MATHEMATICS ACHIEVEMENT: TRADITIONAL INSTRUCTION AND TECHNOLOGY-ASSISTED COURSE DELIVERY METHODS

by

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ABSTRACT

The purpose of this study was to analyze technology-assisted course delivery methods to determine their overall effectiveness as it pertains to mathematics courses. This study analyzed both current and historical data in mathematics classes in the areas of achievement, retention, and grade distribution. The goal of this study was to determine if the use of technology-assisted course delivery methods had an effect in courses where it has been implemented. Additionally, the level of the effect and whether it was positive or negative was determined and analyzed. A second goal was to determine if there is a significant difference in the achievement level, grade distributions, and retention rates of technology-assisted courses versus traditional courses and then determine what implementation strategy yielded the greatest results. Research questions for the study were: a) Will there be a difference in achievement between students in technology-assisted courses and students in traditional courses?; b) Will there be a difference in grade distribution between a technology-assisted course and a traditional course?; c) Will there be a difference in retention rate between a technology-assisted course and a traditional course?; and d) Is the amount of time spent in the course a significant factor in student performance and retention? The study included 14562 students enrolled during Fall 2007 to Fall 2012 in Pre-Calculus Algebra at a Southeastern University. Students were grouped by method of instruction and course length. Significant differences were found in student achievement as determined by course grade point average. Students in the traditional course scored 0.444238996 higher in average course grade point average. Students in the traditional courses also had a significantly higher number of A’s and a significantly lower number of F’s in the grade distribution. There
was not a significant difference in the overall retention rate between the 18-week traditional courses and the technology-assisted courses, but there was a significant difference between the 9-week traditional and the technology-assisted courses. In general, the students enrolled in the technology-assisted courses did not perform at the same level as the students in the traditional setting.
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CHAPTER 1
INTRODUCTION

The idea of technology-assisted course delivery methods has its roots in the larger field of distance education. Although currently distance education is synonymous with the use of computer and online resources, the idea of utilizing technology to reach nontraditional students is not new. In its infancy, distance education existed as correspondence courses designed to meet the needs of students who were either unable or unwilling to attend a traditional university (Bondeson, 1977). Distance learning students are primarily older students, often with significant responsibilities outside of the classroom that preclude traditional teaching and learning methods. Additionally, many students of correspondence education live in rural parts of the country where they are unable to travel to a university (Matthews, 1999). Because course delivery methods utilized in traditional settings would not be effective in distance education, there has always been a connection between nontraditional education and technology (Keegan, 1986).

Distance education has grown at an amazing rate throughout the last 40 years (Ashby, 2002). The current boom in nontraditional course delivery methods started with the opening of Open University in the United Kingdom in 1969, and has continued to grow, facilitated in large part by an increased access to technology (Matthews, 1999). Although distance education began as a tool to reach nontraditional students who were not able to attend classes in brick-and-mortar universities, students now take distance education for multiple reasons. While distance is still a common rationale, many students now take courses for convenience rather than necessity (Guri-Rosenblit, 2005). Institutions have embraced distance education as a course delivery tool in
order to increase their geographic footprint and recruit students. Online course offerings allow more students to take courses without putting a strain on facilities. Universities are able to offer courses in many forms and at many times to accommodate as many students as possible (Lei & Gupta, 2010).

Although students enrolled in these courses often begin with the best intentions, many lack the necessary time management skills or motivation necessary to complete the courses and thus students are often unsuccessful. In addition to time and motivational issues, students frequently find themselves unable to complete the tasks assigned due to some major change in either their employment or family. Another reason often given for course non-completion is the inability to comprehend the concepts as presented in the course materials (Carr, 2000).

In order to address the issue of comprehension, educators continually search to find methods and mediums where students can receive the instruction that they need (Ince, 2004). The introduction of the internet and the popularization of the personal computer provided educators with a means to provide students quality education from a distance. Additionally, electronic submission of assignments allowed teachers the opportunity to interact with students in a timelier manner and consequently students feel more connected to their class and thus have more incentive to stay on track (St. Pierre & Olsen, 1991).

Additionally, the use of email, course management systems, and discussion boards in these distance-learning courses has provided students with an opportunity to participate in learning communities rather than learning strictly on their own. While the instruction on the internet allowed for significant improvements in distance education, there are still some lingering concerns. Of these concerns, those of integrity and quality are continually on the forefront (Larreamendy-Joerns & Leinhardt, 2006). While there is no guarantee that the student sitting in
a course is actually the student on the roster, it would be significantly more difficult to convince someone to sit in a residence class than to take an online test. Additionally, the lack of oversight in some distance learning programs has skewed public perception and caused a rift among academics (Larreamendy-Joerns & Leinhardt, 2006). Although some may remain skeptical of distance education, it has gained a significant amount of credibility and is becoming a staple in many universities.

One area where distance education has become a widely used is in mathematics. While previous distance learning mediums were not conducive to success in mathematics, the introduction of online services, multimedia tools, and tutorials have proven invaluable (Juan, Huertas, Steegmann, Corcoles, & Serrat, 2008). Currently there are a significant number of universities offering portions of their mathematics instruction via distance learning methods. In addition to courses taught entirely through distance education, there are new methods of instruction including traditional/internet hybrid courses as well as computer-assisted courses. The use of technological tools in mathematics curriculum has increased rapidly to meet growing academic needs of students as well as to meet progressive university goals.

One area of mathematics where the trend has been significantly pro-distance education and pro-internet instruction is the area of developmental studies (Ashby, Sadera, & McNary, 2011). Recently many universities have found it necessary to increase the amount of remedial mathematics course offerings to meet the current need of incoming freshmen. While students have the necessary criteria for admittance into the college, their mathematics skills are frequently substandard and must be enhanced prior to taking a credit course. The rationale behind the use of these instructional methods are varied, including student needs for self-paced instruction, lack of available faculty, the need for quick response on assessment, and the significantly varied
student educational backgrounds. The tool utilized most frequently in these mathematics courses is the course management system. While there are many varieties of this system, mathematics instructors are able to identify skills that students must learn, provide quality instruction, assign problems for practice, and gather assessment information all through the use of these management tools. Because of the length of time needed to develop these materials, teachers often use materials developed by textbook companies (Kennett-Hensel, Sneath, & Pressley, 2007). These companies provide the management systems complete with question banks, homework sets, test/quiz generators, multimedia instructional tools, discussion boards, and many other features. The instructors then choose what they would like the students to learn out of these course modules and assign grades based on student performance on the given tasks. Currently many schools have incorporated courses with either distance or lab components into their regular course offerings (Twigg, 2005). While these online or web-assisted courses have many positive aspects, it is imperative that they are analyzed for overall impact on achievement to determine what gains or losses can be attributed to the implementation of these technologies.

Students are frequently encouraged to take courses that are remedial or developmental via distance learning or web assisted course modules (Olsen, 2000). In order for this to be a valid suggestion, the courses must offer students an advantage over the courses taught in a more traditional setting. Because the implication is that these courses will more readily prepare students for courses that follow, there must be a quantifiable advantage. In order to determine the legitimacy of this type of course offering, the similarities and differences to traditional method instruction must be investigated. Additionally, because these courses offer a bridge to more advanced mathematics coursework, it is reasonable to assume that the success that a student has in a subsequent course can also be attributed to the skills attained while taking these
courses. Finally, because the use of distance learning techniques and computer labs often result in questions of integrity and quality, it is important to examine how these issues are being addressed and what obstacles remain.

Statement of the Problem

Currently there is a tremendous push in mathematics education to put the developmental curriculum into a nontraditional format. Students in remedial mathematics courses are being enrolled in courses that have very little face-to-face contact and are being taught using technology-assisted methods. Many of these online or technology-assisted courses utilize shells and materials generated by textbook companies. Once these courses are built, the individual school decides what sections and problems in particular to assign. Students then work through the course modules, examples, homework, and assessments in order to receive credit for the class, while the faculty assigned to the course acts as a facilitator (Kompf, 2005).

The increase in the utilization of these pre-built courses and the surge in students needing developmental studies courses have created an environment where many students will take their remedial classes via technology-assisted medium then move on to credit bearing classes in residence. The overarching questions regarding these technology-assisted courses are categorized into recurrent categories. These categories consist of quality, integrity, and oversight.

The questions posed on the quality of technology-assisted courses are not dissimilar to those posed about distance education throughout the last 50 years; however, because the primary medium has changed, they bear revisiting. These questions range from fundamental (i.e., mastery) to more qualitative (i.e., student perception). It is important to determine if students
participating in this new medium reach the necessary mastery level for their course (Cotton & Gresty, 2007). Perhaps equally important to mastery of skills is the question of whether students in these technology-assisted courses connect concepts presented in a manner that will facilitate success in subsequent courses? If students master skills and make connections between concepts, it is important that the technology-assisted courses are doing this at a level that is at least on par with that of a traditional classroom. This is particularly important in the case of prerequisite courses. Students who take an online prerequisite for a particular course must have the same level of preparation as students who took the course in residence (Alkharusi, Kazem, & Al-Musawai, 2010). If students are learning the material at the same level, is that similarity carried over into assessments and performance (Yates & Beaudrie, 2009)? Additionally, has the change in medium had a positive or negative effect on student retention rates (Rossett & Schafer, 2003)? After these fundamental questions have been addressed, more qualitative questions concerning student experience should also be considered. Students in a technology-assisted course do not have the same interactions with other students or faculty. Because of this different style of interaction, students may perceive their learning experience differently and it is important to gauge the impact of this change (Jackson & Helms, 2008).

In order to be a viable educational medium, technology-assisted course delivery methods must meet the same standards as a traditional course over the same material. Although it would be significant if technology-assisted courses were found to be more effective, it is not necessary that they exceed the standards set by traditional courses. If these courses are found to be at least equivalent, universities offering developmental studies programs in a technology-assisted format would be confirmed in their decision to use that medium. However, if technology-assisted
course delivery methods are found to be substandard, the decision to move developmental studies from a traditional style course should be revisited.

