple Regression. A multiple regression analysis requires a linear relationship between the variables, homoscedascity (homogeneity of variance), and normal distribution of residuals (predicted minus observed values). A linear relationship was found between each variable. Homoscedasticity was examined by plotting the residuals with the predicted values. The fit mean line was located at zero meaning the variances were constant among the different values of the predicted posttest and no patterns were found in the data. The distribution of the residuals was also examined for normalcy. After checking the assumptions, it was appropriate to continue with the multiple regression analysis.

Predicting the posttest scores from the predictor variables, pretest, group, and homework completion using multiple regression gave an R² of 0.617. This
suggests that 61.7% of the variance in posttest scores is accounted for by the predictors, pretest, group, and homework completion.

The Cohen’s (1992) effect size, \[ f^2 = \frac{R^2}{1-R^2} \], was calculated to be 1.61. Using Cohen’s rough guidelines for multiple regression (.02 small, .15 medium, .35 large), the effect size was large. This indicated that the \( R^2 = .617 \) was of practical significance and explained how statistical significance was achieved even with the small sample size used in this study.

The regression coefficient for homework was statistically significant (\( t = 6.18, \ p < .0001 \)). The regression coefficient for group was not statistically significant (\( t = -1.39, \ p = 0.1725 \)). For pretest, the regression coefficient was statistically significant (\( t = 2.17, \ p = 0.0366 \)). The prediction equation was:

\[
\text{Posttest} = 3.86 + 0.33(\text{pretest}) - 5.95(\text{group}) + 0.71(\text{hwk completion})
\]

This equation shows that if the pretest, group, and homework completion were both zero, then the posttest score would be 3.86. The equation also shows that the posttest score would increase by 0.33 if the pretest is increased by one while group and homework completion remain constant. The equation also shows that the posttest score would decrease by 5.95 if the group is increased by one while pretest and homework completion remain constant. Additionally, the posttest will increase 0.71 if the student’s homework completion is increased by one point while the pretest and group remain constant.
Figure 4.5 Slopes of how student achievement changed depending on homework completion, pretest scores, and which web-based program was used, MyMathLab or ALEKS.

As seen in Figure 4.5, students who had a lower homework score and pretest score in the ALEKS group had a lower achievement score than those in the MyMathLab group. Students in the ALEKS group that scored higher on the homework and pretest scored higher on the posttest than students in the MyMathLab group.
Chapter 5
Conclusions, Implications, and Recommendations

Introduction

The purpose of this study was to determine the relationship each of the mathematics web-based programs, MyMathLab and Assessments and Learning in Knowledge Spaces (ALEKS), had with students’ mathematics achievement. In addition, the study examined the relationship between students’ affective domain and the type of software used as well as student achievement. The affective domain measures were students’ anxiety, self-efficacy, and attitudes towards mathematics. For the purpose of this study, mathematics achievement was defined as students’ intermediate algebra end-of-course comprehensive final exam score. This chapter summarizes and discusses the findings of the study, the limitations, and the implications for research and education.

Summary of Findings

Effect on Student Achievement (RQ1). To determine if there was a significant difference between using one of the web-based programs, MyMathLab or ALEKS, to student achievement, a pretest and a posttest were assessed. When testing for a significant difference in the posttest scores, the pretest was used to control for preexisting knowledge. These results showed that there was not a significant difference in pretest posttest scores whether using MyMathLab or ALEKS. The mean scores of each group differed by less than a point.
White (2006) and Vezmar (2011) both found that there was a significant effect on final exam scores with the utilization of learning resources. MyMathLab and ALEKS both saw an increase in exam scores; however, the difference between the two groups was not significant. As mentioned in Chapter 2, Oshima (2010) integrated ALEKS into one college algebra course and MyMathLab into another. Similar to this study, the sample size was small, and there was no statistically significant difference between the two groups. Taylor (2008), compared ALEKS to a traditional course and also did not find a statistically significant difference. Two other studies found no significant difference when comparing ALEKS to a traditional classroom; however, both found a significant difference when accounting for the amount the students used the program. This was the case for Stillson & Alsup (2003) as well as Carpentar (2006) who compared a group of students who used ALEKS to a group of students that completed a traditional course. Both studies found that students who actually completed the work using ALEKS showed a greater increase in student achievement than students in the traditional classroom.

Possible reasons for the lack of significance could be because there is actually no difference in the programs when measuring for student achievement, because the sample size was too small to determine a significance, or possibly because simply being placed in a course using MyMathLab verse being placed in a course using ALEKS does not affect student achievement. As seen in the additional
analysis later in this study and the research completed by Stillson & Alsup (2003) and Carpentar (2006), when accounting for the amount that students actually use the program, there is a significant difference in student achievement. Also, as noted above, White (2006) and Vezmar (2011) both found that there is a significant effect on final exam scores with the utilization of learning resources. Utilization being the key issue that may explain the lack of effect on student achievement.

**Effect on Affective Domain (RQ2).** The next research question was “is there a significant difference between using one of the web-based programs and students’ affective domain?” This question was broken into the domains of (a) attitudes, (b) self-efficacy, and (c) anxiety. As discussed in Chapter 4, there was not a significant difference between using one of the web-based programs and students’ affective domain.

**Effect on Attitude (RQ2a).** For the first part of this question, it was researched to see if there is a significant difference between using one of the web-based programs and students’ attitude. Students completed the questionnaire at the beginning of the semester and again at the end of the semester. Although it was not significant, both group means decreased. MyMathLab ATMI mean score decreased 6 points while ALEKS mean score decreased 4.16 points.

Vezmar (2011) stated a significant increase in attitudes for students using technology verse students in a traditional classroom. The assessment theory discussed in Chapter 2 explains that self-efficacy, attitude, and motivation increase
when students experience an increase in achievement. While the current study compared two web-based programs, there was no significant difference in achievement or attitude. When comparing students’ attitude towards mathematics at the beginning of the semester to their attitude toward mathematics at the end of the semester, there was a decrease. A possible reason for the decrease in students’ attitudes is possibly because of the timing. The initial questionnaire was given at the beginning of the semester when possibly students were starting the semester with a positive attitude and ready to take on the course. The final questionnaire was given at the end of the semester right before the students completed their final exams. This was during a time that students were possibly stressed about doing well on the final exam and possibly additional stress caused by their upcoming final exams in each of their other courses. Another possible explanation for the lack of significance could be due to the research question not taking into consideration which students are using the program. For example, there might be students who were in the ALEKS group or were in the MyMathLab group that completed little to no work in the program and experienced little to no achievement and possibly decreased their attitude towards mathematics. Simply placing a student in a classroom using a certain program may not affect their achievement or attitude, but if they actually used the program, the student might have increased their knowledge and therefore increased their achievement and possibly their attitude towards the
subject. As Vezmar found, students that used the technology had a higher increase in attitudes than students in a traditional classroom.

**Effect on Self-Efficacy (RQ2b).** For the second part of this question, it was researched to see if there was a significant difference between using one of the web-based programs and students’ self-efficacy. Students completed the questionnaire at the beginning of the semester and again at the end of the semester. Although it was not significant, both group means decreased. MyMathLab ATMI mean score decreased 1.86 points while ALEKS mean score decreased .79 points.

Hagerty, Smith, & Goodwin (2010) reported an increase in self-efficacy. While the current study compared two web-based programs (MyMathLab and ALEKS), Hagerty, Smith, & Goodwin (2010) compared ALEKS to a traditional classroom. As Chapter 2 discussed, self-efficacy can increase when students experience mastery accomplishments. A possible reason for the decrease in students’ self-efficacy from the beginning of the semester to the end of the semester, again, is possibly because of the timing. The initial questionnaire was given at the beginning of the semester when possibly students were starting the semester with strong self-efficacy and ready for the challenges of completing the course. The final questionnaire was given at the end of the semester right before the students completed their final exams. This is during a time that students are possibly stressed about doing well on the final exam which possibly effected the
students’ self-efficacy. As Bandura (1986) explained, self-efficacy is built and/or destroyed through performance accomplishments.

