A Dissertation

entitled

A Study of Student Perceptions on Adaptive Learning Systems in College Algebra and
Their Effect on Learning Outcomes

By

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Low levels of student success in introductory college math courses are rampant. There are several reasons for low pass rates in these courses, with the most serious issue being lack of concept mastery. To aid students in concept mastery, adaptive learning systems were created. These systems adapt instruction for each student and create an individualized learning path, opening new content areas only after the student masters the current content area. However, research on adaptive learning systems is very limited, as these systems are somewhat new, and the research is lacking especially in mathematics courses where the systems are needed most.

The purpose of this study was to examine students’ self-reported satisfaction about the use of the adaptive learning system. Additionally, final grades of students who used the system were compared to the final grades of students who did not use the system.
The results revealed that student satisfaction with mathematics in general did not affect their perceptions about the adaptive learning system and its benefits to their learning. However, overall student satisfaction with the system was low and they did not consider the system beneficial. Nonetheless, students who used the system had higher final grades than students who did not use the system. Therefore, it would benefit students to improve the system based on their suggestions and continue its use in introductory math courses.
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Chapter One

Introduction

Imagine stepping into a calculus class offered at a local university. Upon entering the room, you see that each desk has a 10-year-old student sitting in the chair. The students have notebooks, pencils, and are copying numbers from the board upon which the instructor is writing. The students go home and complete their homework, study for their tests, and pass the course with high grades.

This scenario sounds ridiculous because it is uncommon for a 10-year-old to be taking a college-level calculus course. The question to which this leads is: why are young students not taking higher-level math courses? The reason is that they have not made it to that step in the staircase of mathematics. Students must progress step-by-step through content in most mathematics courses in order to make it to the end. Each concept builds upon the previous, and to make it to the top, students must understand the material each step of the way. However, so many of the country’s students are not even standing on the steps. Instead, they are at the bottom.

Statement of Problem

Low levels of student success in introductory college math courses are rampant. These courses emphasize the basics of math and are heavily populated by students who typically have not had success in the subject. Between 60 and 75 percent of first-year college students in the nation require introductory math courses, and less than one-half of these students are able to pass on the first attempt (Hackett, 1985; Boggs, Shore, &
Shore, 2004). As these students fail to pass the required math courses for graduation, they are much more likely to leave college without earning their degree.

There are many reasons for low pass rates in introductory math courses: the use of disengaging material, poor curriculum design, lack of students’ pre-requisite knowledge. However, the most serious issue among the reasons for low pass rates is lack of concept mastery. Just as an engineer cannot construct the ninth floor without building the first eight floors, so too a student cannot learn an advanced concept without first having learned the preceding concepts. Yet math education in this country is designed without any regard for mastery of each step; students are forced to navigate through courses at a standardized speed. This poor curriculum design hurts students who struggle with mathematical concepts, as these students are left behind while non-struggling students move to the next concept.

To prevent students from falling behind and not succeeding in a course, the design of the curriculum can be altered. Students can work at their own pace and only move to the next concept once they have proven mastery of the current concept. This is for what adaptive learning systems were created. These systems are “web-based application programs that provide a personalized learning environment for each learner by adapting both the presentation and the wandering in content,” (Özyurt, Özyurt, Balik, & Güven, 2013). Students log into an online system where they take a pre-test, letting the system detect each student’s existing knowledge and learning preferences. Students discover on which step of the staircase they stand for the course in which they are enrolled. The system then adapts instruction for each student and creates an individualized path, opening new content areas only after the student masters the current content area. The
system also uses an algorithm to determine which question types students prefer during the pre-test and then assigns questions to each student based on that information. By having the opportunity to use an adaptive learning system, students are able to spend more time with content on which they struggle and only move to the next step once the present step is mastered. Such a computerized system guides students so that they do not fall into the trap of missing a step and falling behind, making adaptive learning systems a key technology in improving higher education.

However, research on adaptive learning systems is very limited, as these systems are somewhat new and the research is lacking, especially in mathematics courses where the systems are needed the most (Fischman, 2011). The studies that do exist involve low numbers of participants. These small studies, which were conducted mostly in secondary schools rather than in higher education, are qualitative studies that do not offer statistical analyses that quantitative studies can. In addition, the studies that have been completed were not done in isolation, so the effectiveness of adaptive learning systems is undetermined (Fischman, 2011). Although the concept of these systems works in theory, whether or not they work has yet to be determined. In order for a new technology to work, students must first buy into the concept. A new technology could potentially revolutionize education with its concept, but without student interest, the technology would offer no benefit to learning.

**Significance of Study**

This study investigated the level of engagement of College Algebra students in the use of an adaptive learning system via a self-report survey. It provided valuable insight on how
students viewed the system as beneficial to their learning and how it affected the amount of time they spent using the system to aid in their study of College Algebra content. This study provided students opportunities to reflect on their use of the system and how it changed their learning. The findings will help faculty determine whether or not to include the use of an adaptive learning system in the curriculum design for future College Algebra courses.

This study explored results from both face-to-face and online sections of College Algebra. Therefore, the use of an adaptive learning system by traditional students was compared to the use of an adaptive learning system by online students. The differences found will be able to help faculty alter curriculum for each of these two very different modes of teaching.

In addition to the self-report survey, student grades from past semesters of College Algebra, both online and face-to-face, in which the adaptive learning system was not utilized were compared to student grades from the current semester, both online and face-to-face, in which the system was being used. By comparing grades of students who did not use the system to grades of students who did use the system, the researcher was able to gain a deeper understanding of the effectiveness of the adaptive learning system in teaching and learning.

**Purpose Statement**

The purpose of this study was to examine students’ self-reported satisfaction about the use of the adaptive learning system and how much time they invested in its use.
Additionally, the final grades of students who used the system were compared to the final grades of students who did not use the system.

**Research Questions**

1. How satisfied are students in College Algebra with the use of an adaptive learning system in the course?
2. Is there a relationship between how satisfied students are with the system and how much time they invest into using the system?
3. Is there a relationship between how satisfied students are with the adaptive learning system and their satisfaction of mathematics?
4. Are there differences in student satisfaction of the adaptive learning system between students taking online College Algebra and students taking face-to-face College Algebra?
5. Are there differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system?

**Operational Definitions**

Several definitions for terms related to general education and online learning exist. For the purpose of this study, the researcher has described these definitions as follows:

**General education course**

A general education course is a course based upon requirements students must fulfill in order to graduate with their degree (Fagette, Chen, Baran, Samuel, & Kiani, 2013).
Online learning

Online learning refers to synchronous and asynchronous learning that is “written, communicated, active, supported and managed with the use of Internet technology” (Morrison, 2003).

Synchronous online learning

Synchronous online learning is when instructors and students communicate live (Chen, Ko, Kinshuk, & Lin, 2005). This most often is done through the use of video conferencing tools or a telephone conference call.

Asynchronous online learning

Asynchronous online learning allows interaction among students and instructors at different times (Chen et. al., 2005). This is usually done through the use of blogs, discussion boards, and email.

Web 2.0 tools

Web 2.0 tools are websites and applications that use technology and the World Wide Web as a platform for users to interact with content (O’Reilly, 2009).

Mastery learning

Mastery learning is learning that requires students to master a concept before moving to the next (Lin et al., 2013).

Adaptive learning system

An adaptive learning system is a computer system that allows students to work at their own pace and move to the next concept once they have proven mastery of the current concept.
ALEKS

ALEKS is an adaptive learning system that assesses what students’ knowledge base is.

Organization of Study

This research is organized into five additional chapters. Chapter 2 reviews the literature and discusses current issues related to the success rate in introductory math courses, how curriculum design can change success rate, and the role of adaptive learning systems in this endeavor. Chapter 3 discusses the methodology for the study, along with the Rasch Model and how it was used to analyze data. Chapter 4 presents results for the study. Chapter 5 contains the discussion, conclusions, and recommendations.
Chapter Two

Literature Review

The purpose of this literature review is to provide the background information that supports the study on student satisfaction and learning outcomes of an adaptive learning system to help cultivate student success in both face-to-face and online introductory math courses. Failure in college introductory math courses is rampant, but this problem may be remedied through the use of adaptive learning systems, which incorporate many of the best practices research has shown to be effective for increased student success. To understand how adaptive learning systems can be effective, it is important to first understand the theories and best practices upon which these systems were created. First, the review will investigate the issue of failure in introductory math courses and what the known causes are. Second, the background of Engagement Theory will be examined to connect engagement with the use of adaptive learning systems. Best practices in course design will then be explored to demonstrate how the use of an adaptive learning system encompasses sound course design. This review will summarize information about how adaptive learning systems incorporate all of the ideas discussed in this section in order to solve the known causes of failure in introductory math courses. Lastly, the researcher will consider the benefits of student buy-in with adaptive learning systems and how that may affect their learning.

Low Success Rates in Introductory College Math Courses

Failure in introductory math courses is at an all-time high (Boggs, Shore, & Shore, 2004). Failure, as defined by the Department of Mathematics at Allegany College of Maryland,
is earning a score of less than seventy percent on a test or other assignment (Boggs et. al., 2004). These courses also are typically general education courses that are required for students to graduate. Therefore, when students are unable to pass the course, they are unable to graduate. Introductory math courses are classes that emphasize the basics of math and are often heavily populated by students who have not previously had success in math. For students who struggle with mathematical concepts, they are left in the dust as their classmates move to the next concept, and they fall farther behind.

Between 60 and 75 percent of first-year students in the nation require introductory math courses, and less than one-half of these students are able to pass with the first attempt (Hackett, 1985; Boggs et al., 2004). This failure rate may cause low self-efficacy, more expenses for schools and students, and decreasing retention rates (Bahr, 2013). Bahr’s study (2013) examined 79,545 students in California community colleges and found that only 16% of students who withdrew from their introductory math course completed any type of credential afterward, including transferring to a four-year institution. This number indicates a correlation between failure in introductory math courses and graduation rates. Because students who pass introductory courses in their first semester of college are more likely to graduate than any other population of students (Blum, 2007), decreases in failure rates of introductory math courses must occur.

In order to decrease failure rates in math courses, the reasons for failure must be known. The first issue many researchers have argued is that the structure of these courses lacks good curriculum design. Courses with high failure rates often have bad curriculum design and are not engaging (Koszalka & Ganesan, 2004; Lai, 1994; Swan, 2001; Bolliger, 2004; Nash, 2005). For instance, Gningue, Peach, and Schroder found that
when teachers design their curriculum to be student-centered, students are more engaged in mathematics and thus have higher pass rates (2013). These researchers defined engagement as students being on-task and completing assignments fully and on-time (Gningue et al., 2013). In addition to lack of engagement, lack of mastery also contributes to high failure rates. Math courses specifically have been well-known for having high failure rates when students are forced to move through content without mastery (Kulik & Kulik, 1990). Therefore, to increase success in remedial math courses, the curriculum should first be examined to be engaging and to include mastery learning.

Failure in math courses is not only a result of poor curriculum design but also could be caused by the different backgrounds of students. This leads to another pressing issue in introductory math courses: typically students come to the course with varying levels of pre-requisite knowledge. However, course design often does not take this issue into consideration. College-level courses are taught at one level, assuming that all students have the necessary background knowledge, which is “not something acceptable since individual differences, pre-information and the needs of students can be different,” (Özyurt, Özyurt, Baki & Güven, 2013). When students have different levels of knowledge and lack the expected background content needed for a course, they often struggle to succeed with a passing grade (Özyurt et al., 2013). Therefore, math courses need to be designed in such a way that students can fulfill their mathematical deficiencies and also master the new content presented in the course.