The issue of integrity in technology-assisted courses raises the same questions that have followed distance education since its inception. Because of the asynchronous nature and mobility of technology-assisted courses, the ability of faculty to ensure the integrity of their exams is significantly limited. The level of concern with reliability in assessment is directly correlated to the amount of freedom given to the student in completing the assignment. Integrity questions stem from the freedom inherent in completing an assignment outside the confines of a controlled environment. If a student is in a technology-assisted course where assessments are taken online, how can the instructor be sure that the student taking the assessment is the student registered for the course? Even if it is the student taking the course who is completing the assessment, what assurance does the instructor have that the student does not have access to additional study aids? Additionally, there may be some variation on student success due to differences in the style of assessment. Because of the apprehension inherent in allowing students to complete assignments outside of traditional parameters, instructors must address the questions of integrity when designing and implementing a technology-assisted course. Without careful consideration of these questions, the courses may be deemed inadequate or unreliable (Mastin, Peszka, & Lilly, 2009).

Technology-assisted course delivery methods have grown at a tremendous rate and due to the success and versatility of the internet, the increase in use will most likely continue. This new medium in course delivery allows students to gain access to their courses from almost anywhere on the globe. It also has introduced a new era of competition between institutions (Lease & Brown, 2009). Students are no longer bound to brick-and-mortar locations and are not bound by
geographic region. Seeing the increased opportunity for growth, many universities have developed separate colleges or departments to handle their technology-assisted programs (Keaster, 2005). Even in areas where the course delivery is only enhanced by technology, an information technology department usually handles the facilitation of that portion of the program. Because these technologies are often handled by entities outside the discipline in which the course is taught, the issue of oversight is often a concern among academics. It is important to establish credible individuals responsible for the academic program rather than just relying on those who control the technology. Additionally, potential instructors must be screened by individuals who can properly analyze and certify applicants. Once these applicants have been hired, they need to be trained to ensure that they meet institutional guidelines for instruction. In the case of technology-assisted courses, the technology departments housing the course often conduct this training. The individual departments, however, are stakeholders in the implementation of the course and should therefore have some influence on the training of instructors. Finally, due to standards established by the institution, accrediting agencies, and industry, it is important that technology-assisted courses satisfy the same requirements as traditional courses.

Without considering these issues, the department responsible for technology-assisted course delivery will not be able to adequately defend its programs from scrutiny and will lose credibility among academics. Programs must be rigorous and meaningful; without proper oversight that will become impossible.

In order for technology-assisted course delivery methods to be accepted as a medium for quality education, the questions stemming from quality, integrity, and oversight must be addressed. These questions stem from the core of academia. In order for something to be
regarded as credible it must receive the support of the experts for that particular field, and in order to gain the acceptance of these leaders those questions must be answered (Bondeson, 1977).

Theoretical Framework

Using technology to enhance education is a topic that touches on several educational theories. The two theories that are most closely related to the motivation behind this study are those of the Cognitive Theory of Multimedia Learning and Transactional Distance Theory. Each of these theories plays a central role in the use of technology-assisted education and offers a lens through which to analyze the methods of instruction in the study. The Cognitive Theory of Multimedia Learning proposed by Richard Mayer argues that the brain processes audio and visual information in different manners (Moreno & Mayer, 1999). If a particular concept can be demonstrated through the use of multimedia tools, a student will have the potential to gain a better understanding than through the use of a single media. Technology-assisted courses use multimedia tools as a primary method for student instruction. Because the use of multimedia tools is so prevalent in technology-assisted courses, there should be some difference in the achievement of those students who take a class in a traditional manner versus those who take one that is technologically assisted. Transactional Distance Theory has been an important theory in distance education since the 1970s. The key constructs to this Theory are the educator, the learner, and communication (Kang & Gyorke, 2008). In a traditional classroom, there is a considerable amount of interaction between the student and the teacher. In a technology-assisted course, there is significantly less interaction. The interplay between the instructor, the student, and the communication between these parties in the technology-assisted courses are what
constitutes an educational “transaction.” Both of these theories offer insight into why the current embodiment of technology-assisted courses should be preferable and offer some tangible academic difference over the traditional classroom. This study analyzed courses and attempted to determine if there is a significant difference in student retention and grade distribution. The results were compared to the current educational theories and determined the significance of the findings.

Statement of the Purpose

The purpose of this study was to analyze technology-assisted course delivery methods to determine their overall effectiveness as it pertains to mathematics courses. This study analyzed both current and historical data in mathematics classes in the areas of retention and grade distribution. The goal of this study was to determine if the use of technology-assisted course delivery methods had an effect in the courses where it has been implemented. Additionally, the level of the effect and whether it was positive or negative was determined and analyzed. A second goal of this study was to determine if there was a significant difference in the grade distributions and retention rates of technology-assisted courses versus traditional courses, then from this analysis determine what implementation strategy yielded the greatest results.

Significance of the Problem

The massive increase in technology-assisted courses was brought on by many factors both inside and outside academia. The massive glut of students needing to take remedial courses before beginning their program of study necessitated the institution of classes not offered before at many universities. With this new demand came the need for instructors. Rather than hire
more adjunct instructors or teach the courses themselves, many universities made the decision to place their developmental studies programs in a technology-assisted format (Twigg, 2005). This format allowed control of content without the need to instruct the course. Additionally, the increase in saturation of personal computers coupled with increased internet availability allowed courses to transcend brick-and-mortar structures. Finally, the downturn in the economy affected institutions’ bottom lines to the point where it was not just desirable to recruit students, it was necessary. This recruitment turned education into a buyer’s market where academics took a backseat to financial interests and consumer desire took precedence over everything (Lease & Brown, 2009). Because of the educational climate, many instructors were apprehensive when it came to technology-assisted courses, and others simply dismissed it. It was imperative at this juncture that a study be conducted to determine what, if any, effect the current trends were having on education as a whole and more specifically what effect they are having on mathematics instruction. While studies had been conducted in the past concerning distance education and technology-assisted course delivery methods, there was a need for a study that delved deeper into these courses. This study may validate or invalidate the current methodologies in place at many colleges and will supply the necessary analysis to determine what areas need to be modified, enhanced, or eliminated. This turn in education, particularly in mathematics education, to use technology-assisted courses happened so quickly that there have been few studies. The technology is changing so quickly that many of the studies that were completed are no longer viable. Given the state of education, and the controversy that surrounds technology-assisted courses, this study could not be more timely, or relevant.
Research Questions

1. Will there be a difference in achievement between students in technology-assisted courses and students in traditional courses?

2. Will there be a difference in grade distribution between a technology-assisted course and a traditional course?

3. Will there be a difference in retention rate between a technology-assisted course and a traditional course?

4. Is the amount of time spent in the course a significant factor in student performance and retention?

Assumptions of the Study

This study assumed that the data generated by the study university concerning its mathematics courses were accurate and unmodified. This study assumed that all data gathered were unbiased and represented a natural cross section of the University.

Limitations of the Study

The limitations of this study existed primarily in incomplete data sets. Any portion of the data that was missing caused some of the research questions to remain unanswered. If the university failed to release data or somehow modified the data, then the analysis was inconclusive. The mitigation strategy for scenarios such as limited data is volume. By including many sections of the courses, any effect of limited data in one area was offset by the data from the others. Additionally, because the data sets analyzed were from mathematics courses, complete generalization to any subject area proved difficult. Other limitations of the study included variation among instructors and variation in student populations. Although the course
being studied had common course objectives and a common textbook, some variation in teaching and assessment may have occurred. Additionally, the student population who took the traditional course may have differed from the student population who took the technology-assisted course. These limitations were mitigated by the size and length of the study.

Definition of Terms

*Blackboard:* a proprietary course management system.

*CourseCompass:* a proprietary course management system.

*Course management system:* a computer-based shell where information about a course is stored, student work is submitted, and information is disseminated.

*Developmental studies:* any course that is a prerequisite for a general studies class.

*For credit course:* any course where the credits earned count towards graduation.

*General studies:* any course that is required of all majors at a given university.

*iLrn:* a proprietary course management system.

*MyMathLab:* a proprietary course management system. **Non-credit course:** any course where the credits earned do not count towards graduation.

*Remedial course:* any course where the level of study is below freshman level.

*Technology-assisted course:* any course where students are required to use technology such as Blackboard, WebCT, CourseCompass, iLrn, WebAssign, etc. to complete tasks necessary for course completion.

*Technology-assisted course delivery:* any course where all or a portion of the instruction is given through a technology dependent medium.

*WebAssign:* a proprietary course management system.
WebCT: a proprietary course management system.

Summary

This study endeavored to analyze the current and historical data from several universities in mathematics courses where technology-assisted courses have been implemented. The goal of this study was to determine overall effectiveness of this new medium as it pertains to mathematics instruction. In Chapter 1 of this dissertation, the historical construct and recurrent questions of distance education were applied to the new area of technology-assisted course delivery. The significant research questions were stated, as well as the significance of the problems as it pertained to the use of the technology-assisted tools. Additionally, assumptions and limitations of the study were identified, and mitigation strategies were implemented.

Chapter 2 of this dissertation consists of a thorough review of the literature available on the historical construct of distance education, the inherent problems in distance education, instruction using technology-assisted mediums, mathematics instruction via distance education, and mathematics education via technology-assisted course delivery. This literature further cements the necessity for a study in which the new methods of technology-assisted course delivery are compared to those of a traditionally delivered course. The literature review also reinforces the rationale behind the research questions as well as supplies necessary background information for many of the current questions that surround this method of course delivery.

Once the problem was identified, the questions isolated, and the relevant reviewed, the study was developed. Chapter 3 of this dissertation outlined the methodologies employed in this study as well as the tests that were used to determine statistical significance. This chapter provided the framework for the study and served as an invaluable resource as the data came in
and the analysis began. All information concerning process, participants, data collection methods, and data analysis methods are contained in this section.