**Effect on Anxiety (RQ2c).** For the third part of this question, data was collected to answer the question “is there a significant difference between using one of the web-based programs and students’ anxiety?” Students completed the questionnaire at the beginning of the semester and again at the end of the semester. Anxiety seemed to increase for MyMathLab students, although it was not statistically significant. ALEKS students’ anxiety scores neither increased nor decreased.

Again, the assessment theory discussed in Chapter 2 explains that self-efficacy, attitude, and motivation increase when students experience an increase in achievement. A possible reason for the increase in anxiety for the MyMathLab students from the beginning of the semester to the end of the semester, again, is possibly because of the timing. The initial questionnaire was completed when students were starting the course with a healthy level of anxiety as they were exited to begin the semester. The final questionnaire was given at the end of the class right before the students completed their final exams. This is during a time that students are possibly stressed about doing well on the final exam. If the questionnaires were administered after the posttest, it is possible that the scores could have been significantly different between the two groups.
Effect of Affective Domain Relating to Student Achievement (RQ3).
The last research question asked “what is the interaction between using one of the web-based programs and students’ affective domain as they relate to student achievement?” This question was broken into the domains of (a) attitudes, (b) self-efficacy, and (c) anxiety. As discussed in Chapter 4, there is insufficient evidence to support the claim that students using ALEKS will have a greater increase in their affective domain with respect to student achievement than students using MyMathLab.

Effect of Attitude Relating to Student Achievement (RQ3a). This research question asked “what is the interaction between using one of the web-based programs and students’ attitude as they relate to student achievement?” Students completed the questionnaire at the beginning of the semester and again at the end of the semester. Students’ attitude towards mathematics decreased for MyMathLab and ALEKS students, although it was not statistically significant. A possible reason for the decrease in attitudes for the MyMathLab students from the beginning of the semester to the end of the semester is possibly because of the timing. The first questionnaire was completed when students were starting the course. At this time, students may have had a higher attitude with a positive outlook on the semester. The final questionnaire was given at the end of the class right before the students completed their final exams. This is during a time that students are possibly stressed about doing well on the final exam which decreased their attitude towards
the subject. There was greater student achievement for students with higher attitudes towards mathematics in the ALEKS group than students with higher attitudes in the MyMathLab group. However, as discussed in Chapter 4, it was not a significant difference. If the questionnaires were administered after the posttest, it is possible that the scores between the two groups would have been significantly different.

**Effect of Self-Efficacy Relating to Student Achievement (RQ3b).** This research question asked “what is the interaction between using one of the web-based programs and students’ self-efficacy as they relate to student achievement?”

This study showed an average decrease in self-efficacy for both groups. A possible reason for the decrease in students’ self-efficacy from the beginning of the semester to the end of the semester is possibly because of the timing of the measurements. Again, the initial questionnaire was given at the beginning of the semester when possibly students were starting the semester with a higher self-efficacy and ready to complete the course. The final questionnaire was given at the end of the semester right before the students completed their final exams. This is during a time that students are possibly stressed about doing well on the final exam and even possibly stressed about doing well on their other courses as well. As Bandura (1986) explained, self-efficacy is built and/or destroyed through performance accomplishments. Chapter 2 discussed that self-efficacy can increase when students experience mastery accomplishments. The assessment theory
discussed in Chapter 2 explains that self-efficacy, attitude, and motivation increase when students experience an increase in achievement. As theory shows, the scores on the self-efficacy questionnaire may have been different if the students completed the questionnaire after completing the final exam. Because the questionnaires were administered before the final exam, self-efficacy and which web-based program was used may have actually had an effect on student achievement. As seen in Figure 4.2, students that scored higher on the posttest saw a larger increase in self-efficacy than students who used MyMathLab. However, the difference between the two groups was not statistically significant.

**Effect of Anxiety Relating to Student Achievement (RQ3c).** The third part of this research question asked “what is the interaction between using one of the web-based programs and students’ anxiety as they relate to student achievement?” Students completed the questionnaire at the beginning of the semester and again at the end of the semester. Anxiety seemed to increase for MyMathLab students, although it was not statistically significant. A possible reason for the increase in anxiety for the MyMathLab students from the beginning of the semester to the end of the semester, again, is possibly because of the timing. The initial questionnaire was completed when students were starting the course with a healthy level of anxiety as they were possibly exited to begin the semester. The final questionnaire was given at the end of the class right before the students completed their final exams. This is during a time that students are possibly stressed about doing well on
the final exam and have higher anxiety. The average ALEKS students’ anxiety scores neither increased nor decreased. There was higher student achievement for students with lower anxiety in the ALEKS group than students with lower anxiety in the MyMathLab group. However, as discussed in Chapter 4, it was not a significant difference. If the questionnaires were administered after the posttest, it is possible that the scores between the two groups would have been significantly different.

**Additional Analysis.** Results of this study were not consistent with Stillson & Alsup (2003) or Carpenter (2006) who found that students that use the programs will have higher achievement. For this reason, additional analysis was completed to account for the extent of which students used the web-based program. Homework completion was added as a variable to see if students who completed the assignments in the web-based program had higher achievement in one group versus the other. Additionally, a multiple regression equation was created as a prediction equation of the posttest scores using the pretest, homework completion, and group.

**Homework Completion and Group.** As stated in prior research (Stillson & Alsup, 2003; Carpenter, 2006), students who use the web-based program have higher achievement than students in a traditional classroom. For this study, students that completed the work in ALEKS had higher achievement than students who completed the homework in MyMathLab
**Pretest, Homework Completion, and Group.** The additional analysis found that the pretest, the amount of homework completed, and which web-based program was used are predictive of the posttest score. Students who completed the work in the web-based program ALEKS and had a higher pretest score, had higher achievement than students who had a higher pretest score and completed the work in MyMathLab.

**Limitations**

**Course curriculum.** MAT 1033 Intermediate Algebra is a common course offered throughout Florida’s colleges and the curriculum is well-defined. As a result, a similar study using a different curriculum may not yield the same results. For example, if a similar study is completed in college algebra, the results may differ from the current study.

**Instructional schedule.** For this study, the class met two days per week during a 16-week semester. Some courses may meet one or 3 days a week and the course might be offered during a 10-week or 12-week semester. As a result, similar studies involving a different instructional schedule might yield different results. For example, a course may include lab hours where the students are required to work inside the web-based program. This would increase the student usage of the program which could significantly affect the results of the study.

**Sample demographics.** The demographics of the sample are listed in Chapter 3. Similar studies with different demographics may not yield the same results. For
example, if the students in a similar study have a much larger average age or much lower average age, this could possibly change the results of the study.

**Course prerequisites.** During this study, a group of students were able to enter the course without the requirement of taking a common placement test or to enroll in developmental education courses. By Florida legislature SB 1720, this group includes “students who entered ninth grade in a Florida public school in 2003-2004 or thereafter and who earned a standard Florida High School diploma; or students who are serving as active duty members of the United States Armed Services” (Florida Senate, 2013). If a similar study has different prerequisite requirements, the study may yield different results.

**Delimitations**

**Campus location.** The current study was conducted at Eastern Florida State College at the Palm Bay campus. If this study is conducted at a different location, the results may differ. For example, if the study were conducted in a different geographical location like a different state, different community, etc. then the results may differ from the current study.

**Participating instructors.** This study was implemented using a single instructor who was also the researcher. Similar studies that employ different instructors may not yield the same results. For example, if the study was completed with a different instructor or multiple instructors, the results may vary. Instructors
may teach in a way that is more similar to ALEKS or more similar to MyMathLab which could affect the results of the study.

**Semester.** This study was conducted during the spring semester. The characteristics of students during the fall and spring semester may differ. For example, the fall semester may include mainly freshmen whereas the students in the spring semester may include more sophomores, juniors, and seniors. As a result, studies conducted during a different semester may yield different results.

**Student achievement.** For this study, student achievement was measured using a comprehensive final exam created by the EFSC Palm Bay mathematics faculty. Similar studies that use a different instrument to assess student achievement may yield different results.