As discussed, failure in college math courses is still an ongoing phenomenon. Lack of student engagement, along with poor curriculum design, is a significant contributor to student failure. In addition, pushing students through a course without
mastering content plays a role in student failure. Many researchers have responded to these issues by providing best practices in engagement and curriculum design. Thus, the following sections will examine these theories and best practices in more detail, followed by the importance of incorporating mastery learning into introductory math courses.

**Student Engagement**

Being engaged in coursework is vital to students’ achievement, yet studies over the last twenty years have shown that low levels of engagement often exist in the classroom (Marks, 2000). Engagement is a “collection of mindfully goal-directed states in which motivation arising from positive emotions serves to grab and sustain the learner’s cognitive and motor competencies,” (Deater-Deckard, Chang, & Evans, 2013). This means that engaged students are motivated to learn and have positive emotions related to course content. Students who are not interested in their coursework learn less than their peers who do show an interest (Corno et al., 2002). Therefore, lack of student engagement is a problem that should not be taken lightly. Luckily engagement levels are malleable, but to create engaging lessons, it is necessary to first know what it is that students find fascinating.

History has shown that students find technology fascinating. Each technology introduced to society is often adopted and grows at a faster rate than the previous. To reach an audience of 50 million, the radio required 38 years, the television 13 years, the Internet 4 years, the iPod 3 years, and Facebook only 2 years (Brenman, Fisch, & McLeod, 2008). In addition to technology tools, the growth of Internet-based applications has been exponential since the inception of the Internet (Odlyzko, 2003).
The world is filled with ubiquitous digital technologies, because technologies are engaging to users (Galbraith et al., 2013). By the prodigious growth of these tools, it is clear that technologies are the answer to what students find fascinating and, therefore, may be key to engaging students in course content.

Engagement Theory

One educational theory in particular incorporates these technological tools: Engagement Theory. Additionally, this theory, which relies heavily on Internet-based applications, offers educators some solutions to the problem of low student engagement. Engagement Theory, proposed by Greg Kearsley and Ben Shneiderman, suggests that students must be engaged in their learning through activities and other group interactions in order for education to be of value (Kearsley & Shneiderman, 1998). Through emphasis on experimental learning and collaboration, Engagement Theory follows a constructivist approach (Anderson, 1996), which stems from the idea that “people create new meanings through the interactions they establish between ideas, events, and activities they have encountered before,” (Uredi, 2013). Like constructivism, Engagement Theory stresses the importance of social learning and the creation of a community of learners in order for true discovery to take place (Kearsley & Shneiderman, 1998). This involves working in groups “creating, interpreting, and reorganizing information actively according to pre-knowledge,” (Uredi, 2013).

Discovery in a learning community can occur in a variety of ways, but technology is one of the most appealing ways to encourage student connectedness by providing collaborative methods that otherwise would not be available. There are several technology tools that allow students to share their thoughts, mold each other’s ideas into
more solidified beliefs, and even work together synchronously without having to be in the same geographic location or even communicate at the same time (Chen et. al., 2005). Because technology provides so many ways for students to work together with more flexibility, this theory is based on ways that technology can be used to create more meaningful learning. Further, the theory is based on three parts: collaboration, project-base, and outside focus (Kearsley & Shneiderman, 1998). Shneiderman summarized these components by naming them “Relate>Create>Donate,” (1988). “Relates” means that the focus of a course must be relatable to students’ lives. Activities must take place within groups of students, and students must create a project on which they work together. “Donate” means that the project must be one that allows students to make a donation to society or improve a community in some way. Using the “Relate>Create>Donate” method, educators must actually change the way information is presented and connect students in the classroom.

Although Engagement Theory is relatively new, especially compared with other educational theories, the published research consists of positive findings. Miliszewska, Horwood, and McGill (2003) found that students in their courses to which they applied Engagement Theory had much more motivation to learn and better met their goals than students in their courses to which they did not apply Engagement Theory. These researchers also conducted many studies on transnational courses – courses that were delivered online to students in several different countries than the one in which the instructors lived (Miliszewska & Horwood, 2006). Students were put into groups and worked together virtually through the use of various Internet-based applications to collaborate on a final project. The authors found that distance students working virtually
with the “Relate-Create-Donate” method also were better motivated and achieved more than distance students in courses in which this teaching method was not applied (Miliszewska & Horwood, 2004).

Similarly, Hazari, North, and Moreland (2009), in their investigation of the effect of technology tools on learning, incorporated ideas from Engagement Theory into their courses. In order to promote student collaboration and engage learners, the researchers organized groups of students and directed them to use Web 2.0 tools to share their ideas and discuss course content. They found that students were more engaged and, thus, earned higher grades than students in similar, but face-to-face, courses (Hazari, North, & Moreland, 2009). Whether Engagement Theory is applied to distance courses or face-to-face classes, the results show a similar pattern: higher student achievement.

With such optimistic results, Engagement Theory can provide a big impact on education when implemented properly. Understanding how this theory can be put into place is rather simple.

First, the content of a course must be something to which students can relate. For example, rather than have students in a math class solve trivial problems with little meaning to real-life situations, students should receive story problems and scenarios related to events that occur frequently in their lives. When content can be applied to students’ everyday lives, they often find concepts easier to understand and are better able to apply what they learn, which is when true understanding occurs (Dames, 2012).

Applying the ideas from Engagement Theory also requires students to work together in groups or teams. Working in teams involves “communication, planning, management, and social skills,” (Kearsley & Shneiderman, 1998). These are aspects of
group work that are needed in almost every job, so it is important that students practice them. Working in groups also helps students learn better by communicating with peers through each step and working together to solve problems (Kearsley & Shneiderman, 1998).

When students collaborate in order to create a project, this creates a purpose for the work and does not force students to complete arbitrary assignments. Students are forced to “clarify and verbalize their problems, thereby facilitating solutions,” (Kearsley & Shneiderman, 1999). It can also make the project more interesting for students when they are donating work to society, the third facet of Engagement Theory. Rather than assign a list of questions for students to answer based on a reading, students should be required to use critical thinking to complete a group assignment. Instructors can either assign a project to be completed or let students pick one of their own that relates to their interests. Having an outside focus gives students the opportunity to make “a useful contribution while learning” (Kearsley & Shneiderman, 1998). This not only allows students to make an improvement to society, but it also can give them a sense of satisfaction through their work.

When Engagement Theory is applied to curriculum, it offers great learning power to students, as they are engaged in learning activities in which they find value (Marshall, 2007). When students work together on tasks that they find worthwhile, they are more likely to enjoy learning. With meaningful work through collaboration, students will also enjoy deeper learning that extends beyond the scope of one course. This idea of engagement can be applied in a variety of ways, both online and in face-to-face courses. For example, if a math instructor asked each group of students to write about algebra,
they could collaborate through a wiki to share their ideas. They could discuss back and forth, formulating new ideas and reshaping existing ones. Once they get their ideas in paragraph form, those words could be pasted in an ebook creator. The final product could be a new resource on algebra that all math instructors would be able to provide to their students in future courses. This ebook could even be used as part of the reading requirement for a new online course that students might be assigned to pilot. In this proposed math course, students were put into groups, collaborated on a project with the use of wikis, tweaked existing ideas and accepted new ones, and then created a book that could become part of the curriculum for future math courses. That is Engagement Theory at work, made possible by the use of Internet-based applications.

One method used when Engagement Theory is applied to curriculum is the use of the flipped classroom model, which has been shown to increase student interest in content and decrease failure rates (Enfield, 2013). The vision of a flipped classroom is to deliver instruction online before class, and then students complete activities or practice problems together in class (Strayer, 2007). This works by allowing students to watch lectures at home, either through a website that offers educational content or through a learning management system where an instructor uploads his own instructional material (MacIsaac, 2011). Students can take notes at their own pace and read text or watch videos as many times as necessary to comprehend the concepts being taught. When students come together for class, either face-to-face or through the use of a synchronous conferencing tool, they either discuss the content they learned at home, complete a lab or activity, or practice solving problems as a group where they can get support and immediate feedback from the instructor. These activities, which are the basis for
Engagement Theory, are known to improve student learning when implemented into curriculum (Marshall, 2007). The next section will review how these activities are actually implemented and the impact they can have on student learning.

*Flipped Classrooms*

Engagement Theory suggests that when students can collaborate with others to relate content to their interests, they will achieve high satisfaction (Kearsley & Shneiderman, 1998). Using the flipped classroom model allows students to collaborate during class time instead of listening to a lecture that could instead be easily watched from home. Throughout a course that has been flipped, students are more likely to be engaged, enjoy what they are learning, and actually remember the content after they finish the course (Hiltz, 1994). The current research shows that the flipped classroom model may be a revolutionary tool for education because students are engaged during class.

Jeremy Strayer, a former doctoral student studying educational theory and practice at Ohio State University, spent several years studying the flipped classroom model. He wrote in his dissertation that over 50% of freshmen failed English and 44% of freshmen failed math at his institution before implementing the flipped classroom model (Strayer, 2007). After implementing flipped classrooms in these two disciplines, he discovered that 19% of freshmen failed English and only 13% of freshmen failed math (Strayer, 2007). Strayer said he believed that “students would control when they watched the video, thus they would be most likely to be alert and able to take in new information,” (2007). Not only do students benefit by having social interaction during class instead of sitting still and listening to a lecture, but they would also be able to tackle the lecture
during a time of the day when they are alert and ready to take notes.

Recently, the University of Michigan’s math department flipped their calculus classrooms. Students were required to learn the assigned material at home, and then in class they worked together to solve problems. According to their research:

In 2008, Michigan gave concept inventories to students before they started calculus and after they finished and calculated the difference relative to the maximum gain they could have made. Students in Michigan's flipped courses showed gains at about twice the rate of those in traditional lectures at other institutions who took the same inventories. (Berrett, 2012).

Because effective learning is more likely to take place, the flipped classroom model is a top trend in education. Using flipped classrooms is a win-win situation; students benefit from more interaction and support from their instructor and peers, and schools benefit from getting better student-learning outcomes (Berrett, 2012). However, creating engaging courses and implementing flipped classroom methods are only a small part of how curriculum should be designed to ensure student success. The next section will explore curriculum design and how courses should be structured based on research’s best practices leading to student success.

**Curriculum Design**

The effectiveness of a course, and consequently student success, ultimately lies in the quality of the curriculum of the course. Courses today require a more student-centered approach in which faculty are no longer the lecturer in the front of the room (Smith, Ferguson, & Caris, 2001). Rather, they are a facilitator, standing along the sidelines guiding students through course content.

McGiven (1994) found that the most important component of a successful course
was consistent interaction with students (Parker, 1997). To create an environment that allows for this, there are several actions faculty can take: provide clear expectations through the use of learning objectives, use multiple modes of communication, participate in discussions, create interactive content, and provide timely feedback. The following section will review these concepts and why and how these concepts connect with an environment that encourages student success.

**Learning Objectives**

In order for students to be successful, faculty need to communicate clearly with students as to what the expectations are for a course. Writing understandable learning objectives communicates to students what the instructional intent of the course is (Shank, 2005). Well-written learning objectives contain a “specific, measureable, and observable action verb that describes the skill that the learner will exhibit,” (Shank, 2005). By continually providing these objectives throughout a course, students will be clear as to what is required of them. However, learning objectives are not the only method through which faculty should communicate to students what is required of them. In fact, faculty should use multiple modes of communication to reach students.