The purpose of this dissertation was to determine the impact and effectiveness of technology-assisted course delivery methods. This effectiveness was determined through the careful scrutiny of the supplied data, and the analysis of the current data versus historical data. This completed dissertation may offer essential insight into the educational trend specifically in the area of mathematics, and provide recommendations for the effective implementation of these instructional mediums.
CHAPTER 2
REVIEW OF LITERATURE

Introduction

In order to discuss the topic of technology-assisted course delivery methods in mathematics, one must first analyze how current trends in education were formed. While technology-assisted course delivery methods are not synonymous with distance education, the push to utilize technology in the presentation of concepts has been an essential component of distance education from its inception (Keegan, 1986). Because of the natural pairing between distance education and technology, it is prudent to overview the history of distance education, particularly as it relates to both technology and the problems facing technology-assisted instruction. Once the history and issues surrounding distance education have been explored, the topic of mathematics and distance education must also be reviewed. The purpose behind reviewing mathematics and distance education is similar to that of reviewing distance education in general. In order to establish the current educational setting, the current trends must first be mapped back to their origins. Finally, any research and studies into the area of technology-assisted instruction, technology-assisted mathematics instruction, and technology-assisted remedial mathematics instruction must be examined. The result of this review of related literature will be a more refined direction for this study and a more vivid understanding of the questions of quality, integrity, and oversight that surround the issue of technology-assisted instruction in mathematics courses.
Distance Education Historically

Before taking on the current topic of technology-assisted distance education, it is prudent to look back at the previous systems and determine what lessons can be learned both positively and negatively from distance education in general. It is this historical look into distance education that Lease and Brown (2009) bring to light. While the current trend in education is technology-assisted course delivery methods, particularly in the area of distance education, the authors are quick to note that the current trend in using technology to educate a specific group of students is not unique to the current embodiment of distance learning. The first distance education courses relied heavily on the new technology of the postal service. These courses were followed by telegraph-facilitated instruction, then telephone, television, video, and currently they are taught via computer.

Throughout the more than 150-year history of distance education, the one item that appears constant is that of the learner. Although currently there is a group of students who take distance education for convenience, the traditional distance education students were those where flexibility in time and location were essential. Many of the students served by these distance-learning programs had significant time constraints that would preclude them from attending a traditional class or they were limited by geographic location. Because of the tremendous limitations inherent in any distance education course, the instructors of these courses utilized any technological tool available to facilitate learning. As the technology became more available, the number of students taking distance education courses increased. Now with the seemingly infinite availability of the internet, distance education courses can reach students at virtually any location. Because of the pervasiveness of the internet and the convenience offered by distance education classes, the current students in these courses do not follow the traditional
demographics. Additionally, administrators have used distance-learning programs to entice and recruit students from outside their traditional pool. The availability of these online programs has increased competition for enrollments and increased pressure to build programs. Many of the current programs in distance education have been around for less than 10 years, and many universities have strategic plans that call for the increase in enrollments in their distance learning programs. It is, however, imperative that as enrollments and offerings increase, the quality of the educational product remains strong. Without a strong product, this boom could become similar to that of correspondence courses of the 1920s (Lease & Brown, 2009).

Because of the need for oversight in education, most reputable institutions undergo accreditation. This accreditation process is also an essential component of distance learning courses. Casey (2008) chronicled the history of distance education and the utilization of technology in these courses throughout the past 150 years. Casey related some of the struggles in distance education including the need in 1926 to create the National Home Study Council and in 1927 to establish Fair Trade Practice Rules for Home School. These standards and monitoring agencies were initiated due to the massive growth in the distance education market. Casey also conveyed a brief history of completely online universities in the United States. Although the Open University of Britain had been established for some time, the first completely online degree granting institution to be accredited by the Higher Learning Commission was Jones International University in 1993. Since then, many schools have followed suit and gained reputable accreditation for their online programs. The need for effective quality control will remain an important component of any distance-learning program with accreditation being a vital part of a school’s overall academic package (Casey, 2008). In addition to meeting the needs of
current students for accreditation, location, and time, the next trend in distance education is removing the limitations and issues that plague any course taught outside traditional methods. In addition to looking at distance education from a historical vantage point, it is prudent to shift slightly and examine educational technology as a whole. Hooper (2008) reflected on 50 years of educational technology both as an insider and as an outsider. Because of Hooper’s unique position within the framework of educational technology, the observations that are made are keenly insightful. From the vantage point of Hooper, it appears as if educational technology has found its role in education, but that role is somewhat less substantial than originally desired. When educational technology was in its infancy in the mid-20th century, the goal was to revolutionize the educational industry through innovative tools and individualized instruction. The result, however, was that the educational system of today looks much the same as it has for 50 years. The rationale behind the lack of change, irrespective of the massive amounts of money flowing into development, was an innate resistance to change in educational systems. Additionally, Hooper noted that there is no incentive for teachers to change their teaching style, there is an absence of a credible theory for learning, and the tools used in educational technology are not user friendly. Furthermore educational technology as a field often continues instructing in a similar manner to traditional educational systems, thus strengthening the very system it was designed to dismantle. Hooper noted that educational technology has not had the desired impact in the traditional classroom structure, but gains made in educational technology have had tremendous ramifications in distance education. While educational technology has not met its goals in the classroom, the gains made have enabled the current explosion in distance education (Hooper, 2008).
The origins of distance learning as a necessary medium through which to serve students that would otherwise not be able to gain an education is well documented; however, Garcia and Cuello (2010) provided a unique perspective on the rationale behind its formation. While there is no argument about the foundations of distance learning serving those who cannot attend traditional classes, the authors connected education to the Welfare State. The authors contended that because welfare is a redistribution of wealth, education is a necessary component of that system. The rationale behind this assertion is that in order to achieve equal wealth, equal access to education must be provided. Because many people cannot attend a traditional school, equal access to education would necessitate the formation of an alternative educational system in which the obstacles of a traditional education could be overcome.

The result of this need to facilitate an alternative educational system led to the formation of distance education. While this may not be the rationale behind the formation of every distance learning system, it does summon the thought that this welfare system may have contributed at least in part to their formation. In Spain, the formation of the Open University of Catalonia is a key example of the dissemination of education to those who could not attend traditional universities. This university was created as a virtual school devoted to making education accessible to everyone. Through the creation of individualized educational plans, students were able to fashion a program to meet their unique needs and fulfill their educational goals. The backbone of the program at the Open University of Catalonia was the use of information and communications technology. The use of information and communications technology allows for asynchronous learning, which is essential in a program where students are not able to meet at a specific time. In addition to the advantages in time management that are permitted through the use of information and communications technology, there are other
tangible advantages to a virtual system. These advantages to the virtual system include flexibility in both program of study and geographic location. Additionally, in an era where sustainability is an essential component of any program, virtual schools provide educational systems where money is saved on facilities, transportation, and consumables such as paper. The Catalan University Policy of the 1990s has aided in the establishment of a truly universal education plan where students are able to choose educational plans to meet their individualized needs. This freedom, coupled with the advantages of a virtual school, has created a positive learning environment where knowledge is not the right of the fortunate, but is available to all (Garcia & Cuello, 2010).

One major area for growth in distance education is that of communication. Because students very frequently do not interact with their instructors in the online classrooms in the same manner as they would in a traditional classroom, there is currently a movement to personalize the online experience (Casey, 2008). This impersonal nature of distance education has been an obstacle since the introduction of correspondence courses. This problem, together with issues such as learning environment, integrity, and time management, among others, has limited the widespread installation of distance learning courses. These issues surrounding distance education provide keen insight into potential pitfalls that may exist for technology-assisted course delivery.

Problems in Distance Education

While, historically, many distance-learning courses were used for nonacademic certifications, there was a significant number of correspondence courses that were used to achieve college credit. St. Pierre and Olsten (1991) established hypotheses pertaining to correspondence education. These hypotheses outlined essential criteria for student success and
satisfaction in correspondence courses. In order for a student to have as fulfilling an experience as possible they would need to receive constructive feedback from their instructors, be provided an avenue for experiential learning, receive their assessments back quickly, and be afforded opportunity to converse with their instructors. Additionally, students would need to access and digest the materials provided and interact with the support personnel or instructor.

In order to determine the validity of these hypotheses, the authors mailed a questionnaire to a random sample of students. The resulting analysis of the data confirmed each of the seven hypotheses at the 0.05 level of significance (St. Pierre & Olsen, 1991). While these hypotheses were developed and tested on students involved in correspondence education nearly 20 years ago, the hypotheses tested in this study are still viable. Students in online courses have very similar needs and motivations to the students in the earlier correspondence courses. Because of their commonalities, the lessons learned by these researchers should be implemented into online course design to ensure that students have as much opportunity for a positive online experience as possible.

As opportunities for online courses increase, there is a need to address several issues that are inherent in distance education. One issue commonly addressed in distance education is that of student completion rates. Because students in distance education are often self-paced, many students fail to finish the necessary assignments for course completion. This failure to finish has plagued distance education since its inception and in order to combat a student’s inclination to fall behind, it is necessary to look at what factors can be attributed to those students who complete a course versus those who do not.

Aragon and Johnson (2008) analyzed the students enrolled in the online courses of one community college. These students were defined as either “completer” or “non-completer” of
these online courses, and their corresponding demographic, enrollment, academic, and self-directed learning characteristics were analyzed to determine if any correlations could be established. Of the demographic data (including age, gender, ethnicity, and financial aid), any association between the demographic and the completion of the course was either small or insignificant. The enrollment characteristics, however, found that there was a significant difference in the number of online courses taken by completers versus non-completers, with completers taking more courses online than non-completers.