**Implications**

**Implications for Research.** After concluding this research, there are many more questions that need to be answered. Future research can help add to the current body of knowledge created by this research and others before it. The following contains implications for possible future research.

The current study focused on the use of MyMathLab and ALEKS in the intermediate algebra course. Future research should investigate the difference between the two web-based programs in other mathematics courses. This would be helpful in order to determine if there is one course better suited for the use of the web-based programs. For example, MyMathLab may increase student achievement
more for calculus students but ALEKS may increase student achievement more for college algebra students. Again, this is something that should be researched.

The current study had a small sample size. This study should be conducted with a larger sample size which will increase the likelihood that a more diverse sample will have more variability among different groups.

Future research should conduct the study at more than one campus location. This could possibly increase the sample size and the variability among the group. Having a larger sample size will increase the reliability, validity, as well as the generalizability of the results.

In the current study, both MyMathLab and ALEKS group means decreased for the attitude (ATMI) and self-efficacy (MSEAQ self-efficacy). Future research should investigate the decrease in the student’s attitude and self-efficacy. As mentioned earlier, this may be due to the timing of the questionnaires. Research should be completed with the questionnaires administered before the final exam and compare the results to a sample where the questionnaires were administered after the final exam. This research may show that students’ attitude and self-efficacy decrease when the questionnaire is administered before the final exam where the attitudes and self-efficacy may increase when the questionnaire is administered after the final exam. Again, this should be researched.

MyMathLab released the option for instructors to create a course based on mastery. The current study used the original version of MyMathLab. The mastery
feature allows instructors to create assignments based on what the students have not mastered. Future research should investigate and compare ALEKS, originally mastery based, to the released MyMathLab mastery option.

**Implications for Education.** In addition to recommendations for future research, implications of this study also permit recommendations for educational practice. First, the current study found that attitudes and self-efficacy decreased through the semester for both groups. This is something instructors should be aware of and work to increase student’s attitudes and self-efficacy by increasing the ability for students to experience achievement.

A second implication from the results of this study deals with usage of the web-based program. This study found that students who complete their work within the program increase achievement. Simply placing a student in a course using a certain resource is not enough. Teachers and students should be aware of the importance of practicing and completing the assignments in order to learn the material and perform well on exams.

This study also found that completing the work within the web-based was more beneficial for students using ALEKS than it was for students using MyMathLab. Students using ALEKS with higher attitudes, higher self-efficacy, lower anxiety, and completed the assignments within program had higher student achievement than students using MyMathLab. This should be considered when a teacher is deciding between the two programs.
Summary

Results from this study indicate that students’ attitude, self-efficacy, anxiety, which web-based programs is used in the course have an effect on student achievement. Students that completed their work in ALEKS had higher attitudes, higher self-efficacy, lower anxiety, and higher student achievement than students that complete their work in MyMathLab. Additional studies are needed to determine whether or not this holds true in other mathematics courses, other colleges, with larger sample sizes and other instructors. When deciding which web-based program to use in a mathematics course, instructors should be aware of the possible effects. Future studies should explore the effects of other web-based programs as well.
References


http://faculty.ccri.edu/joallen/Research/Perkins%20Report%202007.htm


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Nwaogu, E. (2012). The effect of ALEKS on students' mathematics achievement in an online learning environment and the cognitive complexity of the initial and final assessments.


Turney, A. H. (1931). The effect of frequent short objective tests upon the achievement of college students in educational psychology. *School and Society, 33*, 760-762.


Appendix A: Affective Domain Questionnaire
Section 1: Mathematics Self Efficacy and Anxiety Questionnaire

This inventory consists of statements about your self-efficacy and anxiety towards mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item and circle your response.

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>Never</th>
<th>Seldom</th>
<th>Sometimes</th>
<th>Often</th>
<th>Usually</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I feel confident enough to ask questions in my mathematics class.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>I get tense when I prepare for a mathematics test.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>I get nervous when I have to use mathematics outside of school.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>I believe I can do well on a mathematics test.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>I worry that I will not be able to use mathematics in my future career when needed.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>I worry that I will not be able to get a good grade in my mathematics course.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>I believe I can complete all of the assignments in a mathematics course.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>I worry that I will not be able to do well on mathematics tests.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>I believe I am the kind of person who is good at mathematics.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>I believe I will be able to use mathematics in my future career when needed.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>I feel stressed when listening to mathematics instructors in class.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>I believe I can understand the content in a mathematics course.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>I believe I can get an &quot;A&quot; when I am in a mathematics course.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>I get nervous when asking questions in class.</td>
<td>NR</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
### Section 2:
#### Attitudes Toward Mathematics Inventory

This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Please indicate the degree to which you agree or disagree with each given statement by circling SD, D, N, A, or SA. The number you circle should correspond to the following scale:

<table>
<thead>
<tr>
<th>Strongly Disagree (SD)</th>
<th>Disagree (D)</th>
<th>Neutral (N)</th>
<th>Agree (A)</th>
<th>Strongly Agree (SA)</th>
</tr>
</thead>
</table>

1. Mathematics is a very worthwhile and necessary subject.  
   - SD D N A SA
2. I want to develop my mathematical skills.  
   - SD D N A SA
3. I get a great deal of satisfaction out of solving a mathematics problem.  
   - SD D N A SA
4. Mathematics helps develop the mind and teaches a person to think.  
   - SD D N A SA
5. Mathematics is important to everyday life.  
   - SD D N A SA
6. Mathematics is one of the most important subjects for people to study.  
   - SD D N A SA
7. College level math courses would be very helpful no matter what I decide to study.  
   - SD D N A SA
8. I can think of many ways that I use math outside of school.  
   - SD D N A SA
9. Mathematics is one of my most dreaded subjects.  
   - SD D N A SA
10. My mind goes blank and I am unable to think clearly when working with mathematics.  
    - SD D N A SA
11. Studying mathematics makes me feel nervous.  
    - SD D N A SA
12. Mathematics makes me feel uncomfortable.  
    - SD D N A SA
13. I am always under a terrible strain in a math class.  
    - SD D N A SA
14. When I hear the word mathematics, I have a feeling of dislike.  
    - SD D N A SA
15. It makes me nervous to even think about having to do a mathematics problem.  
    - SD D N A SA
16. Mathematics does not scare me at all.  
    - SD D N A SA
17. I have a lot of self-confidence when it comes to mathematics.  
    - SD D N A SA
18. I am able to solve mathematics problems without too much difficulty.  
    - SD D N A SA
19. I expect to do fairly well in my mathematics class.  
    - SD D N A SA
20. I am always confused in my mathematics class.  
    - SD D N A SA
21. I feel a sense of insecurity when attempting mathematics.  
    - SD D N A SA
22. I learn mathematics easily.  
    - SD D N A SA
23. I am confident that I could learn advanced mathematics.  
    - SD D N A SA
24. I have usually enjoyed studying mathematics in school.  
    - SD D N A SA

---

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Section 3:

Demographic Information

Please respond to the following items:

1. Gender (circle one): Female Male

2. Current age: 

3. Race/Ethnicity (circle one):
   White   Black   Hispanic   Asian   Other

4. Grade level status (circle one):
   Freshman   Sophomore   Junior   Senior   Dual Enrolled

5. Number of hours you currently work per week outside of college: 

6. Number of mathematics courses you took in high school: 

7. Number of mathematics courses you completed in college (do not include semester): 

8. College major or probable college major (if undecided, please state so): 

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Appendix B: MAT 1033 Pretest and Comprehensive Final Exam
Evaluate the expression for the given replacement values.

1) \( \frac{8x - 7y}{7} \) when \( x = 10, y = 5 \)

A) \( \frac{73}{7} \) B) \( \frac{30}{7} \) C) \( \frac{45}{7} \) D) \( \frac{315}{7} \)

Simplify the expression. (Remember the order of operations.)

2) \( 8 - (-6) \times (-20) \)

A) 6 B) -6 C) 22 D) -18

Add.

3) \( (33 + (-53)) + (-10) \)

A) 56 B) -56 C) 0 D) 30

Use the order of operations to simplify the expression.