**Modes of Communication**

Using multiple modes of communication increases the likelihood that students will interact with faculty and with other students. Communication in a course can occur either in a classroom or online. For face-to-face courses, faculty should communicate with students throughout each class meeting. Faculty should provide constant verbal feedback throughout the meeting time and guide students through their learning. For distance learning courses, there are many methods for communicating. Distance learning
is “any learning that occurs with the instructor and students separated by time or location,” (Rybarczyk, 2007). This form of learning comes in two types: asynchronous and synchronous. Asynchronous distance learning allows interaction among students and instructors at different times, and synchronous learning is when instructors and students communicate live (Chen, Ko, Kinshuk, & Lin, 2005). Asynchronous tools, which allow for communication at different times, consist of email, discussion boards, blogs, or wikis (Chen et al., 2005). Synchronous tools, which allow for real-time communication, consist of web conferencing tools such as Skype or FaceTime (Chen et al., 2005). A distance course is more effective when faculty allow students to interact asynchronously through a discussion board or wiki but are also given the opportunities to communicate synchronously with others for immediate feedback (Rob, 2013). Therefore, it is best to use a combination of both asynchronous and synchronous tools so that the needs of students with varying preferences are met.

Faculty should not just lecture in class. Rather, they should participate in discussion and encourage students to interact with each other. In this way, faculty are present but learning is still student-centered. For distance learning courses, faculty need to facilitate discussion in an online environment, much like discussion in a face-to-face classroom (Howell, Saba, Lindsay, & Williams, 2004). When faculty do not make their presence known in an online course, they are seen as invisible, which can make students feel isolated and unimportant (Blignaut & Trollip, 2003). It is the role of faculty in both face-to-face and online courses to guide students through discussion, ensuring that they are kept on-task and are having meaningful conversations related to the content of the
course (Howell et al., 2004). It is this type of interaction that predicts learner satisfaction and achievement (Blignaut & Trollip, 2003), so it is crucial for student success.

When faculty use many different methods to communicate with students, they are more likely to interact and be more active learners. Nevertheless, communication is not the only interactive aspect of a course that should be present; students should also be interacting with course material.

*Content Interaction*

In addition to discussion, course material and content provided should be interactive. Even when a course is taught face-to-face, a lot of content is now delivered through the Internet before class so that meeting time can be spent interacting with peers. Lecture capture, technology that records lectures for student viewing online, adds a personalized element to a course that can create a sense of interaction between students and faculty (Dey, Burn, & Gerdes, 2009). Lectures created through this technology often include video of the instructor himself, so although the videos are not live, students get a sense of connectedness to their instructor (Dey et al., 2009). Students can also get a sense of connectedness to other students in the course through group projects (Williams, Morgan, & Cameron, 2011). Faculty can assign projects either in a classroom or online to groups of students that allow them to apply the knowledge they gained throughout the course in a meaningful way, giving them a sense of accomplishment and purpose (Kearsley & Shneiderman, 1998).

Although student interaction with content can help them feel connected to their instructor and other students, they still need constructive criticism in order to improve
their learning and be successful. Students should receive feedback from their instructors in order to experience deeper learning, which the next section explores.

Providing Feedback to Students

Students receive feedback from each other when working in groups, but they also need to receive timely feedback from their instructors. Students in a face-to-face course are able to get immediate feedback from instructors in a physical classroom, which can occur through verbal and nonverbal cues (Linton, 2013). To provide timely feedback to students in an online course, faculty should communicate often through email, discussion board comments, and synchronous sessions using web conferencing tools (Bonnel, 2008). In addition, faculty should provide thorough feedback to assignments that students submit online.

Another aspect of providing feedback that students need is the ability to work with faculty during their office hours (Chen et al., 2005). For traditional students, it is important that faculty make themselves available to meet in person. Because distance students often live far from campus, they do not have the ability to meet with faculty face-to-face. By offering virtual office hours through the use of a web conferencing tool, online students can interact with faculty much like they would on campus.

These actions, although simple to implement, have great power in any course. Because there is an increase in student demand for communication in courses (NEA, 2000) and because this communication is such a strong predictor of student success (Blignaut & Trollip, 2003), it is important for faculty to maintain ongoing interaction with students. Students need to know what their role is in a course and that faculty are present throughout the course (Blignaut & Trollip, 2003). Faculty’s use of multiple
methods of interaction and feedback will enhance student learning and give them a sense of belonging, rather than feeling isolated and unengaged. When these forms of interaction are combined, faculty can create an effective environment with high levels of student achievement.

Faculty are not the only ones who can provide students with feedback. The use of games and artificial systems in education allow students to interact with content and receive immediate feedback to aid in their learning. The next section delves into the opportunities that gaming, another fragment of curriculum design, can provide students.

**Gaming**

Both the field of education and the field of technology are constantly evolving. When these two fields combine in educational technology, the new trends are greater both in number and in importance. In addition to the aforesaid technologies, another educational technology that has shown to help student success is gaming (Johnson, Adams Becker, Estrada, & Freeman, 2014).

As people watched Jane McGonigal’s TED talk, The Game That Can Give You 10 Extra Years of Life (TEDtalksDirector, 2012), many were moved to tears. Jane talked about having a traumatic brain injury, lying in bed suffering from the side effects, and wanting to die. As people listened to her story about turning to gaming in order to relieve her suffering, many were able to identify with her described feelings. Like Jane, many people turn to games because they are a way to find happiness. Playing games physically increases brain power (Betz, 1995) and has been shown to improve players’ moods (Griffiths, 2005) by allowing them to reach goals, earn rewards, and experience epic wins, which McGonigal defines as “an outcome that is so extraordinarily positive, you
had no idea it was even possible until you achieved it,” (2011). Gaming provides “immediate performance feedback to the players,” (Adams, Cummins, & Johnson, 2012), so players are able to enjoy the rewards from their work right away. These results of gaming – increased brain power, attainment of goals, encouragement to earn rewards, reception of immediate feedback – are the very same aspects that exist in a well-designed course (Fink, 1999).

By incorporating gaming aspects into curriculum, students can be kept at the edge of their abilities (McGonigal, 2011), which in turn keeps them more engaged. “Students engaged in educational games and simulations are interpreting, analyzing, discovering, evaluating, acting, and problem solving,” (Antonacci & Modress, 2008), which is what keeps retention high and offers true learning (Bekebrede, Mayer, & Warmelink, 2011). Because gaming provides students with such rich learning experiences and motivates them to accomplish more, incorporating gaming into a course is a way to provide rich feedback that can help motivate students to achieve success in a course.

Even when the previously mentioned aspects of curriculum are included in a course, introductory math courses often have high failure rates if mastery learning is not also included in the design of the course (Lin et al., 2013). Therefore, the use of mastery learning in an introductory math course is one of the most significant components of a well-designed course.

Mastery Learning

Mastery learning, learning that requires students to master a concept before moving to the next (Lin et al., 2013), has also shown to improve scores and student learning (Boggs et al., 2004). According to Lin et al. (2013), integrating mastery learning
into mathematics curriculum greatly increased students’ mathematics performance. For courses in which concepts build upon one another, mastery learning should be the standard method of instruction. If students in an introductory math course must understand each unit before moving to the next, then instructors can ensure that students are building concepts upon a solid foundation rather than falling behind and constantly fighting an uphill battle. Research indicates that mastery learning has several advantages over non-mastery approaches. Students tend to have better attitudes toward the subject matter, learn more, and perform at higher levels on classroom assessments (Kulik & Kulik 1990; Shuell, 1996), which is especially ideal for students in introductory math courses who often times have poor mathematical self-efficacy based on previous failures (Eppler et al., 2003).

Teachers who use mastery learning provide feedback to students quite frequently in order to identify what students know well and what they still need to understand before moving to the next unit (Guskey, 2007). Providing constant feedback in a class with many students can be difficult, if not impossible, in a college course. In a face-to-face classroom, instructors would have a difficult time creating multiple versions of each test, grading these multiple versions when students are at a variety of stages, scheduling time for students to re-take tests, and teaching students at different stages (Boggs et al., 2004). However, using a learning management system (LMS) can easily eliminate these problems. An LMS can provide a stimulating learning environment that can engage students through reflection, application, and interaction (Macdonald, Vasquez, & Caverly, 2002). By setting computerized tests for students, instructors can provide personalized feedback that students will automatically receive for each question they
answer incorrectly. Computerized testing permits students to attempt a test multiple times with quick grading. In addition to tests, discussion boards allow for more feedback than an instructor could give in a classroom. Discussion boards allow for more conversation among students that may take place in a face-to-face environment, since there is no limit in an LMS as to the number of simultaneous discussions.

Mastery learning is not a new concept; many research studies have shown that requiring mastery learning in a course leads to higher success rates. In Lin, Liu, and Yuan’s study (2008) of students who failed to pass their math course, 85.7% of them passed the second time with the use of an adaptive learning system. The use of such a system has even allowed at-risk students to perform better and earn higher exam scores than their peers who are not considered at-risk (Rae & Samuels, 2011). Not only does mastery learning help students succeed in their current math course, but the improved self-efficacies they gain is carried with them in future courses (Zimmerman & Dibenedetto, 2008).

The aforementioned aspects of curriculum design (incorporating Engagement Theory, providing measurable learning objectives, communicating with students, allowing students to interact with content, providing valuable feedback, using gaming methods, integrating mastery learning) are the educational approaches discussed that exist in a well-designed course. This is true for both an online course and a face-to-face course; all of these methods can be applied to either mode of course delivery. However, because introductory math courses can be offered online or face-to-face, it is imperative that both modes are considered when it comes to making changes that will help students succeed. Making an online course equivalent to a face-to-face course is a new hurdle for
faculty due to the originality of online courses. In addition, designing and teaching an
online course is not the same as designing and teaching a face-to-face course. To be sure
that students succeed in an online course, faculty need to consider more than just
providing feedback, writing learning objectives, and communicating with students. The
next section examines how online courses should be designed to certify that issues
specific to online learning are not preventing students from succeeding in introductory
math courses, and, therefore, are not at a disadvantage from face-to-face students.

Making an Online Course Equivalent to a Face-to-Face Course

Online courses are valuable for adult learners who have full-time jobs or families
and need flexible learning options. Online learning is also useful for students who live
far from campus and are unable to travel. Because there are so many students who
benefit from online education, it is important to offer these types of courses. However,
there are many aspects of an online course that do not exist in face-to-face courses, and
these aspects require attention in order for online courses to be equivalent to face-to-face
courses. Online students often are lost when they log into their online course for the first
time, not knowing where to find information or how to navigate through the course
(Wang, Shannon, & Ross, 2013). Students in online courses have reported that they feel
isolated and do not have much interaction with classmates or instructors like they do in
face-to-face courses (Saadé, He, & Kira, 2007). Many times students are not even aware
of who others are in their online courses, because they do not have this interaction.
Students must have a sense of belonging, because when they do not feel like an essential
part of the online environment, they often have low levels of achievement and find it
difficult to succeed (Hill, 2012). Asynchronous learning also does not offer the time and
space for students to work together in groups as easily as they do in a classroom, which also may lead to feelings of isolation (Chen et al., 2005). Distance students can work together through the use of wikis, email, and discussion boards, but responses from group members are not immediate, which can make moving forward in a project difficult (Tong, 2011).

To overcome these obstacles, synchronous courses are becoming more widely available to distance learning students. While they were once a rare commodity, synchronous courses are becoming more prevalent with advances in technology. With an increase in Internet bandwidth and new tools available, students can now use video conferencing tools to communicate live with other students and their instructor from anywhere in the world.