In considering academic readiness for an online course, Aragon and Johnson (2008) found no significant correlation between placement in remedial courses and completion of the online courses; however, student GPA was found to have a low positive correlation with completion of online courses. The self-directed learning readiness of the students involved in the study also did not have a significant correlation to completion of online courses. With the initial categories of this study offering at best small statistical significance for completion or non-completion of a course, the rationale behind the increased attrition rate of those students in online courses must be attributed to other factors. In this study, the authors surveyed those students who had not completed the online courses to ascertain why these students did not complete their course. Of these students, the most common reasons for non-completion were personal or time issues. Students either lacked the necessary motivation to finish the course or had time conflicts that inhibited their completion of the course. In addition to time or personal reasons, course design and communication was a major reason given by non-completers for their lack of success in a course. Students identifying this area cited poor course design or lack of communication with their instructors as the reason for non-completion (Aragon & Johnson, 2008).
In order to increase student completion of online courses, educators need to address the issues of time management, motivation, course design, and communication. Although these issues exist in both online and traditional settings, they are more pronounced in online courses. The motivational and time management problems that students often have in these online courses have been a factor in success rates in distance education throughout its existence. Addressing these issues may also positively affect other areas of concern such as communication. Students who were able to receive guidance on time management or motivation would likely have an increase in communication with their instructor and would thus address other areas contributing to students’ failure to complete online courses.

Another issue in distance education is that of credibility. Because distance education offers such a wide array of programs to a varied set of students, it is imperative that the online programs offered by these institutions meet the standards set forth by traditional universities so that the students are able to meet their needs of flexibility without losing credibility in their education. It is this issue of credibility confronted by Bondeson (1977). Bondeson began by trying to quantify nontraditional learning in an effort to determine the group of students taking this style of courses and the rationale behind the course offering. Once established, the author continued laying out the criteria for an open learning program. In order to develop an open learning system there must first be a program of study. These programs of studies should be such that they lend themselves to an open learning format, meaning that there is not an on-campus requirement and the instructional media can be dispersed through nontraditional methods.

Finally, these programs, while existing outside of the traditional brick-and-mortar schools, must still have a personal component. Personal contact is an essential component of any
educational system and this is particularly true in distance education. One of the best resources for student retention and completion is personal contact. With all of these criteria met, the distance education program still lacks a vital component, that of credibility. It is essential that as these programs are being built they are tied to existing educational systems. As these distance education courses of study are being developed, they should work in conjunction with existing programs to enhance what is currently available.

The programs that currently exist will offer credibility and sustainability to the distance education courses and the distance education courses will offer educational opportunities to a much more diverse group of students and increase a university’s footprint in a given area. Without credibility, the distance education program will lose the ability to recruit quality students for its programs; and without the diversification of instructional methods, traditional universities will continue to fight for the same groups of students. The opening of distance learning programs allows more students to gain education while providing the universities with a larger pool of qualified students (Bondeson, 1977).

Another issue in distance education is that of integrity. Because currently much of distance education takes place on the internet using web-based instruction, there has been a significant increase in opportunities for academic dishonesty. These issues are confronted by Grijalva, Nowell, and Kerkvliet (2006) and by Baron and Crooks (2005). Grijalva et al. used emailed surveys with a randomized response question to determine cheating frequency among online students. After analyzing the data, they determined that online students had a 3% probability of committing academic dishonesty. This indicated that rather than students having a higher propensity to cheat in an online environment, the students exhibited a rate consistent with students in a traditional setting (Grijalva et al., 2006).
Many feel that the online environment is an easy place to commit acts of academic dishonesty; it is these perceptions that Barron and Crooks (2005) confronted. Barron and Crooks contended that the perception of student cheating online has more to do with conventional wisdom than actual data (Baron & Crooks, 2005). Although they related some chilling statistics with regard to student cheating percentages, the study contended that online acts of academic dishonesty are not dissimilar to those in traditional courses. The article referenced Duke University’s Center for Academic Integrity and related an astounding 75% cheating percentage among students at 21 different college campuses. In addition to the percentages, the author also conveyed some of the most egregious cheating instances ranging from copying and pasting entire documents to lifting answers from websites and turning them in as original. While these instances of academic dishonesty occurred in distance education courses, they are no different from what is seen in traditional classrooms as well. The authors continued by contending that some faculty defend distance education courses in the area of academic integrity in that because all assignments are turned in electronically, it is easier to catch a student who is cheating.

While cheating may not be easier in a distance-learning format, it is still imperative that institutions find methods for uncovering and combating it. The suggestions for limiting the amount of academic dishonesty include contracts with students so that expectations are made clear at the beginning of the course. Additionally, increased discussion board use with more formalized written assignments should be implemented so that an accurate portfolio of a student’s written work is available. Also, assessments should be modified to ensure that students have a more active role in the writing process and an accurate picture of student capability is available.
Other tools for fighting academic dishonesty outlined by the authors include plagiarism tools such as Turnitin.com, curriculum rotation to ensure that students are not simply sharing their answers, and proctored exams. While some of these steps may seem excessive, the indication is that academic dishonesty is occurring at a remarkable level. With this in mind, it is essential that educators find methods to limit any issues of integrity. Furthermore, because distance education offers the most freedom in education both in location and time restraints, there is a perceived ability of those in distance education courses to commit academic dishonesty more frequently. Because of these issues inherent in distance education, instructors must be more vigilant than their traditional counterparts to ensure the overall integrity of the distance-learning program (Baron & Crooks, 2005).

Mathematics in Distance Education

Although the concepts of mathematics have been taught using correspondence courses, the introduction of computer-based distance education has allowed mathematics education to flourish. The medium of the internet and computer allow for students to visualize complex tasks using cutting edge graphical interfaces, and the use of tutorial aids in breaking the information down into understandable portions. Juan, Huertas, Steegman, Corcoles, and Serrat (2008) related a successful implementation of a distance-learning program in mathematics. This program used mathematical software, online discussions, and group projects to facilitate student learning. According to the authors, the benefits of taking mathematics classes via distance learning using these tools is an increased graphical understanding, an experiential scaffolding of mathematics concepts, a more complete understanding of how mathematics is used in practice,
and the ability to avoid tedious mathematical computations once the overarching theory has been learned.

These distance-learning courses have been in use for 10 years at the Open University of Catalonia, and the findings are that the use of these techniques increases student motivation, which, in turn, leads students to a more positive performance. While there are many positive aspects to mathematics distance education, there are several areas for concern. One of the most significant areas of concern is that of prerequisite knowledge. Students who take mathematics courses often come from very diverse backgrounds. This diversity does not lessen in distance education. Because a student with seemingly similar prerequisite knowledge may have widely varied mathematical ability, administrators must pay special attention to how students are placed into mathematics classrooms (Parker, 2005).

Another area of concern is students’ inability to budget an appropriate amount of time for their mathematics courses. While a mathematics course may have the same number of credit hours as a student’s other classes, the mathematics class may be significantly more involved. Students need to allow enough time to ensure proper mastery of the topics and not overload themselves with other coursework (Taylor & Mander, 2003). Another major issue in mathematics instruction via distance learning methods is the inability of computers to use mathematical symbols (Loch & McDonald, 2007). While some programs have mathematical symbols that can be used, still others are needed to decode the meaning in the symbols. In order to have a flourishing distance learning program, students must be able to determine quickly the proper syntax through which to submit their solutions, and must be able to see problems in a manner that is consistent with what is written in the text.
Because of the unique challenges of a mathematics distance learning system, the authors pointed out that learning mathematics online is a very difficult undertaking. In order to meet the needs of their students, the designers of the mathematics program increased the amount of contact time between peer groups and student-instructor interaction. The developers then retooled the educational software creating a more traditional format and they increased the availability of mathematical symbols. Additionally, the administrators of the online mathematics programs have taken a top-down approach to mathematics education so that the courses more appropriately line up with skills needed in particular degree programs and the mathematics courses are geared to a more skills-based approach than theory so that students can see immediate usefulness of their training. After implementing these changes, it was noted that students are now have a more positive evaluation of these courses, and the level of student interest in mathematics has increased (Juan, Huertas, Steegmann, Corcoles, & Serrat, 2008).

While some argue that mathematics instruction is more difficult when done via distance learning methods, the methodology through which the instruction takes place appears to be more important than the location. Amin and Kuiyuan (2010) began by relating the geographic challenges that exist for students who live on the Florida panhandle. While these students may live in the same state, there is a tremendous amount of geography and students may not be able to find a central location where instruction can take place. Because of the inability to find a location suitable for instruction, the developers for these courses determined that they would use distance education. Rather than construct a distance-learning program using traditional methods of asynchronous instruction, the developers determined that the courses would be taught using synchronous lectures. These courses would have students that would be enrolled in a traditional
face-to-face course and those students who were enrolled via distance learning would be enrolled in an online course where they would still be able to attend the in-class sessions via the internet.

The primary reason behind the desire to make these sessions synchronous was the well-documented issue of instructor-student interaction in asynchronous courses. The course developers did not want students to feel distant and therefore provided the opportunity for students to participate as they would in a traditional course. Because of the steps taken in designing this online course, there was no significant difference between the distance-learning group and the traditional group. While the use of synchronous learning may not be possible in all distance learning situations, the positive effects of its use in this study are quite compelling (Amin & Li, 2010).

Technology-assisted Mathematics Instruction

The idea of moving from a traditional classroom to one that is an online hybrid or one that is completely online is tremendously controversial. While many think that the branching out of education into online learning is both necessary and innovative, others argue against the merits of online education (Larreamendy-Joerns & Leinhardt, 2006). While online learning and distance education are being implemented into many curricula, there are those that would argue that although students do get academic value from these courses, the level that is acquired using these alternative mediums is substandard and inferior to what would be received in a traditional classroom.

Barbour and Mulcahy (2008) addressed the issue of efficacy and equality of online courses. In order to determine student success in these courses, the authors analyzed online courses and their traditional counterparts as well as both urban and rural students. This study
took place over 4 school years from 2001 to 2005 and included thousands of students. While some may argue that online courses have grade distributions inconsistent with traditional classrooms, the authors found that the scores given in the online courses were very similar to those in a traditional course. Additionally, in those courses where a public examination was required, students taking the course online did as well as those students taking the course in a classroom. The results of this study indicate that although there is some scrutiny over the use of online courses, students can expect the same level of academic achievement in these courses as they would in a traditional course. One area of note in this study is that for the students in the online sections of these courses as much as 80% of the students scheduled contact time was spent in synchronous instruction using a virtual classroom. While this study illustrates the effectiveness of online courses in comparison to traditional courses, it should be noted that online courses are more frequently asynchronous than synchronous; therefore, the results achieved in this study may not be indicative of an online program of this type (Barbour & Mulcahy, 2008).