4) \( \frac{2^{3/2} \left( \frac{1}{2} - \frac{1}{6} \right)}{3} \)

A) \( \frac{4}{3} \) B) \( \frac{8}{9} \) C) \( \frac{2}{9} \) D) \( \frac{5}{9} \)

Simplify the expression.

5) \( 14 + (5 \times 20) \times 5 \)

A) 18 B) 33 C) 21 D) 22
MAT 0028 FINAL EXAM

Evaluate the expression.

6) \( 22 - [7 - (6 - 9)] + (1 - 3)^3 \)
   A) -20  B) 26
   C) 4  D) 20

7) Identify the property illustrated by the statement.
   7) \( 9 \times (15 + 17) = (9 + 15) \times 17 \)
       identity element for addition
       B) commutative property of addition
       C) distributive property
       D) associative property of addition

8) Solve the equation.
   8) \(-8x + 5(3x - 6) = -21 - 2x\)
      A) -1  B) \(-\frac{17}{3}\)
      C) 1  D) \(-\frac{51}{3}\)

9) \(\frac{3}{2}x + \frac{1}{3} - \frac{7}{5}x\)
   A) -16  B) 2
   C) 16  D) -2

10) Solve.
   10) You have taken up gardening for relaxation and have decided to fence in your new rectangular shaped masterpiece. The length of the garden is 2 meters and 46 meters of fencing is required to completely enclose it. What is the width of the garden?
       A) 21 m  B) 23 m
       C) 92 m  D) 42 m

A-2

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The circle graph below shows the number of pizzas consumed by college students in a typical month. Use the graph to answer the question.

11) If State University has approximately 26,000 students, about how many would you expect to consume 5-6 pizzas in a typical month?
   A) 8840 students   B) 4680 students   C) 884 students   D) 468 students

12) Solve the equation for the indicated variable.
    \( P = 3L + 2W \)
    A) \( L = \frac{P - 2W}{3} \)   B) \( L = \frac{P - W}{2} \)   C) \( L = \frac{P - 2W}{2} \)   D) \( L = \frac{P - 2W}{3} \)

13) Solve the inequality.
    \( 20x + 45 \geq 5(3x + 18) \)
    A) \( x \geq 9 \)   B) \( x \leq 9 \)   C) \( x > 9 \)   D) \( x < 9 \)
14) 9x ≤ 4 - 3x < 10 + 4x ≤ 8

A) \{x \mid x > 11\}

B) \{x \mid x < 7\}

C) \{x \mid x < 11\}

D) \{x \mid x > 7\}

15) \frac{m^6}{m^7} = m^{-4} \cdot m

A) m^{-6}

B) \frac{1}{m^{18}}

C) m^{16}

D) \frac{1}{m^{16}}

16) (5x^2)(x^3)

A) 15x^6

B) 8x^7

C) 9x^6

D) 11x^7

17) \frac{8x^5}{11x^7} \cdot \frac{1}{x^3}

A) \frac{5x^5}{11}

B) \frac{8x^5}{11}

C) \frac{8}{11x^8}

D) \frac{8}{11x^8}

18) A mountain's peak is 26,800 feet above sea level.

A) 2.68 \times 10^{-5}

B) 2.68 \times 10^5

C) 2.68 \times 10^4

D) 2.68 \times 10^6

A-4
MAT 0028 FINAL EXAM

Complete the table for the polynomial.

19) \(10x^2 + 3x + 13\)

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10x^2)</td>
<td>?</td>
</tr>
<tr>
<td>(3x)</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>(10x^2)</td>
<td>2</td>
</tr>
<tr>
<td>(3x)</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
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</tbody>
</table>

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<tr>
<td>(3x)</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
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</tr>
<tr>
<td>(3x)</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Find the degree of the following polynomial and determine whether it is a monomial, binomial, trinomial, or none of these.

20) \(-13x^5 - 2\)

A) 6; binomial  B) -13; monomial  C) 5; binomial  D) 0; binomial

Multiply.

21) \(4x(-9x - 2)\)

A) \(-36x^2 - 2x\)  B) \(-9x^2 - 8x\)  C) \(-44x^2\)  D) \(-36x^2 - 8x\)

22) \((w - 6)^2\)

A) \(w + 36\)  B) \(36w^2 - 12w + 36\)  C) \(w^2 - 12w + 36\)  D) \(w^2 + 36\)

Multiply using the FOIL method.

23) \((5x - 11)(5x + 2)\)

A) \(8x^2 - 23x - 22\)  B) \(8x^2 - 22x - 23\)  C) \(15x^2 - 23x - 22\)  D) \(15x^2 - 23x - 22\)

Perform the division.

24) \(\frac{10x^{10} - 35x^6}{5x^2}\)

A) \(-5x^4\)  B) \(10x^{10} - 7x^4\)  C) \(2x^8 - 35x^6\)  D) \(2x^8 - 7x^4\)  A-5

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Factor the polynomial completely. If the polynomial cannot be factored, write "prime."

25) \( xy^2 + 6y^2 - 9x - 54 \)
   - A) \((x + 6)(y^2 - 9)\)
   - B) \((x + 6)(y - 3)^2\)
   - C) \((x - 6)(y + 3)(y - 3)\)
   - D) \((x + 6)(y + 3)(y - 3)\)

Simplify the expression.

26) \( \frac{5x^2 + 15x - 3}{12x - 36x^2} \)
   - A) \( \frac{5x + 15x^3}{12x + 36} \)
   - B) \( \frac{5x}{12} \)
   - C) \( \frac{5}{12} \)
   - D) \( \frac{5x^2 + 15x^3}{12x + 36x^2} \)

27) \( \frac{y^2 + 9y + 20}{y^2 + 10y + 25} \)
   - A) \( \frac{y + 20}{10y + 25} \)
   - B) \( \frac{y^2 + 9y + 20}{y^2 + 10y + 25} \)
   - C) \( \frac{9y + 4}{10y + 5} \)
   - D) \( \frac{y + 4}{y + 3} \)

Find the quotient and simplify.

28) \( \frac{x^2 - 10x + 25}{7x - 35} \)
   - A) \( \frac{(x - 5)^2}{49} \)
   - B) \( 28 \)
   - C) \( 1 \)
   - D) \( \frac{x^2 - 10x + 25}{(x - 5)^2} \)

A-6

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Solve the equation.

29) \( x^2 - x = 30 \)
A) 5, 6
B) -5, -6
C) -5, 6
D) 1, 30

Convert as indicated. Express your answer as a mixed number.

30) 31 inches = _____ feet
A) \( 4 \frac{1}{4} \)
B) \( 6 \frac{3}{4} \)
C) \( 5 \frac{2}{5} \)
D) \( 3 \frac{9}{16} \)

Perform the indicated operation. Simplify if possible.

31) \( \frac{x^2 - 7x + 10}{x - 2} \)
A) \( x - 2 \)
B) \( x + 5 \)
C) \( x + 2 \)
D) \( x = 5 \)

32) \( \frac{28}{4x} - \frac{54}{9x} \)
A) \( \frac{12}{2x} \)
B) \( \frac{13}{x} \)
C) \( \frac{468}{36x} \)
D) \( \frac{33}{x^2} \)

33) \( \frac{\frac{3}{x} - \frac{4}{x^2}}{\frac{4x - 3}{x}} \)
A) \( \frac{3x + 4}{x^2} \)
B) \( \frac{4x - 3}{x} \)
C) \( \frac{3 - 4x}{x^2} \)
D) \( \frac{3 + 4x}{x^2} \)

A-7
34) The ratio of a basketball player's completed free throws to attempted free throws is 5 to 6. If she completed 20 free throws, find how many free throws she attempted. Round to the nearest whole number if necessary.
   A) 5 free throws   B) 24 free throws   C) 4 free throws   D) 17 free throws

36) Find the root. Assume that all variables represent positive numbers.
   \( \sqrt[5]{64x^{10}} \)
   A) 64x^5   B) 8x^5   C) x^2\sqrt{x}   D) 8x^{10}

36) Add or subtract by first simplifying each radical and then combining any like radicals. Assume that all variables represent positive numbers.
   \( 6\sqrt{5} + 2\sqrt{20} \)
   A) 10\sqrt{5}   B) 8\sqrt{5}   C) -10\sqrt{5}   D) -2\sqrt{5}

37) Multiply and simplify. Assume that all variables represent positive real numbers.
   \( \sqrt[3]{2} \times \sqrt[3]{6} \)
   A) 2\sqrt[3]{3}   B) 2\sqrt[3]{6}   C) 6\sqrt[3]{3}   D) 2\sqrt[3]{6}

38) Use the Pythagorean theorem to find the length of the unknown side of the right triangle. Give an exact answer.
   \[ \text{A) 14} \quad \text{B) 11} \quad \text{C) 12} \quad \text{D) 15} \]
MAT 0028 FINAL EXAM

Name the quadrant or axis in which the point lies.