Video conferencing is a method used to connect two or more people at their respective geographic locations (Chen et al., 2005). Until recently, video conferencing required expensive equipment for all parties wanting to participate. Now video conferencing usually involves connecting to others through an Internet browser (Chen et al., 2005). Most conferencing tools allow users to share video and audio of themselves through the use of a webcam and microphone. Often there is an interactive whiteboard upon which users can write, and users have the ability to share applications or desktops. All of these elements can be easily utilized by having instructors and students simply visit a link in their browser that opens a virtual conferencing room.

With the ease of use of such a powerful tool, many of the problems existing in distance education can be eliminated. Instructors can give a tour of their online course to help students understand the various parts of the course. Students can log into the virtual
room, and instructors can share their desktop while explaining to those in the room what the various parts of the course are and how to navigate each component. Rather than feel isolated and not have much interaction, students can use video conferencing to feel like they belong to a group. Students can see and hear each other, much like a face-to-face course. Students can meet virtually and accomplish the same tasks they would in a classroom working on a project or having a discussion. Students can meet virtually for instructor office hours, group work, or tutoring, something that has never even been possible for distance students in the past. By having these real-time components in a course, students can receive immediate feedback rather than waiting hours or days.

Although the use of video conferencing in distance education is new, the advantages that it offers have shown to improve student learning. Giving distance students the opportunity to be present and participate in a real-time class increases their level of motivation, and they are more likely to be successful (Chen et al., 2005). While comparing examination results between distance students who used video conferencing and those who did not, Frindt found that the group who did use the tool had an eight percent higher average (2008). She also found that all of the students who participated synchronously passed, while there were several students in the asynchronous group who did not pass (2008). Additionally, offering online students the opportunity to meet synchronously makes online courses more equivalent to face-to-face courses.

As the Internet becomes more widely available, synchronous learning is becoming more widespread, and the use of video conferencing in this type of distance education has positive findings. Access to education is made easier as students are encouraged to meet in real-time with each other and their instructors through the web.
Using video conferencing in online education offers students possibilities to achieve greater learning than ever before.

With the vast number of tools available, online education can be as effective as face-to-face education. Incorporating the previously mentioned tools and teaching methods into a course is extremely challenging and even impossible if the right support is not available. The recent development of adaptive learning systems, however, can aid in the development of a well-designed course and provide solutions to issues that exist in introductory math courses that cause students to not succeed. The next section will look at these systems and how they are designed to improve math education.

**Adaptive Learning Systems**

Building a course that is engaging, incorporates mastery learning, and is based on good curriculum design practices is no easy task. However, adaptive learning systems are able to put all of the previously discussed components of an exceptional course into one system.

Using an adaptive learning system, students can work at their own pace and only move to the next concept once they have proven mastery of the current concept. These systems are “web-based application programs that provide a personalized learning environment for each learner by adapting both the presentation and the wandering in content,” (Özyurt et al., 2013). Students log into an online system where they take a pre-test, letting the system detect the student’s existing knowledge and learning preferences. Students discover on which step of the staircase they stand for the course in which they are enrolled. The system then adapts instruction for each student and creates an
individualized path, opening new content areas only after the student masters the current content area. By incorporating mastery learning in the system, students are able to spend more time with content on which they struggle and only move to the next step once the present step is mastered. Such a computerized system guides students so that they do not fall into the trap of missing a step and falling behind, making adaptive learning systems a key technology that could improve math education.

*Features in Adaptive Learning Systems*

Adaptive learning systems help students succeed by communicating clearly what is expected of them. Teams of subject matter and education experts work together to create clear learning objectives that are tied to each question and activity in the system (Griff & Matter, 2013). These well-written objectives from the experts help guide students so that they know exactly what is expected of them.

Another aspect of the system that aids students in their learning is the way in which it assigns questions to students. The system uses an algorithm to determine which question types students prefer during the pre-test and then assigns questions to each student based on that information. Instructors can find it difficult to manage a course and help students succeed when some students think the course is paced too quickly and fall behind, while others think the course is paced too slowly and are bored. By being assigned questions based on learner preferences, students may be more likely to be engaged in the content (Clayton, Blumberg, & Auld, 2010) and also will be learning content that is not too far ahead or too far behind where they are cognitively with course content (Walkington, 2013). Furthermore, all questions and videos in the system require student interaction, helping them to feel connected to what they are learning.
These systems were created to also engage students in course content through the various aspects of gaming that are incorporated. These systems set goals for students and allow them to earn virtual rewards when they meet these goals, which can offer students a sense of accomplishment (Hark, 1997). Students also receive immediate feedback with each question they answer in the system, providing students the opportunity to enjoy rewards from their work right away. After they submit an answer, either they receive a written explanation of why the answer was incorrect, or they receive written compliments for being correct. Additionally, the immediate feedback students receive from the system helps them identify what they know well and what they still need to understand before moving to the next unit. This feedback is a type of interaction students can have with course content any time during the day or night. Rather than rely on faculty and other students to provide communication, students can interact with avatars and other characters within the adaptive learning system, which adds another mode of communication for students. This can keep students on task and offer students a sense of connectedness to course content (Falloon, 2010).

With adaptive learning systems, students having varying levels of pre-requisite knowledge is no longer a pressing issue. Courses are not taught at one level since the adaptive learning system detects at what level students are and takes them through the content from where they start. Students who lack the expected background content can gain that knowledge through remediation in the adaptive learning system (Howard, Remenyi, & Pap, 2006).

Students in a course have different learning preferences, pre-information, and learning abilities (Özyurt et al., 2013), all of which greatly impact an individual’s
learning. Many students in introductory math courses have been labeled as at-risk students or students who have learning difficulties. However, through the use of adaptive learning systems that provide students with the appropriate environment and stimulants preferential to each student (Özyurt et al., 2013), at-risk students may be capable of learning just as well as their peers who do not struggle (Özyurt et al., 2013).

Course Delivery Mode

Adaptive learning systems, although accessed through the use of a computer, can be utilized in both online courses and face-to-face courses. Using these systems in either type of course allows students to work through content on their own. Then time communicating online or communicating face-to-face can be spent collaborating and engaging with each other for a deeper learning experience, applying what they learned from the adaptive learning systems through the Relate-Create-Donate model of Engagement Theory.

ALEKS

ALEKS is an adaptive learning system in particular that incorporates each of the aforementioned parts of a well-designed course. ALEKS, which stands for Assessment and Learning in Knowledge Spaces, allows students to take a placement test the first time they log into the system. Upon completion of the 25-35 questions, the system creates a pie chart with a corresponding report (See Figure 1), giving students a summary of what they know, what they do not know, and what they have left to accomplish before the end of the semester (Craig et al., 2013). Students select portions of the pie chart through which to work, and as they do so, they interact with videos, questions, and other content. Each student’s pie chart continually updates to show mastery throughout the
semester. Students are continually assessed by the system to detect what they know and what they have left to accomplish, receiving feedback from the system each step of the way.

![Figure 1. Screenshot of the ALEKS student homepage](image)

**Impact of Adaptive Learning Systems**

Although adaptive learning systems incorporate each aspect of good course design, the true impact of the use of an adaptive learning system is unknown. There is a lack of research on user evaluation of adaptive systems, especially in mathematics courses where these systems are needed the most (Fischman, 2011). The studies that do exist involve low numbers of participants. These small studies, which were conducted mostly in secondary schools rather than in higher education, are qualitative studies that do not offer statistical analyses that quantitative studies can. In addition, the studies that have been completed were not done in isolation, so the effectiveness of adaptive learning systems is undetermined (Fischman, 2011). Although the concept of these systems works in theory, whether or not they work has yet to be determined. In order for a new technology to work, students must first buy into the concept. A new technology could potentially revolutionize education with its concept, but without student interest, the
technology would offer no benefit to learning, making students’ attitudes toward the systems the most important aspect in their effectiveness. However, to truly measure the system’s effectiveness, changes in grades with the use of the system must also be evaluated.
Chapter Three

Methodology

This study strived to determine students’ perceived benefits of using an adaptive learning system in an introductory college math course and to evaluate their reports in comparison to the amount of time they spent in the system. The researcher also studied the relationship between these results for different groups of students. Additionally, the researcher studied the difference in grades between students who used the system and students who did not use the system. Specifically, the researcher attempted to answer the following questions:

1. How satisfied are students in College Algebra with the use of an adaptive learning system in the course?
2. Is there a relationship between how satisfied students are with the system and how much time they invest into using the system?
3. Is there a relationship between how satisfied students are with the adaptive learning system and their satisfaction of mathematics?
4. Are there differences in student satisfaction of the adaptive learning system between students taking online College Algebra and students taking face-to-face College Algebra?
5. Are there differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system?

A cross-sectional survey study was completed to collect data from students in a first-year introductory math course. Using this study design, the researcher was able to collect data at one point in time: near the end of the semester after all content in the adaptive
learning system was covered. This allowed the researcher to examine students’ opinions after fully assessing the adaptive learning system.

To obtain grade information, a chosen assistant from the mathematics department collected final grades in a document and removed student names. This information was then sent to the researcher for conducting data analyses.

**Instrumentation**

Very little research has been conducted to examine the effectiveness of adaptive learning systems. Of the previous research that does exist, researchers did not address students’ perceptions of the systems or whether or not students attributed their success in the course to the use of the system. Also lacking in the research are studies conducted in higher education, as the few studies that have been completed were done so in secondary schools. To examine these issues in a higher education course, there was a need to construct an instrument.

The instrument was a self-reporting electronic questionnaire with 17 items. The first two items measured how much time students reported they spent in the system. The third item asked students whether or not they enjoy math, as the information from that item could be correlated to how beneficial they found the adaptive learning system and was used to help answer the third research question. Items 4-11 examined students’ perceptions about the adaptive learning system. In other words, the researcher was trying to gauge whether or not students believed that the use of the system helped them earn a better grade than if they had not had access to the system. Although Item 12 was originally included in the survey to examine students’ perceptions about the usefulness of
the adaptive learning system, this item was not included in any of the analyses, as its relation to the adaptive learning system was not clear. The last five items were open-ended questions used to collect more information about why students did or did not think that the system was beneficial to their learning and the purpose of the system.

All items preceding the open-ended questions on the instrument were designed with a 4-point Likert scale. The four choices were Strongly Disagree, Disagree, Agree, and Strongly Agree. This allowed for one set of instructions for the instrument, making it easier for the respondents to complete. All questions on the instrument were statements.

Having the survey reviewed by several experts in online learning and mathematics education ensured content validity. A measurement and survey expert also reviewed instrument items. Items were written with simple language and used positive statements. The questions were close-ended with ordered choices, except for the last five open-ended questions, which helped to minimize measurement error.

**Research Design**

This was a non-experimental survey study. Students were surveyed with questions about personal beliefs related to adaptive learning systems and their perceived effect on learning. Therefore, there was no manipulation of variables. No control group was used with respect to the survey, but a control group was used with respect to grades affected by the use of the adaptive learning system. No cause-effect inferences were made, but the researcher was able to make generalizations of the population’s beliefs about the effects of adaptive learning systems in education.
All sections of College Algebra that utilized the adaptive learning system had the same curriculum design through the use of a learning management system. The online sections used a web conferencing tool to meet with students synchronously to answer questions and conduct other class activities. The face-to-face sections, which were designed using the flipped classroom model, met in person to answer questions and conduct the same class activities as the online sections. Students in both types of sections were instructed to watch videos and complete lessons on their own before meeting together synchronously. Common variables for the two groups were controlled by having the same curriculum design and delivery of content through similar methods, such as PowerPoint presentations, practice review sheets, and homework follow-ups. Additionally, the same group of instructors taught both groups of students.

After conducting Independent t-tests with grade information, final grades of students who did not use the adaptive learning system from a previous semester were compared to students who did use the adaptive learning system. Students in a past section that did not use the adaptive learning system were compared to students who did use the system. By gathering grade data of students from the past who did not use the system, this study had a control group. Inferences about the effectiveness of adaptive learning systems in teaching and learning were suggested about the population.