Currently, many colleges and universities are turning to distance learning methods in order to meet the increasing remediation needs of their students (Twigg, 2004). Additionally, many secondary schools are turning to online courses in order to reach high-risk students and provide an avenue where students can work at their own pace to catch up to where they need to be academically. With these trends in mathematics education, the same arguments for strength of instruction and academic achievement exist.

While other studies have addressed the issue of effectiveness in online courses, it is the mathematics discipline specifically that Hughes, McLeod, Brown, Yukiko, and Choi (2007) address. The authors analyzed data from the algebra courses of three virtual and three traditional
The students in these courses were evaluated for understanding of algebra (using the Assessment of Algebraic Understanding test) and for perception (using the What is Happening in this Class? classroom perceptions instrument). Utilizing these methods of measurement, the authors addressed the issue of whether algebra achievement varies dependent upon instructional medium and whether student perceptions of their learning environment vary in response to the instructional medium as well. Of the four areas measured by the Assessment of Algebraic Understanding, two of the areas were found to have a significant difference between the online courses and the traditional courses. Additionally, the overall measure of Algebraic Understanding showed a significant difference between those students in an online course and the traditional course. Students in the online courses showed an increased level of algebraic understanding in regard to their traditional school counterparts. In consideration of student perceptions of their classrooms, the virtual school students showed a higher score for teacher support, while the students in the traditional classrooms had higher scores in cohesiveness, involvement, and cooperation. While this study suggested that students in an online environment may not just meet current expectations of traditional mathematics students but exceed them, the study did have some limitations. Although the students were enrolled in similar courses in the six schools that were studied, the authors did not have access to student academic records and were not able to assess the students’ algebra knowledge upon entering the course. This study did, however, indicate that the use of online courses in mathematics can provide instruction at the same level as a traditional course (Hughes et al., 2007).

In addition to problems of perception, there are inherent problems that exist when combining technology with any established system. These problems range from interface issues where students have trouble accessing the material to motivational issues where students are not
used to working in the given environment and have trouble adapting (Muilenburg & Berge, 2005). It is these issues that the online resources and course management system attempts to solve. By creating a user-friendly environment, the software companies have softened the technological edge and made the material accessible; and by developing course management systems, companies have provided a shell where multiple courses can be built all having similar characteristics and thus becoming easier to navigate. Additionally, software companies have teamed up with publishers to offer systems where the tutorials, homework questions, even quizzes and tests are built into the system and thus teachers are able to use these tools in their instruction. The use of these products in online courses has eased the transition from traditional to online, but it is unknown to what extent these systems have affected the learning outcomes of the courses. Have these tools provided the learning experiences that were promised or have they somehow fallen short?

One obstacle in moving the instruction of mathematics from a traditional classroom to an online venue is that of grading. One of the benefits of online mathematics courses is the ability to give immediate response to students as they answer questions. While this can be an advantage, if the system is not flexible enough or programmed well enough, it will discount solutions to mathematics problems that are equivalent. While many course tools simply avoid this issue by using multiple-choice assessments, there have been suggestions made to help deal with this issue. Naismith and Sangwin (2004) offered an open source system known as The Computer Algebra Based Learning and Evaluation (CABLE) system as a possible solution to the problem. This system, according to the authors, has the ability to determine mathematical equivalence of solutions thus determining if a student supplied an equivalent solution to the one desired. Additionally, the use of this computer algebra system allowed teachers to give problem
parameters rather than specific questions. These problems would be constructed so that the computer would generate the actual question while falling under the instructor’s guidelines for framework and overall question type. The computer would then implement variations of this question as students took the assessment allowing no two tests to be the same and thus increasing test security. This system is designed to be modular and to fit into the various course management systems such as MyMathLab as well as others (Naismith & Sangwin, 2004).

Another method for dealing with assessment in online mathematics courses is through the use of online and paper evaluations. Engelbrecht and Harding (2004) outlined a possible remedy in dealing with assessment issues in online courses. Englebrecht and Harding outlined several of the problems inherent in paper testing and online testing. In paper testing there is a significant time requirement of the instructor, the need to arrange testing sites or proctoring service, and potential test anxiety. The advantages of this method of assessment are that the tests are more secure, the tests can contain more flexible question types, and it is easier to establish guidelines for partial credit. Online testing has the advantage of being quicker to grade, flexible in administration, and offers students the ability to take the test on a modified schedule. The online tests are also not as secure and offer fewer options for question types.

In this article, the authors argued that the combination of these two mediums is the most efficient method for dealing with assessment. The use of online tests allows students to stay on track and to monitor their progress in the course. The online assessments also allow the instructor more time due to decreased responsibility in test grading. The use of in-class assessments establishes course integrity, allows the instructor to award partial credit, and allows the students to participate in a known environment. Through the blending of traditional
assessment with online assessment, students can get the best of both worlds while maintaining the established standards for the course (Engelbrecht & Harding, 2004).

In *The National Assessment of Educational Progress Online Assessment in Mathematics and Writing: Reports From the NAEP Technology-Based Assessment Project, Research and Development Series* (2005), the U.S. Department of Education conducted an experiment to determine how students performed on a standardized test given on one of three mediums: paper and pencil, standard school computer, and NAEP provided laptops. From this study, it was determined that students performed at a significantly lower rate (four points lower) when taking the test on a computer versus taking the test using traditional methods. Additionally, it was determined that students who had greater familiarity with the computer were able to perform at a higher level on computerized tests than those who had less experience. Another problem area highlighted by the NAEP study was that students traditionally did more poorly on computerized versions of constructed-response items where the questions were open-ended. This could be attributed to grading incongruities found in the computerized system. When grading the constructed response questions, the computer grading did not agree with human grading. Finally, it was determined that the students did better on school computers than on NAEP provided laptops, but this may have been due to technical problems exhibited by the laptops (U.S. Department of Education, 2005).

This report highlights several key issues with online education. First, the ability of a given student to do well in an online course is directly affected by that student’s level of exposure to computers and the online system that he is dealing with. Secondly, it is difficult to develop adequate constructed response questions in an online assessment and once the questions have been developed, it is difficult to establish agreed upon benchmarks for partial credit on
problems. Additionally, if students are faced with technical difficulties, they are going to perform at a lower level than they would traditionally.

Although the format and function of student tests is of the utmost importance, issues continue to arise concerning the integrity of online programs, particularly the integrity of online testing. One method for dealing with this problem is through the use of proctors. Yates and Beaudrie (2009) examined the impact of proctoring on the final grades of community college students in their distance learning mathematics courses. In this study, the population of online students was split into two groups, one in which assessments were given under the supervision of a proctor, and another where the assessments were completely online. The authors compared the grade point averages of those students in each of the groups for five different online mathematics courses. These courses were Basic Mathematics, PreAlgebra, Beginning Algebra, Intermediate Algebra, and Liberal Arts Math. They also considered the pooled results from all of the courses. For each of these pairings of proctored assessment versus online assessment there was no significant difference between the grade point averages of the students in these courses.

While the authors admitted that this study was rather limited in scope (the online mathematics students of one community college), the results of this study were consistent with several others (Olsen, Slawson, & Ho, 1986; Tucker, 2000). The authors noted that if a student’s mathematical ability in one course was being measured, the result on a summative assessment should be similar regardless of the medium. More simply, if a student did not know the material she would not do well in either circumstance. A larger fear among academics is that of the integrity of the test and student cheating. Yates and Beaudrie (2009) noted that in either case cheating did not seem to be an issue; rather, students who were going to cheat would do so in either environment. Additionally, consideration must be given to this study, because it only
addresses courses where the online exams would be identical to the proctored exams. In the
event that the online exams were of a different form, such as multiple-choice when the proctored
exam was short-answer, there may be more variability in the grades. In addition, in the event
that different instructors taught the courses, the grades may also show variability not addressed
in this study. The understanding implied by this study would be that if the students were given
the same assessment online as when they were proctored, the results would be similar to these
findings.

One argument in the discussion of online courses versus traditional courses is that of cost
and non-differentiability. Because of the high technological demands of online learning, the
production of online courses can be quite cost inhibitive. These courses, if determined only to
provide education at a similar level to those of traditional classrooms, are destined to be removed
from course schedules. If, however, the university can provide a course that is better than the
traditional class, online course offerings will continue to increase.

Karr, Weck, Sunal, and Cook (2003) utilized three forms of instruction for the same
course. The first form of instruction was that of the traditional direct-instruction lecture, the
second form was that of online delivery only, and the third form was a hybrid course consisting
of both online and traditional instruction. In this study, no significant difference was found
between the three methods of instruction. It should be noted that the group that had access to
both the online instruction and the traditional instruction did perform better than the other
groups, but not at a significant level. The rationale behind the performance of the all-online
group and the all-traditional group indicated two important consequences of the medium for
instruction. The first result was that students who were assigned to the online portion of this
course scored at a higher level than students in the traditional setting on the take-home part of the
exam, conversely the traditional students were more successful on the in-class portion of the examination. Each of these attributes was explained through the nature of course interactions inherent to the type of instruction. In the completely online course, students were forced to learn the material by themselves and therefore learned the material at a deeper level than those involved in the traditional instruction. Alternatively, the ability of the students in the traditional classroom to discern possible test material from the course lectures allowed them to score higher on the in-class portions of the examinations (Karr et al., 2003).