39) (-19, 11)
   A) quadrant I
   B) quadrant II
   C) quadrant III
   D) quadrant IV

40) (3, 0)
   A) quadrant I
   B) quadrant II
   C) x-axis
   D) y-axis

Graph the linear equation.

41) \( y = -5 \)

42) \( x - 5y = 6 \)

43) \( y = \frac{1}{6}x + 7 \)
MAT 1033 – Intermediate Algebra  
Final Exam  
Name: ____________________

Solve the equation and check your solution(s).

1) \( \frac{x + 8}{2} + \frac{x - 2}{5} = \frac{43}{10} \)

\[ \text{A)} 43 \quad \text{B)} 0 \quad \text{C)} 1 \quad \text{D)} \frac{37}{2} \]

Solve.

2) Find the measures of the angles of a triangle if the measure of the first angle is twice the measure of the second angle and the third angle is 24° more than the second angle.

\[ \text{A)} 31°, 57°, 102° \quad \text{B)} 62°, 31°, 57° \quad \text{C)} 63°, 59°, 76° \quad \text{D)} 54°, 27°, 99° \]

Solve the formula for the specified variable.

3) \( F = \frac{9}{5}C + 32 \) for \( C \)

\[ \text{A)} C = \frac{5}{9}(F - 32) \quad \text{B)} C = \frac{5}{9}(F - 32) \quad \text{C)} C = \frac{F - 32}{9} \quad \text{D)} C = \frac{5}{9}(F - 32) \]
Write the solution set using interval notation.

4) \(-2(y - 5) \leq -4y + 10\)
   A) \((-\infty, 0]\)  B) \((-\infty, 10]\)  C) \([0, \infty)\)  D) \((0, \infty)\)

Solve the absolute value equation.

5) \(|5x + 8| + 4 = 6\)
   A) \(-\frac{3}{4}, -\frac{3}{4}\)  B) \(-\frac{6}{5}, -2\)  C) \(\emptyset\)  D) \(\frac{6}{5}, 2\)

Graph the equation.

6) \(y = -\frac{1}{4}x + 7\)

A) [Graph Image]
B) [Graph Image]
C) [Graph Image]
D) [Graph Image]
Graph the function by finding x- and y-intercepts.

7x - 3y = 9
Find the domain and the range of the relation. Use the vertical line test to determine whether the graph is the graph of a function.

8)

\begin{align*}
\text{A) domain: } & (-\infty, =) & \text{B) domain: } & (-4, =) \\
\text{range: } & [-4, =) & \text{range: } & (-\infty, =) \\
\text{not a function} & & \text{not a function} & \\
\text{C) domain: } & [-4, =) & \text{D) domain: } & (-\infty, =) \\
\text{range: } & (-\infty, =) & \text{range: } & [-4, =) \\
\text{function} & & \text{function} & 
\end{align*}

Find an equation of the line. Write the equation using function notation.

9) Through (3, -21) and (-5, 11)

\begin{align*}
\text{A) } y &= -\frac{1}{4}x - \frac{31}{4} & \text{B) } f(x) &= -4x - 9 \\
\text{C) } f(x) &= 4x - 33 & \text{D) } f(x) &= \frac{1}{4}x - \frac{87}{4}
\end{align*}
10) Graph the inequality.
\[ 3x + 5y > 15 \]

A) B)

C) D)

11) University Theater sold 478 tickets for a play. Tickets cost $20 per adult and $13 per senior citizen. If total receipts were $6970, how many senior citizen tickets were sold?

A) 198 senior citizen tickets
B) 108 senior citizen tickets
C) 280 senior citizen tickets
D) 370 senior citizen tickets
Graph.

12) The intersection of $x + y \leq -3$ and $x - y \geq 5$

Simplify. Write the answer with positive exponents.

13) $(3x^2y^5)^2(y^5)^{-3}$

A) $\frac{9}{x^{12}y^{11}}$
B) $\frac{9y^{11}}{x^{12}}$
C) $\frac{y^{11}}{9x^{12}}$
D) $9x^{12}y^{11}$
Multiply.
14) \((x - 11)(x^2 + 9x - 5)\)
   \(A) \quad x^3 + 20x^2 + 104x - 55\)
   \(B) \quad x^3 + 20x^2 + 94x - 55\)
   \(C) \quad x^3 - 2x^2 - 94x - 55\)
   \(D) \quad x^3 - 2x^2 - 104x + 55\)

Solve the equation and check your solution(s).
15) \(x(5x + 8) = 4\)
   \(A) \quad \frac{5}{2}, 2\)
   \(B) \quad 0, \frac{8}{5}\)
   \(C) \quad 0, -\frac{8}{5}\)
   \(D) \quad \frac{2}{5}, -2\)

Divide. Simplify completely.
16) \(\frac{x^2 - 8x + xy - 8y}{6x^2 - 6y^2}\) \(\div\) \(\frac{x - 8}{11x - 11y}\)
   \(A) \quad \frac{11(x^2 - 8x + xy - 8y)}{6(x + y)(x - 8)}\)
   \(B) \quad \frac{(x - 8)^2}{66(x - y)^2}\)
   \(C) \quad \frac{11}{6}\)
   \(D) \quad 1\)
17) \[
\frac{25s^2 - 64t^2}{st} = \frac{5s - 8t}{s - t}
\]

A) 8s + 5t
B) 5s + 8t
C) \frac{st}{5s + 8t}
D) \frac{8s + 5t}{st}

18) \(-15x^3 - 34x^2 - 35x - 9\div (5x + 3)\)

A) \(-3x^2 - 5x - 4 + \frac{3}{5x + 3}\)
B) \(x^2 - 4 + \frac{5}{5x + 3}\)
C) \(-3x^2 - 5x - 4\)
D) \(-3x^2 - 5x - 4 + \frac{6}{5x + 3}\)

19) \(\frac{1}{a} + \frac{1}{b} = c\) for b

A) \(b = \frac{1}{ac}\)
B) \(b = \frac{a}{ac - 1}\)
C) \(b = \frac{1}{c} - a\)
D) \(b = ac - \frac{1}{a}\)
Simplify the radical expression. Assume that all variables represent positive real numbers.

20) \(\sqrt{48k^2q^3}\)
   A) \(4k^3q^3\sqrt{3k}\)
   B) \(4q^4\sqrt{3k^2}\)
   C) \(4k^3q^4\sqrt{3}\)
   D) \(4k^3q^4\sqrt{3k}\)

Rationalize the denominator and simplify. Assume that all variables represent positive real numbers.

21) \(-\frac{4}{\sqrt{x} + 9}\)
   A) \(\frac{36 - 4\sqrt{x}}{x - 81}\)
   B) \(\frac{36 - 4\sqrt{x}}{x^2 - 81}\)
   C) \(\frac{36 + 4\sqrt{x}}{x - 81}\)
   D) \(\frac{36 + 4\sqrt{x}}{x + 81}\)

Solve the equation and check your solution(s).

22) \(\sqrt{57} - x = x - 1\)
   A) \(-7, 8\)
   B) \(-7\)
   C) \(8\)
   D) \(\emptyset\)
Solve the equation by completing the square.