**Participants and Research Site**

The participants in this study were students in a mathematics course at a university in Ohio. The university became a member of the state university system in 1967 and forms the third-largest public university in the state. The university is accredited by The Higher
Learning Commission of the North Central Association of Colleges and Schools. With over 300 programs, the university serves 23,000 students.

The mathematics course in which the participants were enrolled is a course for which faculty incorporate an adaptive learning system into the curriculum. The only course for which this is implemented at the university is College Algebra. Therefore, the sample was taken from students in this specific course.

Participants had diverse backgrounds of knowledge, but College Algebra was the first college-level math course for most of the students. Although the majority of students were freshmen, their declared majors varied.

**Data Collection**

Students from the sample began using the adaptive learning system in August 2014. By the end of the semester, students had been using the system for 16 weeks and had an understanding of how the system affected their learning. Therefore, the link to the survey was given to all students during the last week of the semester before the final exam.

Students were notified ahead of time that their participation was not mandatory. They were informed that if they do participate, their answers would be confidential. They were also told about the purpose and value of the study, who was analyzing the results and how they would used to benefit students, how to provide responses, and who to contact if they had any questions or feedback.

The survey was posted in the learning management system for each section of the course. Students were asked to complete the survey within seven days of the link being posted. Two follow-up messages were sent to students before the expiration of the
survey. The response rate was calculated by dividing the number of completed surveys (211) by the number of students who had access to completing the survey (728). Therefore, the survey had a response rate of 29%.

By surveying students who had a full semester of experience working in an adaptive learning system, the researcher was able to study what their perceived ideas about the system were with respect to the success of their education. Knowing how well students value the system, faculty can gain a better grasp of how effective the system will be to their future students’ learning.

To compare grades between the control group and the students from this past semester, a chosen assistant from the mathematics department gathered all grades. This person compiled grades from students who took College Algebra in the Spring 2013 semester, the last semester of students who did not use ALEKS, and the Fall 2014 semester. This person deidentified student names and sent the file to the researcher. By analyzing this deidentified data, the researcher was able to take a deeper look at the difference in grades between the control group and all students who completed College Algebra this past semester.

**Data Analysis**

In order to answer the research questions, both descriptive and inferential statistical analyses were conducted. A Chi-Square test was used to study how satisfied students were with the use of an adaptive learning system (Question 1). Responses to the open-ended questions on the instrument were reviewed to collect more information on students’ satisfaction with the system. Students’ answers to these questions were
categorized into two groups: positive attitudes toward the adaptive learning system and negative attitudes toward the system. Upon categorization, responses were classified into themes using key words.

A correlation test was used to examine if there was a relationship between how much time students invested in using the adaptive learning system to aid their studies with how well they reported being satisfied with the system (Question 2). To find if there was a relationship between student satisfaction with the adaptive learning system and their satisfaction of mathematics (Question 3), a Chi-Square test was conducted. To compare online to face-to-face students with respect to their reported levels of satisfaction (Question 4), the researcher performed an Independent t-test between the two groups. Lastly, an Independent t-test was used to find differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system (Question 5). Table 1 summarizes each research question and the statistical analyses that were conducted in order to answer the question.
<table>
<thead>
<tr>
<th>Research Question</th>
<th>Variable</th>
<th>Instrument</th>
<th>Scale &amp; Measurement</th>
<th>Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>How satisfied are students in College Algebra with the use of an adaptive learning system in the course?</td>
<td>reported level of satisfaction</td>
<td>Items 4-11</td>
<td>1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree</td>
<td>Chi-Square</td>
</tr>
<tr>
<td>Is there a relationship between how satisfied students are with the system and how much time they invest into using the system?</td>
<td>reported level of satisfaction; time invested in using the adaptive learning system</td>
<td>Items 1-2, 4-11</td>
<td>1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree</td>
<td>Correlation</td>
</tr>
<tr>
<td>Is there a relationship between how satisfied students are with the adaptive learning system and their satisfaction of mathematics?</td>
<td>reported level of satisfaction of adaptive learning system; reported level of satisfaction of mathematics</td>
<td>Items 3-12</td>
<td>1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree</td>
<td>Chi-Square</td>
</tr>
<tr>
<td>Are there differences in student satisfaction of the adaptive learning system between students taking online College Algebra and students taking face-to-face College Algebra?</td>
<td>IV: online or face-to-face  DV: reported level of satisfaction</td>
<td>Items 4-11</td>
<td>1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree</td>
<td>Independent t-test</td>
</tr>
<tr>
<td>Are there differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system?</td>
<td>IV: use of an adaptive learning system in College Algebra (dichotomous)  DV: final grade (continuous)</td>
<td>N/A</td>
<td>Letter grade</td>
<td>Independent t-test</td>
</tr>
</tbody>
</table>

In addition to the aforementioned tests, the Rasch model was used for analysis of data collected from Items 1-12 of the instrument (see Appendix C). These items were used to analyze students’ reported satisfaction with the adaptive learning system, which answered Research Questions 1, 2, 3, and 4.

The Rasch model provides a framework that allows researchers to compare patterns of responses for the construct being measured (Bond & Fox, 2007). The model
is based on the idea that “useful measurement involves examination of only one human attribute at a time (unidimensionality) on a hierarchical more than/less than line of inquiry” (Bond & Fox, 2007, p. 41). Therefore, the model can be used to estimate item difficulties and plot these measures along a linear representation of students’ reported satisfaction with the adaptive learning system.

Analyses with the Rasch model allowed the researcher to estimate person ability and item difficulty in a meaningful way since each item analyzed contributed to the measure of a single attribute: how satisfied students were with the adaptive learning system. Analyses of attitude scales with the Rasch model allowed the researcher to investigate fit, separation, reliability, and validity of the instrument.

The Rasch Model

The Rasch Model is a measurement model that uses a single construct (Snyder & Sheehan, 1992). In other words, this method measures one attribute at a time by converting raw scores into linear measures (Wright & Stone, 1979). The Rasch Model allows each item difficulty and person ability to be measured using a logit scale, including an estimate of error (Bond & Fox, 2007). The use of a logit scale allows for raw scores from ordinal data to be converted to a common interval scale for statistical analysis (You, 2010). Using a logit value of 0 as the mean of the item difficulty estimates, researchers can express item difficulty for each survey responder (Bond & Fox, 2007). Person ability can be assessed with respect to item difficulty estimates (Bond & Fox, 2007). Using error estimates and item and person reliability, researchers can
provide replicability of the item and person estimates (Bond & Fox, 2007) by using the following mathematical expression:

\[ P_{ni} \left( X_{ni} = \frac{1}{B_n D_i} \right) = \frac{e^{(B_n - D_i)}}{1 + e^{B_n - D_i}} \]

Using this formula, researchers can determine item difficulty of each question in a survey and person ability of each student who completes a survey.

**Reliability**

There are two types of reliability: item reliability and person reliability. Item reliability tells the researcher what the replicability of item responses would be if the same items were given to another sample of similar respondents (Bond & Fox, 2007). Person reliability tells the researcher what the replicability of person ordering would be expected if the sample was given another similar set of items measuring the same construct (Bond & Fox, 2007). In addition, person reliability indicates whether or not “items are targeted at the ability level of the sample” (Bond & Fox, 2007, p. 40). A high reliability indicates that the researcher can expect consistency in inferences (Bond & Fox, 2007). Logically, reliability is the amount of variance remaining after measurement error is subtracted (Wright, 1996), called the True Variance.

**Separation**

Separation is the ratio of the adjusted standard deviation and the root mean square standard error that indicates how well the instrument can distinguish between items and persons (Linacre, 2009). The larger the separation, the better the instrument is at distinguishing between the two.

**Dimensionality**

Dimensionality examines if groups of items share similar patterns of
unexpectedness. Specifically, researchers examine the variance explained by the first contrast in order to determine if a second dimension is in effect (Bond & Fox, 2007).

**Item Difficulty**

Item difficulty gives researchers an estimate of the probability that an item will draw a positive response from the responder (Bond & Fox, 2007). In other words, the more difficult an item is, the fewer respondents will agree with the statement.

**Person Ability**

Person ability is the respondent’s tendency to agree to a question on the survey (Bond & Fox, 2007). In other words, the higher a respondent’s person ability, the more likely that respondent is to agree to the questions.

In summary, items that are more difficult and respondents who are more likely to agree with the questions are reported as positive logits (You, 2010). According to Bond and Fox, there are several measures in the Rasch Model that are used to order persons according to their ability and item difficulty: fit, separation, reliability, and validity.

**Fit**

Fit is a calculated number that explains how well the observed responses and the model expectations match (You, 2010). There are two types of fit: item fit and person fit. Each item from a survey is examined through all responses to that item, while each respondent is also examined through all items to which they responded. Both item fit and person fit are single numbers attributed to the item or respondent, respectively, to describe the pattern of responses. Respondents agree with difficult items less frequently than they agree with less difficult items. Difficult persons are less likely to agree with items than persons who are not difficult. When values for item fit and person fit fall
within an accepted range for the study, researchers can provide meaningful summaries of the observations. Researchers are able to relate items and persons in a way that represents the construct being investigated (Bond & Fox, 2007). On the other hand, when fit values do not fall within an accepted range, researchers may need to investigate those items or persons.

Validity

Construct validity is related to the idea that responses are reflections of a single underlying construct and by the respondents’ ability (Bond & Fox, 2007). Construct validity is supported by item fit: if the infit mean square is close to one, then it is considered acceptable (You, 2010). Values not close to one indicate that the items were easy to support and thus need further investigation.

Winsteps

Data collected through the instrument was coded and analyzed with Winsteps, a Rasch-model computer software. Winsteps was used to analyze whether or not each question provided a meaningful summary of persons, helping to eliminate measurement error. The researcher then examined items that did not fit the model, followed by persons who did not fit.
Chapter Four

Results

The purpose of this chapter is to present student responses to the adaptive learning questionnaire used in this study and to report the differences in grades between students who did not use the adaptive learning system and students who did use the system. There were four identified purposes to this study. The first purpose of the study was to determine if there was a relationship between how satisfied students were with an adaptive learning system in their College Algebra course and how much time they invested into using the system. The second purpose of the study was to explore a possible relationship between how satisfied students were with the system and their satisfaction of mathematics. The third purpose of the study was to investigate differences in satisfaction of the system between students taking College Algebra online and students taking College Algebra face-to-face. The fourth purpose of the study was to examine differences in final grades between students who did not use the system and students who did use the system.

Based on the limited research on adaptive learning systems, especially in mathematics courses, this study posed the following research questions:

1. How satisfied are students in College Algebra with the use of an adaptive learning system in the course?
2. Is there a relationship between how satisfied students are with the system and how much time they invest into using the system?
3. Is there a relationship between how satisfied students are with the adaptive learning system and their satisfaction of mathematics?
4. Are there differences in student satisfaction of the adaptive learning system between students taking online College Algebra and students taking face-to-face College Algebra?

5. Are there differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system?

**Overview of the Instrument**

Before calculating results for each research question, the Rasch Model was used for analysis of the survey. This model is useful in understanding whether or not a survey is effective in measuring what it was intended to measure (Fink, 2007). Data was run through Winsteps, Rasch Analysis computer software, to evaluate item difficulty, person ability, fit, separation, and reliability. These data were examined in order to assess the instrument.

The instrument was a self-reporting electronic questionnaire with 17 items. The first 12 items gave respondents the choices of Strongly Disagree, Disagree, Agree, and Strongly Agree. The last five items were open-ended questions that were analyzed qualitatively.