If there is no significant difference between instruction given via traditional methods and instruction given via distance education methods, then there must be some other rationale for the increase in online course offerings other than simply staying on the cutting edge. The rationale for the use of online methods to teach a course is most frequently that of convenience. Students take online courses so that they can access the course at any time and from any location. Students control their hours and the students can control their pace and thus can work the online course around whatever schedule they already have and are able to avoid potential conflicts that would undoubtedly occur in a traditional setting. Chao and Davis (2001) identified convenience as one of the driving factors in the increase of online courses. The authors also attested that several other factors influence students’ decisions to take these online courses. The first of these alternative reasons is that of design. In a traditional classroom, students are taught using mainly direct instruction; and, other than time used for questions and answers, students rarely are given the opportunity to interact. The online courses are developed with the knowledge that the students are going to have to gain this information and that not all students learn in the same manner; therefore, the online courses have many activities incorporated into the content to ensure concept understanding. Because of the increased emphasis on proper online pedagogy, students
are able to gain at least as much from their online course as a traditional course, possibly more. In addition to the activities utilized in the development of concepts, the authors indicate that the entire focus of online instruction differs from that of traditional coursework. In traditional coursework, the teacher is the center of instruction, but in online courses, the student is the center of the course and the activities center around each student individually. The individualized instruction and the increased focus on student involvement allow students a learning environment that is uniquely situated to fit their needs, thus causing the increase in online offerings noted by the authors (Chao & Davis, 2001).

Online courses have become increasingly popular, but in many cases the gains attributed to these courses are simply that they are “just as good” or “the same as” traditional courses of the same type. The development of online and hybrid courses is a tremendous area of growth in academia, but only if more care is taken in developing the online courses. Twigg (2004) outlined several key steps in the design of quality educational programs. The first step in developing a good program is course redesign. While this may sound daunting, it is important that instructors share this responsibility and avoid repeating work unnecessarily. Next, the focus of the course must shift from teacher-centered to learner-centered with learner-based activities playing the central role. There must be computer-based learning resources that students can work through as well as modules that allow students to gain mastery and to hit specific benchmarks as they work through the course. Additionally, technical support and alternative support are both needed. Technical support is essential so that any problem can be dealt with expediently. The alternative support is that of an undergraduate tutoring center or other lower cost support personnel. Through the use of course redesign, students who would have previously been unsuccessful will be more likely to succeed (Twigg, 2004).
Technology-assisted Developmental Mathematics Instruction

Another area where online courses are used is in the remediation of students both in coursework as well as on standardized state proficiency tests. Because the scores on these tests are linked to Adequate Yearly Progress (AYP) goals, the demand for effective remediation strategies is in high demand. Schools often turn to online or software tools for remediation for several reasons. First, students who are identified as needing remediation are often at different points academically, and the use of computerized remediation techniques allows schools the ability to individualize instruction. Another reason behind the purchase of online tools for remediation is lack of alternative resources. Schools, on average, cannot afford to assign teachers to remediation courses but may be able to afford an aid to watch the students working on the computers. The use of online remediation tools was discussed by Biesinger and Crippen (2008). The authors analyzed a software tool that was used to remediate students for the mathematics portion of their graduation exam. It was determined through their study that students using this software who completed their respective courses were able to pass their exams at a higher rate than those not using the software. While there was no correlation between time spent on the tutorial site and increased scores on the test, the completion of the program had a significant correlation and thus if a student completed the program, they would have an increased probability of passing the exam. The online coursework was also successful at helping those students who had not yet taken the test to prepare. The students who used the software performed better than those who had not among those who had not tested previously. The ability to use remediation software allowed teachers to concentrate more on individual content rather than remediation and thus made the school more efficient (Biesinger & Crippen, 2008).
Summary

Technology-assisted course delivery has its origins in distance education and educational technology. Both of these areas of study have great variety in interpretation and in implementation. These methods for deployment of these instructional methods also have a great deal of variation in results. While some studies have shown no difference in academic results through the utilization of these tools, some showed increased proficiency. Still other studies identified areas of weakness and limitation inherent in these mediums. Because of the great variety represented in these instructional tools, it is important to review the literature generally and then isolate specific areas as they pertain to the topic of technology-assisted mathematics instruction. This was accomplished through reviewing the related literature as it pertains to distance education historically, problems in distance education, mathematics in distance education, technology-assisted mathematics instruction, and technology-assisted developmental mathematics instruction.
CHAPTER 3

METHODS

Introduction

The availability and use of distance education, or more appropriately technology-assisted course delivery, has increased at an extraordinarily fast rate. Colleges, universities, and secondary schools are continually adding to their online, hybrid, and distance education course offerings. These courses are utilized in multiple disciplines and in many forms, but it is the mathematics courses that were addressed in this study. The mathematics departments of many schools now have online or web-enhanced courses in PreAlgebra, Beginning Algebra, Intermediate Algebra, Finite Mathematics, PreCalculus, and Business Calculus, although some schools have increased offerings to include the traditional Calculus series, and still others have even put graduate mathematics courses online. Because PreCalculus is a general studies requirement for many degree programs, there is a wide cross section of students that take the course. Students just entering into their mathematics studies will take this course as well as students who have taken the remediation courses that the institution offers. Additionally, because it is required by so many degree programs, it is presented in multiple formats. This course is taught in a traditional classroom, in a traditional classroom with technology-assisted mathematics lab, and in an online setting.

The use of online education, hybrid courses, and web-enhanced courses has grown at an extremely rapid pace, but questions involving its usefulness still exist. This is apparent in the mathematics community. Many mathematics faculty see the use of online courses as a “cop-out”
for students who struggle in mathematics; others see these courses as a breeding ground for academic dishonesty. Still others in the community see the use of technology-assisted courses as a step backwards from the rigor necessary in the mathematics classroom (Talbata & Johnsrud, 2008). Now, due to the increase in the use of technology-assisted instruction, the questions and apprehensions concerning this type of instruction can be addressed.

This study attempted to determine what effect the use of technology-assisted course delivery has on mathematics education. The primary focus of this study was student achievement in PreCalculus courses taken in which both traditional and alternative course delivery methods were employed. Student achievement in this course was analyzed to determine what, if any, advantage exists for any of the established delivery methods. Through careful analysis in these areas, the overall effectiveness of the various delivery methods were ascertained.

Research Questions

1. Will there be a difference in achievement between students in technology-assisted courses and students in traditional courses?

2. Will there be a difference in grade distribution between a technology-assisted course and a traditional course?

3. Will there be a difference in retention rate between a technology-assisted course and a traditional course?

4. Is the amount of time spent in the course a significant factor in student performance and retention?
Methodology

Setting

The setting for this study was a major university in a southeastern state. While data for this study could very well be ascertained from any university with technology-assisted instruction in their mathematics departments, this public university in this southeastern state had recently moved to this style of instruction and thus still had the historical data needed for the analysis of the new methods.

Participants

A southeastern university, designated as University A, was selected for inclusion in this study. The participants for the study were mathematics students enrolled at this university during the semesters analyzed. The student grade data for the technology-assisted and traditional courses were requested from the registrar’s office and was anonymized for privacy issues. The course data analyzed were from PreCalculus Algebra. This course was taught using several mediums that ranged from completely technology dependent instruction (technology-assisted), to traditional courses where at most a small portion of the student work required technology such as online homework sets. The results from the technology-assisted courses were compared against data from the same courses without a significant technology component.

Instrumentation

There were no instruments used in the study; data that were collected included the final grades for students in the courses and retention information. The quantitative portions of the
study were analyzed using Excel. Data were gathered across several sections of PreCalculus Algebra.

*Data Collection*

The southeastern state in this study has been progressive in the utilization of technology-assisted course delivery methods, particularly in the area of mathematics. University A uses both computer-based mathematics instruction and traditional instruction for its remedial mathematics courses as well as general studies mathematics courses. While all classes that are offered in the mathematics department via traditional instruction are 16-week courses, those offered online are taught on a 9-week basis. During the Summer semester, the online and traditional courses are on the same schedule and thus data collected on students in the Summer semester were biased by time. The data in this study were from all semesters Fall 2007 to Fall 2012. Because the traditional courses were taught on 18-week semesters and 9-week terms, while the technology-assisted courses were only taught on 9-week terms, these data were analyzed together, and then separated to determine if the time in the course affected the results of the study. This university offers mathematics courses via traditional methods, online-methods, and web-enhanced methods. Because the online or web-enhanced courses can be paired with either current traditional offerings or historic course offerings, this university offers significant insight into the ongoing debate over the effectiveness of technology-assisted course delivery methods. In order to facilitate the analysis of these technology-assisted course delivery methods, the university was petitioned to provide historical data concerning the mathematics achievement of its students in the PreCalculus courses that have either online or web-enhanced components. The data were petitioned from the mathematics departments, the technology division of the colleges, and the
registrar’s office. In order to get an accurate depiction of the effect of technology-assisted mathematics instruction, the data included traditional classes and technology-assisted courses.

**Data Analysis**

This is a quantitative study using data from student academic performance. Several different factors were examined in this study, beginning with a proportion test to determine if there was a significant difference in the retention rate of students in the technology-aided classes as compared to the retention rate in traditional classes. The second test was a proportion test to determine if there was a significant difference in the number of passing grades and the number of failing grades, followed by a similar test for every letter grade. These tests established whether there was any significant difference in grade distributions between the technology-assisted classes and the traditional classes. In order to complete this statistical analysis the data were sorted into categories: traditional, traditional with technology component, and completely technology dependent.
CHAPTER 4

RESULTS

Introduction

The data in this study were comprised of end-of-course grades. The letter grades assigned for the course being analyzed were as follows: A (traditionally a numerical grade 90-100), B (traditionally a numerical grade 80-89), C (traditionally a numerical grade 70-79), D (traditionally a numerical grade 60-69), and F (traditionally a grade 59 or below). The data also included grades of FA (failure due to absence), I (incomplete), NG (no grade), P (pass), AU (audit), W (withdrawal), WP (withdrawal passing), WF (withdrawal failing), DR (dropped course), DP (dropped course passing), DF (dropped course with academic penalty), IP (in progress), and FI (course requirements not completed by end of time limit on an incomplete). The purpose of this study was to analyze grade distributions and retention rates in a general studies Pre-Calculus Algebra course to determine if there were any significant differences. The letter grades used to complete qualitative analysis on the grade distributions of this course were A, B, C, D, and F. The letter grades used in the analysis of retention rates are FA, W, WF, WP, DR, DP, and DF.