23) \(x^2 - 14x + 58 = 0\)
   A) 10, 4  
   B) 7 + 3i  
   C) 7 - 9i, 7 + 9i  
   D) 7 + 3i, 7 - 3i

Use the square root properly to solve the equation.

24) \(2x^2 + 22 = 0\)
   A) -11, 11  
   B) \(-\sqrt{11}, \sqrt{11}\)  
   C) \(-\sqrt{11}, \sqrt{11}\)  
   D) -11i, 11i

Use the quadratic formula to solve the equation.

25) \(2x^2 = -8x - 3\)
   A) \(-\frac{4 - \sqrt{10}}{2}, \frac{-8 + \sqrt{10}}{2}\)  
   B) \(-\frac{4 - \sqrt{22}}{2}, \frac{-8 + \sqrt{22}}{2}\)  
   C) \(-\frac{8 - \sqrt{10}}{2}, \frac{-8 + \sqrt{10}}{2}\)  
   D) \(-\frac{4 - \sqrt{10}}{2}, \frac{-4 + \sqrt{10}}{2}\)
Appendix C: Course Coverage
Course: MAT 1033 – Intermediate Algebra

Required Objectives:

1. **Examine linear equations and inequalities with one variable**
   - Define linear equations with one variable
   - Identify linear equations and inequalities
   - Describe the properties of equations and inequalities
   - Solve linear equations
   - Identify contradictions, identities and conditional equations
   - Solve linear inequalities
   - Express solution sets in interval notation
   - Graph solutions to inequalities

2. **Factor polynomials**
   - Multiply polynomials including special cases of binomials, conjugate pairs, and the square of a binomial
   - Identify greatest common factors (GCFs)
   - Apply distributive property to factor out GCF
   - Factor by grouping
Factor by recognizing and applying special product rules including difference of two squares, sum and difference of cubes, and perfect square trinomials

Factor general quadratic polynomials

Factor polynomials that require multiple factoring techniques

Verify the factorization of a polynomial

Apply polynomial equations to solve applications

3. **Manipulate rational expressions**

Build equivalent rational expressions

Reduce rational expressions

Find the quotient of two polynomials using the division algorithm

Perform basic mathematical operations with rational expressions

Simplify complex rational expressions

Apply rational expressions to solve applications

4. **Apply the laws of exponents**

Define zero and negative exponents

State the laws of exponents
Simplify expressions using the laws of exponents

Define rational exponents

Apply the laws of exponents to algebraic expressions containing rational exponents

Apply the laws of exponents to solve applications

5. **Apply the laws of radicals**

Define terminology associated with radicals

Convert expressions with rational exponents to equivalent radical form

Convert radical expressions to equivalent exponent form

Simplify radical expressions

Add and radical expressions

Subtract radical expressions

Multiply radical expressions

Divide radical expressions

Rationalize denominators or numerators of radical expressions

Apply the laws of radicals to solve applications
6. **Examine complex numbers, their properties and operations**

   Identify problems requiring complex numbers

   Define complex numbers

   Identify the properties of complex numbers

   Define conjugates

   Raise "1" to powers

   Perform basic mathematical operations using complex numbers

   Combine addition, subtraction, multiplication and division of complex numbers in a given problem

7. **Examine linear equations and inequalities with two variables**

   Define a Cartesian coordinate system

   Plot points on a Cartesian coordinate system

   Verify the solution of a linear equation in two variables

   Determine the slope, x-and y-intercepts of a line

   Graph equations using standard, point-slope, slope-intercept forms and special cases (horizontal and vertical lines)

   Write equations of a line
Identify linear inequalities in two variables

Graph linear inequalities

Solve an equation for a specified variable

Apply linear equations and inequalities to solve applications

8. Examine non-linear equations

Solve an absolute value equation

Solve quadratic equations by factoring

Solve quadratic equations by using the square root method

Apply the quadratic formula

Solve word problems that require the use of quadratic equations

Solve equations involving one radical

Solve rational equations leading to quadratic equations

Verify the solution of a non-linear equation

Solve an equation for a specified variable

Apply non-linear equations to solve applications

9. Solve systems of equations and inequalities

Solve a linear 2 X 2 system of equations using elimination
Solve a linear 2 X 2 system of equations using substitution

Verify the solution of a linear 2 X 2 system

Apply the concepts of system of equations to solve applications

Graph the solution to a linear system of inequalities

10. **Examine functions**

Define a relation

Determine the domain and range of a relation

Define a function

Determine the domain and range of a function

Determine if a relation is a function

Use the vertical line test to determine if the graph of a relation is a function

Use function notation

Evaluate a function for a specified value in its domain

Graph linear functions
Appendix D: MyMathLab Example Assignment
1. Find the domain of the rational function.

\[ s(t) = \frac{t^2 + 4}{t} \]

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

- **A**. The domain is \( \{ t \mid t \text{ is a real number and } t \neq \square \} \).
  (Simplify your answer. Type an integer or a fraction. Use a comma to separate answers as needed.)

- **B**. The domain is \( \{ t \mid t \text{ is a real number} \} \).

2. Find the domain of the rational function.

\[ C(x) = \frac{x + 3}{x^2 - 25} \]

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

- **A**. The domain is \( \{ x \mid x \text{ is a real number and } x \neq \square \} \).
  (Simplify your answer. Type an integer or a fraction. Use a comma to separate answers as needed.)

- **B**. The domain is \( \{ x \mid x \text{ is a real number} \} \).

3. Simplify the rational expression.

\[ \frac{15x - 75x^2}{15x} = \square \]
4. Simplify the rational expression.  
\[
\frac{8y - 24}{9y - 27}
\]
\[
\frac{8y - 24}{9y - 27} = \square
\]

5. Simplify the rational expression.  
\[
\frac{2x^2 - 9x - 5}{x^2 - 8x + 15}
\]
\[
\frac{2x^2 - 9x - 5}{x^2 - 8x + 15} = \square
\]

6. Simplify the rational expression.  
\[
\frac{x^3 - 343}{4x - 28}
\]
\[
\frac{x^3 - 343}{4x - 28} = \square
\]
(Use integers or fractions for any numbers in the expression.)

7. Simplify the rational expression.  
\[
\frac{4x^2 - 6x + 9}{8x^3 + 27}
\]
\[
\frac{4x^2 - 6x + 9}{8x^3 + 27} = \square
\]
8. Perform the division.

\[ \frac{k^3 - t^3}{k - t} = \]
(Simplify your answer.)

9. Multiply and simplify.

\[ \frac{24x - 8}{7} \cdot \frac{14}{1 - 3x} = \]
(Type an integer or a fraction. Simplify your answer.)

10. Multiply and simplify.

\[ \frac{3x^3 - 81}{4x^2 + 8x - 60} \cdot \frac{8x + 48}{6x^2 + 18x + 54} = \]

11. Multiply and simplify.

\[ \frac{x^2 - 4x - 21}{2x^2 - 98} \cdot \frac{x^2 + 14x + 49}{4x^2 + 40x + 84} = \]
12. Perform the multiplication.

\[
\frac{8x^4 + 5x^2 - 3}{x - 1} \cdot \frac{x + 1}{x^4 - 1}
\]

\[
\frac{8x^4 + 5x^2 - 3}{x - 1} \cdot \frac{x + 1}{x^4 - 1} = \square \quad \text{(Simplify your answer.)}
\]

13. Divide and simplify.

\[
\frac{x^2 - 12x + 36}{x^2 - 3x - 18} ÷ \frac{x^2 - 36}{7}
\]

\[
\frac{x^2 - 12x + 36}{x^2 - 3x - 18} ÷ \frac{x^2 - 36}{7} = \square
\]


\[
\frac{3x - x^2}{x^3 - 27} ÷ \frac{x}{x^2 + 3x + 9}
\]

\[
\frac{3x - x^2}{x^3 - 27} ÷ \frac{x}{x^2 + 3x + 9} = \square \quad \text{(Simplify your answer.)}
\]

15. Divide.

\[
\frac{2x^2 - 8x - 10}{3x^2 - 6x - 18} ÷ \frac{x^2 - 8x + 15}{x^2 + 3x - 18}
\]

\[
\frac{2x^2 - 8x - 10}{3x^2 - 6x - 18} ÷ \frac{x^2 - 8x + 15}{x^2 + 3x - 18} = \square \quad \text{(Simplify your answer.)}
\]
16. Perform each indicated operation.

\[
\frac{4 + 5xy}{x^3} \cdot \frac{10x^3}{x^6} = \text{□ (Simplify your answer.)}
\]

17. Perform each indicated operation.

\[
\frac{4a^2 - 16}{5a^2 - 30a} \div \frac{a^3 + 2a^2}{a^2 - 12a} \cdot \frac{2a^3 + 10a^2}{2a^2 - 4a} = \text{□ (Simplify your answer.)}
\]

18. Find each function value. If \( g(x) = \frac{x^2 + 8}{x^3 - 25x} \), find \( g(3) \), \( g(-1) \), and \( g(1) \).

\( g(3) = \text{□} \)
(Type an integer or a simplified fraction.)