**Reliability and Separation**

To investigate the validity of the instrument, the reliability and separation of both persons and items was analyzed. Reliabilities close to 1.0 indicate strong reliability. According to the Rasch model, reliabilities between 0.7 and 1.0 are desired. Person separation, which classifies people, below 2 indicates that the instrument may not differentiate between low and high performers. Item separation, which classifies items,
below 3 indicates that the person sample may not be large enough to verify construct validity of the instrument. Figure 2 shows that the initial Person Reliability was .86 with a separation of 2.49. This means that there was a separation of 3 or 4 groups of people. The initial Item Reliability was .97 with a separation of 6.16. This means that there was a separation of 7 or 8 groups of items. The mean measure of people was -.01, and the mean measure of items was 0. This means that the people had less of the trait than items had difficulty. In other words, the items were harder to agree with than people. Finally, the mean infit and outfit for items were very close to one, meaning that neither redundancy nor error was present.

![Figure 2. Summary statistics of the instrument](image)

**Summary of Category Structure**

After examining initial summary statistics, scale items were reviewed (Figure 3). According to the Rasch model, there should be approximately equal differences between response categories. The differences between response categories were 1.73, 1.75, and 2.18, respectively. The approximately equal distances between response categories suggest that respondents perceived a clear difference between the categories. Additionally, threshold and category measure for questions 3-12 progressed monotonically, which means that participants understood agree vs. disagree.
Dimensionality

Dimensionality examines if groups of items share similar patterns of unexpectedness. Patterns of unexpectedness may suggest a problem with the instrument or with the people. Therefore, dimensionality was analyzed next (Figure 4) in order to determine if these patterns existed. The raw variance explained by measures was 46.1%, and the unexplained variance in the first contrast was 12.1%. Although the Rasch model suggests that the unexplained variance in the first contrast be below 10%, no relationship was found among items when the first contrast was studied, as shown in Figure 5.

Table of STANDARDIZED RESIDUAL VARINCE (in Eigenvalue Units)

<table>
<thead>
<tr>
<th>Component</th>
<th>-- Empirical --</th>
<th>Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total raw variance in observations</td>
<td>22.8 100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Raw variance explained by measures</td>
<td>10.8 46.1%</td>
<td>45.3%</td>
</tr>
<tr>
<td>Raw variance explained by persons</td>
<td>5.0 22.3%</td>
<td>21.9%</td>
</tr>
<tr>
<td>Raw variance explained by items</td>
<td>3.3 23.8%</td>
<td>23.4%</td>
</tr>
<tr>
<td>Raw unexplained variance (total)</td>
<td>12.0 53.9% 100.0%</td>
<td>54.7%</td>
</tr>
<tr>
<td>Unexplained variance in 1st contrast</td>
<td>2.7 12.1%</td>
<td>22.5%</td>
</tr>
<tr>
<td>Unexplained variance in 2nd contrast</td>
<td>2.2 9.7%</td>
<td>18.0%</td>
</tr>
<tr>
<td>Unexplained variance in 3rd contrast</td>
<td>1.4 6.3%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Unexplained variance in 4th contrast</td>
<td>1.2 5.4%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Unexplained variance in 5th contrast</td>
<td>1.0 4.4%</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

Figure 4. Item dimensionality
Item Fit

To investigate whether or not some items may be causing error, an item fit analysis was conducted. Items should not have negative point biserial values and the mean square statistics (MNSQ) should be in the range of 0.6 to 1.4. No items had a negative point biserial value (Figure 6). However, Item 1 had a high infit value of 2.37, indicating error. This item was: How many hours did you spend in ALEKS each week? This item may have produced error because the question did not offer enough options, or it may have produced error because options b and c had a slight overlap, both including the time of three hours. Additionally, students did not keep track of how much time they spent in the system, so their answers, which were just estimates, may not have been accurate.
Figure 6. Item fit

Reliability and Separation Recalculated

When Item 1 was excluded, test reliability increased from .86 to .88 (Figure 7).

Item reliability increased from .97 to .98 and separation increased from 6.16 to 6.32.

When other items with a MNSQ below 0.6 and above 1.4 were excluded, no difference appeared in reliability or separation.

Figure 7. Summary statistics after removal of item 1
**Dimensionality Recalculated**

After excluding Item 1, dimensionality was analyzed again (Figure 8), with raw variance explained by measures increasing to 51.9%. In addition, unexplained variance in the first contrast decreased to 10.1%. However, because this was a vital question to answering the second research question, since the responses for this item were how the researcher determined the amount of time students spent in the adaptive learning system, and because the recalculated values did not differ much from the original calculated values, this item was not excluded from the data.

![Table of Standardized Residual Variance](image)

*Figure 8. Item dimensionality after removal of item 1*

**Person Fit**

Respondents were analyzed in order to examine which persons fit within an accepted range for the study. When the persons not falling within an MNSQ of .6 and 1.4 were removed from the data, test reliability only increased by .01. Therefore, no respondents were excluded from the data.

**Research Questions**

Once the analysis of the survey was complete, the responses for each item were analyzed by statistical software. These results are presented below for each research question.
Research Question 1: How satisfied are students in College Algebra with the use of an adaptive learning system in the course?

To examine students’ satisfaction with the use of the adaptive learning system in their College Algebra course, a Chi-Square test, via SPSS software, was performed on Items 4-11 of the instrument. This test compared observed to expected frequencies, as shown in Table 2.

| Response Category | Item 4 O | Item 4 E | Item 5 O | Item 5 E | Item 6 O | Item 6 E | Item 7 O | Item 7 E | Item 8 O | Item 8 E | Item 9 O | Item 9 E | Item 10 O | Item 10 E | Item 11 O | Item 11 E |
|-------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| SD                | 57       | 25.8     | 58       | 25.3     | 47       | 25.8     | 26       | 25.8     | 30       | 25.8     | 44       | 25.3     | 39       | 25.3     | 35       | 25.3     |
| D                 | 75       | 25.8     | 77       | 25.3     | 44       | 25.8     | 28       | 25.8     | 61       | 25.8     | 57       | 25.3     | 66       | 25.5     | 31       | 25.3     |
| A                 | 69       | 25.8     | 67       | 25.3     | 92       | 25.8     | 137      | 25.8     | 82       | 25.8     | 80       | 25.3     | 78       | 25.5     | 113      | 25.5     |
| SA                | 10       | 25.8     | 7        | 25.3     | 28       | 25.8     | 20       | 25.8     | 38       | 25.8     | 28       | 25.3     | 27       | 25.5     | 31       | 25.5     |
| Total             | 211      | 210      | 211      | 210      | 211      | 210      | 210      | 210      | 210      | 210      | 210      | 210      | 210      | 210      | 210      | 210      |

The fourth item explored to what extent students enjoyed the material they were studying while using the adaptive learning system. The mean score reported by students was 2.15 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 2. Of the 211 responses, 57 (27.0%) of them strongly disagreed, 75 (35.5%) disagreed, 69 (32.7%) agreed, and 10 (4.7%) strongly agreed with the statement, indicating that they did not enjoy the material they were studying while using the adaptive learning system.

The fifth item explored to what extent students found the questions and activities in the system interesting. The mean score reported by students was 2.11 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 2. Of the 209 responses, 58 (27.8%) of them strongly disagreed, 77 (36.8%) disagreed, 67 (32.1%)
agreed, and 7 (3.3%) strongly agreed with the statement, indicating that they did not find the questions and activities in the system interesting.

The sixth item explored to what extent students found the adaptive learning system easy to use. The mean score reported by students was 2.5 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 3. Of the 211 responses, 47 (22.2%) of them strongly disagreed, 44 (20.9%) disagreed, 92 (43.6%) agreed, and 28 (13.3%) strongly agreed with the statement, indicating that they did find the system easy to use.

The seventh item explored to what extent students liked the colors, images, and physical setup of the adaptive learning system. The mean score reported by students was 2.7 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 3. Of the 211 responses, 26 (12.3%) of them strongly disagreed, 28 (13.3%) disagreed, 137 (64.9%) agreed, and 20 (9.5%) strongly agreed with the statement, indicating that they found the system pleasing to the eye.

The eighth item explored to what extent students spent more time studying for College Algebra than other math courses because they were able to utilize the adaptive learning system. The mean score reported by students was 2.6 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 3. Of the 211 responses, 30 (14.2%) of them strongly disagreed, 61 (28.9%) disagreed, 82 (38.9%) agreed, and 38 (18.0%) strongly agreed with the statement, indicating that they spent more time studying for this math course compared to other math courses because they had access to the adaptive learning system.
The ninth item explored to what extent students thought that the system helped them earn better grades in College Algebra than if they had not had access to the system. The mean score reported by students was 2.4 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 3. Of the 209 responses, 44 (21.1%) of them strongly disagreed, 57 (27.3%) disagreed, 80 (38.3%) agreed, and 28 (13.4%) strongly agreed with the statement, indicating that they believed they earned a better grade in College Algebra than if they had not had access to the adaptive learning system.

The tenth item explored to what extent students understood the material in College Algebra because they had used the adaptive learning system. The mean score reported by students was 2.4 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 2.5. Of the 210 responses, 39 (18.6%) of them strongly disagreed, 66 (31.4%) disagreed, 78 (37.1%) agreed, and 27 (12.9%) strongly agreed with the statement, indicating that they believed they understood the material in the course because they were able to utilize the system.

The eleventh item explored to what extent students thought the questions in the system were relevant to what they were learning in the course. The mean score reported by students was 2.7 on a scale from 1 (Strongly Disagree) to 4 (Strongly Agree), with a median score of 3. Of the 210 responses, 35 (16.7%) of them strongly disagreed, 31 (14.8%) disagreed, 113 (53.8%) agreed, and 31 (14.8%) strongly agreed with the statement, indicating that they thought the questions in the system were relevant to what they were learning in College Algebra.

As shown in Table 3 below, all eight items were significant at the $\alpha = .01$ level, which means that frequency distribution differed significantly from theoretical
distribution. This indicates that student satisfaction in College Algebra with the use of the adaptive learning system in the course was statistically significantly different than what was expected.

Table 3

<table>
<thead>
<tr>
<th>Chi-Square Test Statistics for Items 4-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 4</td>
</tr>
<tr>
<td>49.379*</td>
</tr>
</tbody>
</table>

Note. * indicates that the item is significant at $\alpha = .01$

Qualitative analysis of the open-ended questions

The responses to the five open-ended items reinforced student thoughts about the adaptive learning system and how they believed it affected their learning. These items included the purpose of the adaptive learning system, how beneficial the system was to learning, improvements that could be made to the system, and what parts of the course students liked and disliked.

The first open-ended item solicited responses about the purpose of the system in the course. Of the 154 responses, 127 (82.4%) of them were positive responses and 27 (17.5%) were negative. Of the positive responses, most indicated that the purpose of the system was to practice solving problems and help students deepen their understanding of the content. Students also responded that the system was meant to supplement what they were learning in class and to assess their understanding of the topics. Of the negative responses, most students answered that the system was meant to teach them the material rather than learn from a professor or that they did not know what the purpose was.

The second open-ended item solicited responses from students as to whether or not they thought the system was beneficial to their learning and why. Of the 161
responses, 74 (46.0%) of them were that the system was beneficial, 80 (49.7%) were that the system was not beneficial, and 7 (4.3%) were neutral. Of the responses that the system was beneficial, most indicated that the system helped them learn the material, understand problems that they answered incorrectly, and helped them to practice problems for mastery. Of the responses that the system was not beneficial, most indicated that the system contained insufficient explanations to problems, was difficult to use, assigned too much homework, or was not aligned with what they were learning in class. Of the neutral responses, students indicated that they did not believe the system helped them, nor did it hurt their learning.