Organization of Data

The data in this study were grouped by the method of instruction and the semester or term when the course was taught. Courses were taught in a traditional format and in a technology-assisted format via online delivery method. The courses were taught in either a 9-week format or
an 18-week format. All of the technology-assisted courses were taught on a 9-week term while the traditional courses were taught on either an 18-week semester or a 9-week term depending on the course. Because of the differences in the course length, the data were analyzed first by just delivery method, then by delivery methods and the length of the course. Additionally, a third analysis was completed because a significant change in course grades was noted in the Fall of 2010. Because of this abrupt change in grade distributions, the data were also grouped into courses taught prior to Fall 2010 and courses taught Fall 2010 and after.

Demographic Information

The data in this study are population data for a Southeastern university for a general studies mathematics course, Pre-Calculus Algebra. Every student that enrolled in this course from the Fall of 2007 to the Fall of 2012 at this university is represented in this study. The students in this study were both traditional and nontraditional students of various ages and ethnicities. Because this is a general studies requirement for the university, a large majority of the students enrolled at this university are required to take this course.

Research Question 1

Research Question 1 was to determine if there was a difference in achievement between students in a traditional course and students in a technology-assisted course. In this case, achievement was measured as the overall performance of a student in the course. This value was quantified using average course grade point averages for each course in the study, including both traditional and technology-assisted. The average course grade point average for the traditional course was a 2.13949479 and the average course grade point average for the technology-assisted

47
course was a 1.695256. The null hypothesis of “there is no significant difference in the overall achievement of students in a traditional course and those in a technology-assisted course” was tested using a \( t \) test for means at the 0.05 level of significance. The \( t \) test yielded a \( t \) value of 4.2764 with 30 degrees of freedom. The critical \( t \) value at the 0.05 level of confidence with 30 degrees of freedom is \( t = 2.0423 \). The null hypothesis was rejected. The results of this analysis are shown in Table 1 and Figure 1.

Table 1

*Average Course GPA Mean, Standard Deviation, and \( t \)-value*

<table>
<thead>
<tr>
<th>Group</th>
<th>Traditional</th>
<th>Technology-Assisted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.13949479</td>
<td>1.6952558</td>
</tr>
<tr>
<td>SD</td>
<td>0.184285244</td>
<td>0.3724216</td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

\( t \) value = 4.2764

*Note.* degrees of freedom = 30.

![Average Course GPA](image)

*Figure 1.* Average course GPA: Traditional and technology-assisted.
The \( t \) test of these course grade point averages indicates that there is a significant difference in the average student achievement in the traditional courses and the technology-assisted courses, with the traditional courses having higher course grade point averages.

Research Question 2

Research Question 2 was to determine if there is a difference in grade distribution between students in technology-assisted courses and students in traditional courses. This question was analyzed using the null hypothesis “There will be no significant difference in the grade distributions of traditional courses and technology-assisted courses” and was analyzed using a proportion test. The grades analyzed in this test were the letter grades of A, B, C, D, and F. The data were grouped into traditional and technology-assisted courses over the semesters from Fall 2007 to Fall 2012 and each assigned grade was analyzed at the 0.05 level of significance to determine if there was a significant difference in the proportion of the grades assigned. The proportion test yielded the following \( z \)-scores: the grade of A, \( z = 12.42128 \); the grade of B, \( z = 1.62389 \); the grade of C, \( z = 1.7064 \); the grade of D, \( z = -0.85415 \); and the grade of F, \( z = -14.2038 \). At the 0.05 level of significance, the critical \( z \)-score is 1.95996. At the 0.05 level of significance for the grades of A and F, the null hypothesis was rejected. At the 0.05 level of significance for the grades of B, C, and D the null hypothesis was not rejected. The results of this analysis are shown in Table 2 and Figure 2.
Table 2

Grade Distribution and z-score for Traditional and Technology-assisted Courses

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL Total Enrollment</td>
<td>2734</td>
<td>3168</td>
<td>3374</td>
<td>1420</td>
<td>2135</td>
</tr>
<tr>
<td>Total Traditional</td>
<td>2084</td>
<td>2132</td>
<td>2271</td>
<td>924</td>
<td>1124</td>
</tr>
<tr>
<td>Total Technology-assisted</td>
<td>650</td>
<td>1036</td>
<td>1103</td>
<td>496</td>
<td>1011</td>
</tr>
<tr>
<td>Percentage</td>
<td>0.216542</td>
<td>0.22153</td>
<td>0.236</td>
<td>0.09601</td>
<td>0.116791</td>
</tr>
<tr>
<td></td>
<td>0.131632</td>
<td>0.2098</td>
<td>0.2234</td>
<td>0.100446</td>
<td>0.204739</td>
</tr>
<tr>
<td>Z-score</td>
<td>12.42128</td>
<td>1.62389</td>
<td>1.7064</td>
<td>-0.85415</td>
<td>-14.2038</td>
</tr>
</tbody>
</table>

Figure 2. Grade distribution for traditional and technology-assisted courses.

The assumption with a proportion test is that the proportions of a specific characteristic in two samples will show no significant difference. The analysis of this data yielded z-scores of 12.42128 for the letter grade A and -14.2038 for the letter grade of F, indicating a significant difference in the proportion of the A’s and F’s in the grade distribution of the traditional and the technology-assisted courses. The change in grade distribution was a significantly higher
proportion of A’s in the traditional courses and a significantly higher number of F’s in the
technology-assisted courses.

Research Question 3

Research Question 3 addresses the issue of retention rate in the traditional and
technology-assisted courses. To determine if there is a difference in the retention rate in these
two methods of course delivery, the end-of-course grades were analyzed to determine if there is a
significant difference in the proportion of students not completing a traditional course and
students not completing a technology-assisted course. The grades that indicate a failure to finish
a course are FA, W, WF, WP, DR, DP, and DF. These data were analyzed using the proportion
test with the null hypothesis “There is no significant difference in the retention rates of students
in traditional courses and those in technology-assisted courses.” The data were grouped into
traditional and technology-assisted groups over the semesters from Fall 2007 to Fall 2012 and
each assigned grade was analyzed to determine if there was a significant difference at the 0.05
level of significance in the proportion of the grades assigned. The proportion test yielded the
following z-scores: the grade of FA, \( z = 1.386277 \); the grade of W, \( z = -5.47475 \); the grade of
WF, \( z = -4.886 \); the grade of WP, \( z = -2.79676 \); the grade of DR, \( z = -0.60523 \); the grade of DP, \( z
= 1.971083 \); and the grade of DF, \( z = -2.79676 \). At the 0.05 level of significance, the critical
z-score was 1.95996. At the 0.05 level of significance for the grades of W, WF, WP, DP, and
DF, the null hypothesis was rejected. At the 0.05 level of significance for the grades of FA and
DR, the null hypothesis was not rejected. In addition to looking at the grades associated with
non-completion of a course and determining if there is a significant difference in the proportion
of the grades, the overall total of non-completion grades was analyzed to determine if the total
proportion of students who did not complete the course has a different proportion in traditional courses than in technology-assisted courses. The null hypothesis is “There will be no significant difference in the proportion of total of non-completing grades in a traditional course and a technology-assisted course.” These data were analyzed using a proportion test and it was determined that the z-score for the proportion of non-completing grades in a traditional course to the number of non-completing grades in a technology-assisted course was -3.09411. This is beyond the critical z-score at the 0.05 level of confidence so the null hypothesis was rejected. The results of this analysis are shown in Table 3 and Figure 3.
Table 3

*Grade Distribution of Non-completion Grades in Traditional and Technology-Assisted Courses*

<table>
<thead>
<tr>
<th></th>
<th>FA</th>
<th>DP</th>
<th>DF</th>
<th>DR</th>
<th>W</th>
<th>WP</th>
<th>WF</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Enrollment</td>
<td>438</td>
<td>125</td>
<td>47</td>
<td>753</td>
<td>261</td>
<td>47</td>
<td>34</td>
<td>1705</td>
</tr>
<tr>
<td>Total Traditional</td>
<td>303</td>
<td>93</td>
<td>22</td>
<td>490</td>
<td>131</td>
<td>22</td>
<td>9</td>
<td>1070</td>
</tr>
<tr>
<td>Total E-Course</td>
<td>135</td>
<td>32</td>
<td>25</td>
<td>263</td>
<td>130</td>
<td>25</td>
<td>25</td>
<td>635</td>
</tr>
<tr>
<td>Percentage</td>
<td>0.031483</td>
<td>0.009663</td>
<td>0.002286</td>
<td>0.0509144</td>
<td>0.0136118</td>
<td>0.002286</td>
<td>0.000935162</td>
<td>0.11118</td>
</tr>
<tr>
<td></td>
<td>0.027339</td>
<td>0.006480</td>
<td>0.005063</td>
<td>0.0532604</td>
<td>0.02632645</td>
<td>0.0050628</td>
<td>0.005062778</td>
<td>0.12859</td>
</tr>
<tr>
<td>Z-score</td>
<td>1.386277</td>
<td>1.971083</td>
<td>-2.796760</td>
<td>-0.6052325</td>
<td>-5.4747541</td>
<td>-2.79676</td>
<td>-4.8856329</td>
<td>-3.09411</td>
</tr>
</tbody>
</table>


The proportion test assumes that there will be no significant difference in the proportions of a specific characteristic within two samples. In the case of the grades DP, DF, W, WP, and WF with z-scores of 1.97108, -2.797, -5.47475, 2.79676, and -4.8856327, respectively there is a significant difference in the proportions indicating that there is a difference in the retention rates of traditional courses and technology-assisted courses. Additionally, the differences in the total proportion of grades that are non-completion grades are significant with a z-score of -3.09411.