\( g(-1) = \text{□} \)
(Type an integer or a simplified fraction.)

\( g(1) = \text{□} \)
(Type an integer or a simplified fraction.)
19. Which of the expressions are equivalent to \( \frac{x}{4-x} \)?

\[
\frac{-x}{4-x} \quad \frac{-x}{4+x} \quad \frac{x}{x-4} \quad \frac{-x}{x-4}
\]

Select all equivalent expressions.

- [ ] A. \( \frac{-x}{x-4} \)
- [ ] B. \( \frac{-x}{4+x} \)
- [ ] C. \( \frac{x}{x-4} \)
- [ ] D. \( \frac{-x}{x-4} \)

20. Explain how to simplify a rational expression.

Choose the correct answer below.

- [ ] A. Replace the variable with any number and perform the indicated operation.
- [ ] B. Perform the indicated operation to obtain an expression with one fraction bar. Then rewrite the result without variables.
- [ ] C. Perform the indicated operation, if any, to obtain an expression with one fraction bar. Then divide the numerator and denominator by their common factors.
- [ ] D. Perform the indicated operation to obtain an expression with one fraction bar.
Appendix E: ALEKS Example Assignment
Divide.

\[
\frac{\frac{x^2}{y^2}}{\frac{a^3}{b^3}}
\]

Simplify your answer as much as possible.

---

Divide.

\[
\frac{2x}{5y}
\]

Simplify your answer as much as possible.

---

Divide.

\[
\frac{\frac{9y}{4x}}{\frac{2y}{3x}}
\]

Simplify your answer as much as possible.
Appendix F: FIT IRB Approval and Application
Notice of Exempt Review Status

From: Florida Tech Institutional Review Board
FWA00014339, IRB00001690

To: Holly Wendel

Date: November 2, 2015

IRB Number: 15-188

Study Title: Effects of intelligent computer generated interactive mathematics programs on students' achievement and affective domain

Dear Researcher:

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.101, your study has been determined to be minimal risk for human subjects and exempt from 45 CFR46 federal regulations and further IRB review or renewal unless you change the protocol or add the use of participant identifiers. This study is approved for one year from the above date. If data collection continues past this date, a Continuing Review Form must be submitted.

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

The category for which exempt status has been determined for this protocol is as follows:

1. Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as:
   a. Research on regular and special education instruction strategies, or
   b. Research on the effectiveness of or the comparison among instruction techniques, curricula, or classroom management methods.
   a. The confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
RESEARCH INVOLVING HUMAN SUBJECTS
Exempt Application

This form shall be used if there is minimal risk to human subjects and one or more of the conditions below apply: if there is more than minimal risk associated with the research (none of the conditions below apply) or if the research utilizes a special population (children, prisoners, institutionalized individuals, etc.), please use the full application form found on the IRB website.

You should consult the university's document "Principles, Policy, and Applicability for Research Involving Human Subjects" prior to completion of this form. Copies may be obtained from the Office of Sponsored Programs and on the IRB website.

Name: Holly Wandoel
Date: 10/13/2015
Academic Unit: Education & Interdisciplinary
Email: Hogan3012@ftc.edu

Title of Project: Effects of Intelligent Computer-Generated Interactive Mathematics Programs on Students' Achievement and Affective Domain

☑ 1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as:
   a. research on regular and special education instruction strategies, or
   b. research on the effectiveness of or the comparison among instruction techniques, curricula, or classroom management methods.

☐ 2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior unless:
   a. the subjects can be identified, directly or through identifiers linked to the subjects and
   b. any disclosure of subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Note: This exemption does not apply to survey procedures or interviews involving minors.

☐ 3) Research involving the use of educational tests, survey or interview procedures, or observation of public behavior if:
   a. the subjects are elected or appointed public officials or candidates for public office or
   b. the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

☐ 4) Research involving the collection or study of existing data, documents, records, or specimens if
   a. these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, indirectly or through identifiers linked to the subjects.

☐ 5) Research and demonstration projects that are conducted by or subject to the approval of Department or Agency heads and that are designed to study, evaluate, or otherwise examine:
   a. public benefit or service programs,
   b. procedures for obtaining benefits or services under those programs,
   c. possible changes in or alternatives to those programs or procedures, or
   d. possible changes in methods or levels of payment for benefits or services under those programs.

☐ 6) Taste and food quality evaluation and consumer acceptance studies if:
   a. wholesome foods without additives are consumed or
   b. food is consumed that contains food ingredients found to be safe by the Food and Drug Administration or
      approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.
1. List the objectives of the proposed project.

Examine the relationship between using one of the web-based programs, MyMathLab or ALEKS, on student achievement.
Examine the relationship between using one of the web-based programs and students' affective domain and interaction with student achievement.
Examine the relationship between the total time spent in the web-based program and student achievement and interaction with the type of web-based program used.

2. Describe the research project design/methodology. Discuss how you will conduct your study, and what measurement instruments you are using. If your project will use a questionnaire or a structured interview, attach. Please describe your study in enough detail so the IRB can identify what you are doing and why.

The proposed study will employ a quasi-experimental methodology, pretest-posttest design involving intact classes. The purpose of this study is to determine the relationship each of the mathematics web-based programs, MyMathLab and Assessments and Learning in Knowledge Spaces (ALEKS), has with students' mathematics achievement. In addition, the study proposes to examine the relationship between students' affective domain and the type of software as well as student achievement. The affective domain measures are students' anxiety, self-efficacy as well as their attitudes towards mathematics. For the purpose of this study, mathematics achievement is defined as students' intermediate algebra end-of-course comprehensive final exam score.

There are many studies that compare traditional courses completing pencil and paper homework to courses using technology to complete their homework. However, there is little to no systematic research comparing the different types of technology in a mathematics course. This leaves a large gap in research that needs to be filled. This study will inform colleges, instructors, and the mathematics research community about the effect of the two main web-based programs being used: MyMathLab and ALEKS.

Another significance of the proposed study is that it will examine the interactions between the web-based program used and the students' affective domain. It is important to know the effects of web-based programs on the feelings and emotions of the students. Knowing that one program in more beneficial in lowering anxiety, increasing attitudes towards math, and/or increasing math self-efficacy will not only allow the colleges and instructors to choose a program best fitted for the courses but also make publishers aware of these outcomes so they are able to adjust and better their programs to help students face higher achievements.

A third significance of the proposed study is that it will examine the interactions between time spent in the program and student achievement. This will allow students and instructors see the importance of using each program. Just assigning a program to a course is not enough; students must spend time in the program to reap the benefits.

The following instruments will be used and are attached:
Attitudes Toward Mathematics Inventory (ATMI) Marime Tapia, 1996
Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) Dr. Diana (Kay) Swanagan
Comprehensive MAT 1033 Final Exam

3. Describe the characteristics of the subject population, including number, age, sex, and recruitment strategy (attach actual recruitment email text, recruitment flyers, etc).