The third open-ended item solicited responses from students about improvements that could be made to the system. Of the 137 responses, the majority of students indicated that the system needed better explanations of problems or more than one explanation for each problem, that answers in the system were marked incorrectly when actually they were correct, and that they were given too many extra problems to solve if they answered a problem incorrectly. Of the responses, 17 (12.4%) of them said to abolish the system completely from the course, and 25 (18.2%) said that the system contained too many topics to cover in a one-semester course. Additionally, 10 (7.3%) responded that the structure of the site needed to be changed, as it was not user-friendly and took too much time to navigate.

The fourth open-ended item solicited responses from students about what they liked most in the course. Of the 128 responses, 28 (21.9%) of them gave a response related to the content in the course and the topics they were learning, 10 (7.8%) responded that they liked everything in the course, 12 (10%) said that they liked the
course because it was easy, and 24 (18.8%) responded that what they liked most was the professor they had. Of all the responses, only 11 (8.6%) said that the adaptive learning system was what they liked most. There were 33 (25.6%) responses that indicated that they liked nothing about the course.

The fifth open-ended item solicited responses from students about what they liked the least in the course. Of the 137 responses, 49 (35.8%) of them indicated that the adaptive learning system was what they liked least, 22 (16.1%) answered that it was content, and 17 (12.4%) responded that what they liked least was the professor they had. There were 24 (17.5%) responses that indicated that what they liked least about the course was everything.

Research Question 2: Is there a relationship between how satisfied students are with the system and how much time they invest into using the system?

A multivariate correlation test was performed between Items 1 and 2, responses related to time invested in the system, against Items 4-11, responses related to satisfaction with the adaptive learning system. As shown in Table 4, there was no correlation between how many hours students spent in the system and satisfaction of the system. Additionally, there was no correlation between how many times they logged into the system and their satisfaction of the system. However, when the two values were considered together, the correlation between time invested and satisfaction of the system was significant at $\alpha = .01$, indicating as time spent in the system and number of times logged into the system increase together, satisfaction also increases.
Research Question 3: Is there a relationship between how satisfied students are with the adaptive learning system and their satisfaction of mathematics?

To examine if there is a relationship between student satisfaction with the system and satisfaction of mathematics, Items 4-11, items related to satisfaction with the system, were individually correlated with Item 3, an item related to satisfaction with mathematics. As shown in Table 5, the only significant relationship was between Item 3, to what extent students enjoy math, and Item 4, to what extent students enjoyed the material they were studying while logged into the system.

Table 5
Chi-Square Goodness of Fit Between Item 3 and Items 4-11

<table>
<thead>
<tr>
<th>Item</th>
<th>Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 4</td>
<td>22.563*</td>
</tr>
<tr>
<td>Item 5</td>
<td>10.394</td>
</tr>
<tr>
<td>Item 6</td>
<td>11.531</td>
</tr>
<tr>
<td>Item 7</td>
<td>3.733</td>
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<td>Item 8</td>
<td>6.378</td>
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<td>Item 9</td>
<td>5.697</td>
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<tr>
<td>Item 10</td>
<td>8.612</td>
</tr>
<tr>
<td>Item 11</td>
<td>.911</td>
</tr>
</tbody>
</table>

Note. * indicates that the item is significant at \( \alpha = .01 \)

Research question 4: Are there differences in student satisfaction of the adaptive learning system between students taking online College Algebra and students taking face-to-face College Algebra?

To analyze differences in satisfaction of the system between students in online and face-to-face sections of the course, an Independent t-test was performed on Items 4-11 between the two groups. As shown in Table 6, none of the items between the two groups were significant at \( \alpha = .01 \). This indicates that there is no statistically significant
difference between satisfaction of the adaptive learning system between students who took College Algebra online and students who took College Algebra face-to-face

Table 6
Independent t-test on Items 4-11 Between Face-to-Face Students and Online Students

<table>
<thead>
<tr>
<th>Item</th>
<th>Equal Variances Assumed</th>
<th>F</th>
<th>Sig.</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 4</td>
<td>Equal Variances Assumed</td>
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</tr>
<tr>
<td>Item 5</td>
<td>Equal Variances Assumed</td>
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<td>Item 6</td>
<td>Equal Variances Assumed</td>
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<td>Equal Variances Assumed</td>
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<td>Item 9</td>
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<td>Item 10</td>
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<td>Item 11</td>
<td>Equal Variances Assumed</td>
<td>1.875</td>
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<td>-1.128</td>
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Note. * indicates that the item is significant at $\alpha = .01$

Research Question 5: Are there differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system?

To analyze differences in final grades between students who did not use the system and students who did, first descriptive statistics were examined for each semester. As shown in Table 7, of the 426 students in Spring 2013, 96 of them (22.5%) earned As, 56 (13.1%) earned Bs, 90 (21.1%) earned Cs, and 184 (43.2%) did not pass the course.
Table 7
*Section Grade Cross-Tabulation for Spring 2013*

<table>
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<tr>
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<th>A</th>
<th>A-</th>
<th>B</th>
<th>B-</th>
<th>B+</th>
<th>C</th>
<th>C-</th>
<th>C+</th>
<th>D</th>
<th>D-</th>
<th>D+</th>
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<td>1</td>
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<td>13</td>
<td>14</td>
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<td>12</td>
<td>7</td>
<td>57</td>
<td>6</td>
<td>7</td>
<td>114</td>
<td>426</td>
</tr>
</tbody>
</table>

As shown in Table 8, of the 728 students in Fall 2014, 200 of them (27.5%) earned As,

159 (21.8%) earned Bs, 133 (18.3%) earned Cs, and 236 (32.4%) did not pass the course.
When compared to Spring 2013, the Fall 2014 semester had a higher percentage of As and Bs and a lower percentage of failures. A summary of these statistics can be found in Table 9.
Table 9  
*Summary of Grade Cross-Tabulation for Fall 2014 and Spring 2013*

<table>
<thead>
<tr>
<th></th>
<th>Fall 2014</th>
<th>Spring 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>200 (27.5%)</td>
<td>96 (22.5%)</td>
</tr>
<tr>
<td>Bs</td>
<td>159 (21.8%)</td>
<td>56 (13.1%)</td>
</tr>
<tr>
<td>Cs</td>
<td>133 (18.3%)</td>
<td>90 (21.1%)</td>
</tr>
<tr>
<td>Fail</td>
<td>236 (32.4%)</td>
<td>184 (43.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>728</td>
<td>426</td>
</tr>
</tbody>
</table>

After analyzing descriptive statistics, an Independent t-test was conducted between the two groups. As shown in Table 10, the mean for Fall 2014 grades was much lower than the mean for Spring 2013 grades, which signifies the higher percentage of As and Bs in Fall 2014. Additionally, Fall 2014’s lower standard deviation indicates less variability in grades.

Table 10  
*Group Statistics for Fall 2014 and Spring 2013*

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2014</td>
<td>728</td>
<td>23.85</td>
<td>37.072</td>
<td>1.374</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>426</td>
<td>30.95</td>
<td>40.466</td>
<td>1.961</td>
</tr>
</tbody>
</table>

As shown in Table 11 through an Independent t-test, the grades between these two semesters differed significantly, indicating that there is a statistically significant difference in grades between those who used the system in Fall 2014 and those who did not use the system in Spring 2013. This difference indicates that students using the adaptive learning system earned significantly higher grades than students who did not use the adaptive learning system.
<table>
<thead>
<tr>
<th>Equal variances assumed</th>
<th>Equal variances not assumed</th>
</tr>
</thead>
</table>

*Note.* * indicates that the item is significant at $\alpha = .01$
Chapter Five

Discussion & Conclusions

A review of literature revealed a low level of student success in introductory college math courses. Between 60 and 75 percent of first-year college students in the nation require introductory math courses, and less than one-half of these students are able to pass on the first attempt (Hackett, 1985; Boggs, Shore, & Shore, 2004). There are several reasons for low pass rates in introductory math courses, but the most serious issue among them is the lack of concept mastery. To prevent students from falling behind and not succeeding in a course, adaptive learning systems were created. However, research on these systems is limited, especially in mathematics courses where they are needed most (Fischman, 2011). The studies that do exist do not include higher education institutions. Additionally, the research lacks information about student interests and their beliefs in these systems’ benefits to their learning.

There were four identified purposes to this study. Adaptive learning systems were created to prevent students from falling behind. However, no valid research instrument has been developed to measure students’ satisfaction with these types of systems, nor have grades of students who use these systems been compared to grades of students who do not use the systems. Therefore, the first purpose of the study was to determine if there was a relationship between how satisfied students were with an adaptive learning system in their College Algebra course and how much time they invested into using the system. The second purpose of the study was to explore a possible relationship between how satisfied students were with the system and their satisfaction of mathematics. The third purpose of the study was to investigate differences
in satisfaction of the system between students taking online College Algebra and students
taking face-to-face College Algebra. The fourth purpose of the study was to examine
differences in final grades between students who did not use the system and students who
did use the system.

Based on the limited research on adaptive learning system, especially in
mathematics courses, this study poses the following research questions:

1. How satisfied are students in College Algebra with the use of an adaptive learning
   system in the course?

2. Is there a relationship between how satisfied students are with the system and how
   much time they invest into using the system?

3. Is there a relationship between how satisfied students are with the adaptive
   learning system and their satisfaction of mathematics?

4. Are there differences in student satisfaction of the adaptive learning system
   between students taking online College Algebra and students taking face-to-face
   College Algebra?

5. Are there differences in final grades between students who did not use the
   adaptive learning system and students who did use the adaptive learning system?

Discussion

In this study, the researcher utilized a 17-item survey instrument to analyze student
satisfaction with the use of an adaptive learning system in their College Algebra course.
Additionally, the researcher compared grades between students who used the system with
students from a previous semester who did not use the system. In this section, the specific findings for each research question will be presented.

*Research Question 1: How satisfied are students in College Algebra with the use of an adaptive learning system in the course?*

The instrument measured how satisfied students were with the use of an adaptive learning system in their College Algebra course. The number of disagree/strongly disagree responses related to students’ interest levels in the content were almost twice as many as the number of agree/strongly agree responses. Therefore, it was shown that students did not enjoy the content. Results also showed that even though students may not enjoy math, that did not affect their satisfaction of the adaptive learning system. Students reported that they were pleased with the adaptive learning system with statements related to the ease of use of the system, in addition to reporting that the colors and images were pleasing to the eye. Since negative and positive responses were approximately equal for items related to the benefits the system had on students’ learning, students did not believe that the system was either beneficial or not beneficial. They did, however, find the system relevant to the material they were learning in their course.

From the analysis of the open-ended questions, it was shown that students understood the purpose of an adaptive learning system in learning math. However, more students believed that the system was not beneficial to their learning than those who believed the system was beneficial. From student responses to the third open-ended item, it was clear that the issues students had with the system are issues that can be altered. Students reported dissatisfaction with the number of questions the system assigned them.
and receiving insufficient explanations to incorrect answers, two issues that could be resolved by altering the design of the system’s webpages in the adaptive learning system. Because only 12.4% of students said to abolish the system completely from curriculum, students do see that a system can be beneficial if designed properly.

Research Question 2: Is there a relationship between how satisfied students are with the system and how much time they invest into using the system?