The principle investigator is a full-time instructor at Eastern Florida State College. Participants will be students enrolled in her mathematics classes. Because this will be done as a class assignment, all students will complete it; however, data from any high school dual enrollment will be excluded for the purpose of this study.

The study will include spring 2016 semester students from four MAT 1033 courses. 14,984 students at EFSC in the spring 2015 semester have mean age of 25 years with 20% female.

4. Describe any potential risks to the subjects (physical, psychological, social, legal, etc.) and assess their likelihood and seriousness. Research involving children must carefully assess risks and describe the safeguards in place to minimize these risks.

There is no potential risk as the data will be collected from normal class assignments.
6. Describe the procedures you will use to maintain the confidentiality and privacy of your research subjects and project data.

Because this includes class assignments, all privacy requirements as outlined by FERPA will be strictly adhered to. Only aggregated results from this study will be reported so that the identification of students cannot be determined.

6. Describe your plan for informed consent (attach proposed form).

Informed consent will not be necessary in this case as this study includes normal class assignments.

7. Discuss the importance of the knowledge that will result from your study and what benefits will accrue to your subjects (if any).

The information gained from this study will provide documentation to show the need for portraying graphs in a way that will not mislead the reader.

8. Explain how your proposed study meets criteria for exemption from Institutional Review Board review (as outlined on page 1 of this form).

The data will be collected from the results of assignments that are already required for each student to complete.
Signature Assurances

I understand Florida Institute of Technology's policy concerning research involving human subjects and I agree:

1. to accept responsibility for the scientific and ethical conduct of this research study,
2. to obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form,
3. to immediately report to the IRB any serious adverse reactions and/or unanticipated effects on subjects which may occur as a result of this study,
4. to complete, on request by the IRB, a Continuation Review Form if the study exceeds its estimated duration.

PI Signature ___________________________ Date: 10/21/2015

Advisor Assurance: If primary investigator is a student
This is to certify that I have reviewed this research protocol and that I attest to the scientific merit of the study, the necessity for the use of human subjects in the study to the student's academic program, and the competency of the student to conduct the project.

Major Advisor ___________________________ Date: 10/21/2015
Major Advisor (pnt) Samantha Fowler

Academic Unit Head: It is the PI's responsibility to obtain this signature
This is to certify that I have reviewed this research protocol and that I attest to the scientific merit of this study and the competency of the investigator(s) to conduct the study.

Academic Unit Head ___________________________ Date: 10/26/2015

FOR IRB USE ONLY

IRB Approval ___________________________ Date: 11-2-15

IRB Approval Name ___________________________

Florida Tech IRB: November 2005

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Appendix G: EFSC IRB Application and Approval
Contact Information

Principal Investigator: Holly Wendel: 321-433-5147; wendelh@easternflorida.edu

Major Advisor: Dr. Fowler: (321) 674-8141; sfowler@fit.edu

Project Description

Title: Effects of Intelligent Computer-Generated Interactive Mathematics Programs on Students' Achievement and Affective Domain

Anticipated Start Date and Duration: Spring 2016

Research Description

1. The rationale and purpose of the study.

   The purpose of this study is to determine the relationship each of the mathematics web-based programs, MyMathLab and Assessments and Learning in Knowledge Spaces (ALEKS), has with students' mathematics achievement. In addition, the study proposes to examine the relationship between students' affective domain and the type of software as well as student achievement. The affective domain measures are students' anxiety, self-efficacy as well as their attitudes towards mathematics. For the purpose of this study, mathematics achievement is defined as students' intermediate algebra end-of-course comprehensive final exam score.

   There are many studies that compare traditional courses completing pencil and paper homework to courses using technology to complete their homework. However, there is little to no systematic research comparing the different types of technology in a mathematics course. This leaves a large gap in research that needs to be filled. This study will inform colleges, instructors, and the mathematics research community about the effect of the two main web-based programs being used: MyMathLab and ALEKS.

   Another significance of the proposed study is that it will examine the interactions between the web-based program used and the students' affective domain. It is important to know the effects of web-based programs on the feelings and emotions of the students. Knowing that one program is more beneficial in lowering anxiety, increasing attitudes towards math, and/or increasing math self-efficacy will not only allow the colleges and instructors to choose a program best suited for the courses but also make publishers aware of these outcomes so they are able to adjust and better their programs to help students face higher achievements.

   A third significance of the proposed study is that it will examine the interactions between time spent in the program and student achievement. This will allow students and instructors to see the importance of using each program. Just assigning a program to a course is not enough; students must spend time in the program to reap the benefits.

2. Provide a description of the participants.

   A proposed sample of 150 Eastern Florida State College students will participate in this study. The students selected will be enrolled in MAT 1033 during the 2016 spring
of company A/B) and asked the same series of questions about their interpretation of the graph. On day four, students will be given both graphs of their topic and asked a series of questions to determine if the student notices a difference between the information contained in the two graphs.

During the second week, students will go through the same process of week one, but this time answering questions on the other topic. For example, if a student answered questions over Obamacare last week, then they will now answer questions on the topic of company sales.

4. List the assessments, questionnaires, survey and interviews expected to be implemented. Include sample copies of each document.

   There are 6 questionnaires (attached):
   1. Opinion of Obamacare
   2. Controversial Topic Questionnaire with Accurate Graph
   3. Controversial Topic Questionnaire with Inaccurate Graph
   4. Neutral Topic Questionnaire with Accurate Graph
   5. Neutral Topic with Inaccurate Graph
   6. Compare and Contrast Questionnaire

5. Provide a copy of both the Institutional Review Board (IRB) application, informed consent form, and any documents that will be used for recruitment purposes.

   Informed consent will not be necessary in this case as it is a normal class assignment.

I agree that I will not contact the participants’ until I have been authorized to do so by the EFSC Institutional Review Board (IRB) Chair. I understand that this application is for proposal purposes only, in that submitting this document does not allow me to begin the proposed research. Failure to adhere to these specifications may result in denial of a proposed project or suspension of a project already in progress.

Principal Investigator Signature ___________________________ Date _____________

Holly Wendel
Signature Assurances

I understand Florida Institute of Technology's policy concerning research involving human subjects and I agree:

1. to accept responsibility for the scientific and ethical conduct of this research study,
2. to obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form,
3. to immediately report to the IRB any serious adverse reactions and/or unanticipated effects on subjects which may occur as a result of this study,
4. to complete, on request by the IRB, a Continuation Review Form if the study exceeds its estimated duration.

PI Signature: Holly Wandel Date: 10/21/2015

Advisor Assurance: If primary investigator is a student
This is to certify that I have reviewed this research protocol and that I attest to the scientific merit of the study, the necessity for the use of human subjects in the study, the student's academic program, and the competency of the student to conduct the project.

Major Advisor: Samantha Fowler Date: 10/21/2015
Major Advisor (print) Samantha Fowler

Academic Unit Head: It is the PI's responsibility to obtain this signature
This is to certify that I have reviewed this research protocol and that I attest to the scientific merit of this study and the competency of the investigator(s) to conduct the study.

Academic Unit Head: [signature] Date: 10/26/2015

FOR IRB USE ONLY

IRB Approval: [signature] Date: 11-2-15

IRB #: [15-156]

Florida Tech IRB: November 2005
Appendix H: EFSC ALEKS Pilot Approval Letters
The Math Cluster has approved Holly Wendel’s request to use ALEKS in MAT 1033 for Spring 2016. The vote was 17 Approve and 6 Reject.

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Please Note: Due to Florida’s very broad public records law, most written communications to or from College employees regarding College business are public records, available to the public and media upon request. Therefore, this email communication may be subject to public disclosure.
ALEKS MAT 1033 Use

Files, Dustin
Sent: Tuesday, November 17, 2015 9:12 AM
To: Wende, Holly

Holly,

I approve your use of ALEKS for the Spring 2016 semester for your MAT 1033 classes.

Regards,

Dustin Files
Mathematics Department Chair
Assistant Professor of Mathematics
Eastern Florida State College
Palm Bay Campus
250 Community College Parkway
Palm Bay, Florida 32909
Office: Building 2, Room 156N
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