A multivariate correlation test was performed between responses related to time invested in the system and responses related to satisfaction with the adaptive learning system. As shown in Table 3, there was no correlation between how many hours students spent in the system or how many times they logged into the system with their satisfaction of the system. However, when the time they spent and the number of times they logged into the system were considered together, the correlation between those variables and their satisfaction of the system was significant at $\alpha = .01$. This may be because students who logged into the system often only spent a few minutes using it, or those who logged into the system once used it for several hours. In order for students to be satisfied, they need to use the system often and also for an increased amount of time. Further research could investigate how many times the students need to log into the system each week as well as how much time students need to spend in the system per logged-in session.

Research Question 3: Is there a relationship between how satisfied students are with the adaptive learning system and their satisfaction of mathematics?
As shown in Table 4, the correlation of student responses about their satisfaction with mathematics and their satisfaction with the adaptive learning system indicates that their satisfaction with mathematics is significantly correlated only with their level of enjoyment of the material they were studying in the system. This indicates that as students reported to be more satisfied with the adaptive learning system, these students also reported a higher level of enjoyment with the material they were studying in the system. However, since the other items did not have a significant correlation with satisfaction of mathematics, students’ beliefs about the benefits of the adaptive learning system were shown to not have been affected by their attitudes towards mathematics in general. In other words, how much students like math is correlated with how much they like the course content, but it is not correlated with how much they like the adaptive learning system. These results could be due to the way the items were worded or because the survey was taken online. Additionally, if students do not like the adaptive learning system, they may not like computers in general and would answer differently if the survey was completed on paper.

Research Question 4: Are there differences in student satisfaction of the adaptive learning system between students taking online College Algebra and students taking face-to-face College Algebra?

To analyze differences in satisfaction between students in the online sections and the face-to-face sections, an Independent t-test was performed. As can be seen in Table 5, none of the items between the two groups were significant at $\alpha = .01$. Therefore, there were no differences in student satisfaction of the adaptive learning system between
students taking College Algebra online and face-to-face.

*Research Question 5: Are there differences in final grades between students who did not use the adaptive learning system and students who did use the adaptive learning system?*

The Spring 2013 semester was the last semester that students in College Algebra did not use the adaptive learning system and, therefore, was used as the control group. The Fall 2014 semester, although not the first semester to have students using the system, was chosen to eliminate error by ensuring that the system was fully implemented into curriculum and that faculty were comfortable in giving thorough instruction to students on how to use the system. When grades from these two semesters were compared, the Fall 2014 semester had a higher percentage of As and Bs and a lower percentage of failures than the Spring 2013 semester. An Independent t-test of grades was conducted, showing that the grades for Fall 2014 differed significantly ($\alpha = .01$) from the grades of Spring 2013. Although the median grade for both semesters was a grade of C, Fall 2014 had a significantly higher passing rate (67.6%) than Spring 2013 (56.8%), in addition to a higher percentage of As and Bs.

**Delimitations & Limitations**

This study is delimited to surveying those who are students at a Midwest Ohio university. Under the Carnegie classification, this university is a large four-year university with high research activity. Therefore, findings of this study may not be applicable to students in other areas of the world. A limitation of this study is that the data was collected through
an online questionnaire, so the researcher was not be able to verify responses from participants.

**Conclusions**

According to the results of this study, students’ beliefs about mathematics as a subject did not affect their perceptions of how much the adaptive learning system benefited their success in College Algebra. For items of the survey related to satisfaction of the system, the number of Strongly Disagree/Disagree responses was greater than the Strongly Agree/Agree responses. Therefore, overall student satisfaction about the use of the adaptive learning system in their course was low. Nevertheless, students who used the system did significantly better than students who did not use the system. Students who used the system had 5% more As, 8.7% more Bs, and 10.8% fewer failures than students who did not use the system. Therefore, even though students did not agree that the system was beneficial, it may be a reason for increased success; students may benefit from the use of the adaptive learning system in an introductory math course.

The findings also suggest that the reasons students were not satisfied with the system were related to design issues of the system that can be altered. With the changes that students suggested to be made to the system and the negative aspects that they reported as being unbeneﬁcial, the system could be seen by students as more beneﬁcial in future semesters.

Because student satisfaction with the system did not affect the amount of time they spent in the system or number of times they logged into the system when analyzed individually but did when combined, more investigation is needed to determine the effect
of student satisfaction on time spent with the system. Because the questions related to the
time they spent with the system were self-reported, student guesses may have caused
error in results for this question.

Although there was no significant difference in satisfaction between students who
took College Algebra face-to-face with those who took the course online, more
investigation is needed. Of the 728 students who used the adaptive learning system, only
42 of those took the course online. Therefore, results for this question may contain error
due to the small sample size of online students.

Error in results from the Independent t-test of grades between the two semesters
may have also occurred due to changes in graduation requirements implemented by the
University during the time of the study. Between the Spring 2013 and Fall 2014
semesters, the business college changed the requirement for business students to take
College Algebra rather than Business Calculus. Therefore, there was an influx in College
Algebra of students majoring in business who normally would have taken Business
Calculus, resulting in more research needed in future semesters to compare to the results
from Fall 2014.

This study provided a big picture of students’ perceptions about an adaptive
learning system in their introductory mathematics course and its effects on their learning.
It also explored the difference between final grades of students who used the system with
final grades of students who did not use the system. A study on future semesters may
provide greater understanding of what was reported by students, as there may be
confounding variables between actual benefits and perceived benefits of an adaptive
learning system. Nevertheless, this study found a possible tool to help eliminate low pass
rates in introductory math courses by using engaging material, good curriculum design, incorporating mastery learning, and solving the issues related to students’ lack of pre-requisite knowledge.

Recommendations for Future Research

Grades from the semester in which the adaptive learning system was implemented were significantly higher than grades from the semester in which the system was not used, despite low student satisfaction with the system. Because the passing rate increased by 10.8%, it appears as though the adaptive learning system was effective. However, to make an even greater impact, developers of the adaptive learning system may want to consider altering the system to incorporate suggestions made by students for improvement. By providing additional explanations for incorrect answers, the system can improve students’ interaction with content and feedback that they receive, two critical components of good course design. Additionally, developers could alter the number of questions a student must answer correctly after an incorrect answer is given so that they do not feel punished for their wrong answers. Developers may also want to add more aspects of gaming to the system in order to encourage students to attain goals, earn rewards, and achieve success in the course.

Future research is needed in order to make further inferences about the effect that an adaptive learning system has on an introductory math course. The survey should be given to students again in following semesters with the exclusion of Item 12. Additionally, the answer choices for Item 1 should be altered so that there is no overlap in options. Alternatively, the researcher could have data pulled from the adaptive
learning system about amount of time each student spent in the system rather than relying on students’ self reports. This would reduce unexplained variance and will strengthen validity in future research.

After altering the adaptive learning system based on student suggestions, the survey should be given to students in a future semester to compare their responses to those from Fall 2014. Additionally, the number of responses to the fifth open-ended question, of which 35.8% of students in Fall 2014 listed the adaptive learning system as what they liked least about the course, should be compared.

Surveying students in future semesters and comparing their grades to Fall 2014 can eliminate error due to the influx of business majors. Additionally, more online students should be studied so that a conclusion can be made about all populations in College Algebra. The survey should also be taken via paper to remove the fact that those who did not like the adaptive learning system may simply just not like computers.
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Appendix A

Instrument Announcement Posted in the Students’ Learning Management System

You are invited to take part in a research study. Participation is voluntary. If you are interested, the research involves a survey about your experience in College Algebra and with ALEKS. Before taking the survey, please read the attached consent form. If you agree to take part, please complete the survey found on the Course News page. On the Course News page, click the “Take Survey” button, fill in your answers, and then click the “Submit” button at the bottom of the page.
Appendix B

Informed Consent

ADULT RESEARCH - INFORMED CONSENT INFORMATION

A Study of Student Perceptions on Adaptive Learning Systems in College Algebra and their Effect on Learning Outcomes

Principal Investigator: Dr. Berhane Tecelehaimanot, professor, 419-530-7979
Claire Stuve, student, 419-530-4383

Purpose: You are invited to participate in the research project entitled A Study of Student Perceptions on Adaptive Learning Systems in College Algebra and their Effect on Learning Outcomes, which is being conducted at The University of Toledo under the direction of Dr. Berhane Tecelehaimanot and Claire Stuve. The purpose of this study is to study the effect of ALEKS, a new adaptive learning system that The University of Toledo Mathematics Department has been utilizing. A research team would like to learn what you think about the system and how it can be improved to make College Algebra better. By collecting your responses, the research team can analyze what makes ALEKS a good system and what parts of ALEKS can be improved in order to create a better learning experience for students.

Description of Procedures: This research will take place in Blackboard from December 8-14. If you decide to participate in this study, you will be asked to complete a short survey about your experience in College Algebra and with ALEKS. The survey is 17 questions and should take less than 15 minutes to complete. By completing the survey, you are providing consent that your anonymized answers may be used for research purposes in improving ALEKS.

Potential Risks: This study involves minimal risk, as all student names will be anonymized. All data will be locked and only accessible by the researchers.

Potential Benefits: By taking part in this study, you will be contributing to research in order to improve the use of ALEKS in mathematics courses at The University of Toledo.

Confidentiality: The researchers will make every effort to prevent anyone who is not on the research team from knowing that you provided this information, or what that information is. The data generated through your survey will be kept anonymous. Although we will make every effort to protect your confidentiality, there is a low risk that this might be breached.

Voluntary Participation: Your refusal to participate in this study will involve no penalty or loss of benefits to which you are otherwise entitled and will not affect your relationship with The University of Toledo or any of your classes. In addition, you may discontinue participation at any time without any penalty or loss of benefits.

Contact Information: Before you decide to accept this invitation to take part in this
study, you may ask any questions that you might have. If you have any questions at any time before, during or after your participation, you should contact a member of the research team (Dr. Berhane Tchelhaimanot, 419-530-7979). If you have questions beyond those answered by the research team or your rights as a research subject or research-related injuries, please feel free to contact the IRB Chair at (419) 530-2844.

By clicking on to the “Take Survey” link and beginning the survey, you are stating that you have read and accept the information above and are giving your consent to participate in this research. You are also confirming that you are 18 years old or over.
Appendix C

Instrument

1. How many hours did you spend in ALEKS each week?
   a. Less than 1 hour
   b. Between 1 and 3 hours
   c. Between 3 and 5 hours
   d. More than 5 hours

2. How many times did you log into ALEKS each week?
   a. 0 times
   b. 1-2 times
   c. 3-4 times
   d. 5 times or more

3. I generally enjoy math.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree

4. I enjoyed the material I was studying when I was logged into ALEKS.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree

5. I found the questions and activities in ALEKS interesting.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree

6. ALEKS was easy to use.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree

7. I liked the colors, images, and setup of ALEKS. It was pleasing to the eye.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree
8. I spent more time studying for this course than other math courses in my past because I was able to use ALEKS.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree

9. ALEKS helped me earn a better grade in College Algebra than if I had not had access to the system.
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree

10. I understand the material in College Algebra because I used ALEKS.
    a. Strongly disagree
    b. Disagree
    c. Agree
    d. Strongly agree

11. The questions in ALEKS were relevant to what I was learning in College Algebra.
    a. Strongly disagree
    b. Disagree
    c. Agree
    d. Strongly Agree

12. I felt that what I was learning in College Algebra was related to the real world.
    a. Strongly disagree
    b. Disagree
    c. Agree
    d. Strongly Agree

13. What do you think was the purpose of ALEKS in this course?

14. Please explain below why you think ALEKS was or was not beneficial to your learning.

15. What improvements do you think could be made to ALEKS?

16. What parts of College Algebra did you like?

17. What parts of College Algebra did you not like?