The grades of DP and WP were significantly higher in the traditional courses, while the grades of DF, W, and WF were more prevalent in the Technology-Assisted courses. The total proportion of non-completion grades were higher in the technology-assisted courses than in the traditional courses.
Research Question 4

Research Question 4 is targeted at the length of instruction of traditional courses and technology-assisted courses. The courses in the study were taught using two different schedules. The traditional courses were taught either in an 18-week semester or in a 9-week term. All of the technology-assisted courses were taught on a 9-week term. Because the time spent in a course can vary, it is important to determine what effect this change in course length has on achievement, grade distribution, and retention rates. In order to answer these questions, the data were separated into three categories: traditional 18-week course, traditional 9-week course, and technology-assisted 9-week course. Once the data were grouped into these categories, the previous research questions were addressed a second time to determine if the time spent in the course affected the results. In Research Question 1, it was determined that there was a significant difference in the student achievement of students in traditional courses and those in technology-assisted courses. After the data were grouped into 18-week traditional, 9-week traditional, and 9-week technology-assisted groups, the null hypotheses, “There will be no significant difference between the achievement of students in an 18-week traditional course and a 9-week technology-assisted course as seen through the average course grade point average,” and “There will be no significant difference between the achievement of students in a 9-week traditional course and a 9-week technology-assisted course as seen through the average course grade point average,” were tested. The first hypothesis was tested using a t test for means and it was determined that the t-score for the 18-week traditional course and the 9-week technology-assisted course was \( t = 2.6913 \) with 25 degrees of freedom. The critical t-value at the 0.05 level of confidence with 30 degrees of freedom was \( t = 2.0596 \), thus the null hypothesis was rejected. The average course grade point average of the 18-week traditional courses was significantly
higher than the average course grade point average for the technology-assisted courses. The second hypothesis was tested using a $t$ test for means and it was determined that the $t$ score for the 9-week traditional course and the 9-week technology-assisted course was $t = 5.3887$ with 35 degrees of freedom. The critical $t$ value at the 0.05 level of confidence with 35 degrees of freedom was $t = 2.0301$, thus the null hypothesis was rejected. The average course grade point average of the 9-week traditional courses was significantly higher than the average course grade point average for the technology-assisted courses. These findings indicate that there is a significant difference in student achievement as indicated by the overall course grade point average. This can be seen in Figure 4.

![Average Course GPA In 18-Week, 9-Week, and Technology-Assisted Courses](attachment:image.png)

*Figure 4. Average course grade point averages for 18-week traditional, 9-week traditional, and technology-assisted courses.*
The grouping of courses into 18-week traditional, 9-week traditional, and 9-week technology-assisted courses does not change the result that there is a significant difference in the achievement of students in traditional courses and those in technology-assisted courses. The average course grade point average of the traditional courses was significantly higher than the average course grade point average for the technology-assisted courses.

The second research question analyzed the grade distributions of the traditional courses and those that are technology-assisted. Once again, the effect of course length can be determined through grouping the courses into three categories: 18-week traditional, 9-week traditional, and technology-assisted. For grade distribution, the grades of A, B, C, D, and F were analyzed using the proportion test. The null hypotheses are, “There will be no significant difference in the grade distributions of 18-week traditional courses and technology-assisted courses,” and “There will be no significant difference in the grade distributions of 9-week traditional courses and technology-assisted courses.” The data were grouped into 18-week traditional, 9-week traditional, and technology-assisted groups over the semesters from Fall 2007 to Fall 2012 and each assigned grade was analyzed at the 0.05 level of significance to determine if there was a significant difference in the proportion of the grades assigned. The proportion test yielded the following z-scores for the 18-week traditional course compared to the technology-assisted course: the grade of A, \( z = 10.22323 \); the grade of B, \( z = -0.1924 \); the grade of C, \( z = 1.9949 \); the grade of D, \( z = 1.105833 \); and the grade of F, \( z = -12.5391 \). At the 0.05 level of significance, the critical z-score was 1.95996. At the 0.05 level of significance for the grades of A, C, and F, the null hypothesis was rejected. At the 0.05 level of significance for the grades of B, and D we failed to reject the null hypothesis. The proportion test yielded the following z-scores for the 9-week traditional course compared to the technology-assisted course: the grade of A, \( z = 13.79957 \); the grade of B,
\( z = 5.51933 \); the grade of C, \( z = 0.1897 \); the grade of D, \( z = -5.92802 \); and the grade of F, \( z = -10.7154 \). At the 0.05 level of significance, the critical \( z \)-score is 1.95996. At the 0.05 level of significance for the grades of A, B, D, and F, the null hypothesis was rejected. At the 0.05 level of significance for the grade of C, the null hypothesis was not rejected. These results are summarized in Table 4 and Figure 5.

Table 4

*Grade Distribution for 18-week Traditional, 9-week Traditional, and Technology-assisted Courses*

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total 18 Weeks Traditional</td>
<td>1539</td>
<td>1583</td>
<td>1814</td>
<td>810</td>
<td>926</td>
</tr>
<tr>
<td>Total 9 Week Traditional</td>
<td>545</td>
<td>549</td>
<td>457</td>
<td>114</td>
<td>198</td>
</tr>
<tr>
<td>Total Technology-Assisted</td>
<td>650</td>
<td>1036</td>
<td>1103</td>
<td>496</td>
<td>1011</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Total 18 Weeks Traditional</th>
<th>0.202580</th>
<th>0.20837</th>
<th>0.2388</th>
<th>0.106621</th>
<th>0.12189</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total 9 Week Traditional</td>
<td>0.268870</td>
<td>0.27084</td>
<td>0.2255</td>
<td>0.056241</td>
<td>0.097681</td>
</tr>
<tr>
<td></td>
<td>Total Technology-Assisted</td>
<td>0.13163</td>
<td>0.2098</td>
<td>0.2234</td>
<td>0.100446</td>
<td>0.204739</td>
</tr>
<tr>
<td>Z-score 18-W and TA</td>
<td>10.22323</td>
<td>-0.1924</td>
<td>1.9949</td>
<td>1.105833</td>
<td>-12.5391</td>
<td></td>
</tr>
<tr>
<td>Z-score 9-W and TA</td>
<td>13.79957</td>
<td>5.51933</td>
<td>0.1897</td>
<td>-5.92802</td>
<td>-10.7154</td>
<td></td>
</tr>
</tbody>
</table>
In the proportion test, it was assumed there would be no significant difference in the proportions of a specific characteristic of the samples. In the case of both the 18-week traditional course and the 9-week traditional course, there were significant differences in the proportions of the grades obtained and those of technology-assisted. There were significantly higher proportions of A’s and B’s in the traditional courses and a significantly higher proportion of D’s and F’s in the technology-assisted courses.

Research Question 3 analyzed the retention rates of traditional courses and those of technology-assisted courses. This was determined through the end-of-course grades, specifically the grades FA, W, WF, WP, DR, DP, and DF. As previously discussed, the effect of course length can be determined through grouping the courses into three categories: 18-week traditional, 9-week traditional, and technology-assisted. The grades indicating course non-completion were analyzed using the proportion test. The null hypotheses are that “There will be no significant
difference in the retention rate of 18-week traditional courses and technology-assisted courses,” and “There will be no significant difference in the retention rate of 9-week traditional courses and technology-assisted courses.” The data were grouped into 18-week traditional, 9-week traditional, and technology-assisted groups over the semesters from Fall 2007 to Fall 2012 and each assigned grade was analyzed at the 0.05 level of significance to determine if there was a significant difference in the proportion of the grades assigned.

The proportion test yielded the following z-scores for the 18-week traditional course compared to the technology-assisted course: the grade of FA, \( z = 2.612604 \); the grade of W, \( z = -6.23883 \); the grade of WF, \( z = -4.48973 \); the grade of WP, \( z = -3.35313 \); the grade of DR, \( z = 0.92325 \); the grade of DP, \( z = 2.48568 \); and the grade of DF, \( z = -3.35313 \). At the 0.05 level of significance, the critical z-score is that of 1.95996. At the 0.05 level of significance for the grades of FA, W, WF, WP, DP, and DF, the null hypothesis was rejected. At the 0.05 level of significance for the grade of DR, the null hypothesis was not rejected. The proportion test yielded the following z-scores for the 9-week traditional course compared to the technology-assisted course: the grade of FA, \( z = -2.99371 \); the grade of W, \( z = -1.12206 \); the grade of WF, \( z = -2.48662 \); the grade of WP, \( z = -0.33870 \); the grade of DR, \( z = -4.64829 \); the grade of DP, \( z = -0.50991 \); and the grade of DF, \( z = -0.33870 \). At the 0.05 level of significance, the critical z-score was 1.95996. At the 0.05 level of significance for the grades of FA, WF, and DR, the null hypothesis was rejected. At the 0.05 level of significance for the grades of W, WP, WF, DP, and DF, the null hypothesis was not rejected.

In addition to looking at the grades associated with non-completion of a course and determining if there was a significant difference in the proportion of the grades, the overall total of non-completion grades was analyzed to determine if the total proportion of students who do
not complete the course had a different proportion in traditional courses than in technology-assisted courses. The null hypotheses are, “There will be no significant difference in the proportion of total of non-completing grades in an 18-week traditional course and a technology-assisted course” and “There will be no significant difference in the proportion of total of non-completing grades in a 9-week traditional course and a technology-assisted course.”

The data were analyzed using proportion tests and it was determined that the z-score for the proportion of non-completing grades in an 18-week traditional course to the number of non-completing grades in a technology-assisted course was -1.51085, which is below the critical z-score needed. The z-score is not large enough at the 0.05 level of confidence to reject the null hypothesis. The z-score for the proportion of non-completing grades in a 9-week traditional course to the number of non-completing grades in a technology-assisted course was -5.79635, which is beyond the critical z-value so the null hypothesis was rejected. The 18-week traditional courses had significant differences in some areas of course non-completion, but the overall proportion of non-completing grades was not significantly different than those in the technology-assisted courses. In the 9-week traditional courses, there were also significant differences in some areas of non-completion, and the overall proportion of non-completing students was significantly higher in the technology-assisted courses than in the 9-week traditional courses. These results are summarized in Table 5 and Figure 6.
Table 5

18-week Traditional, 9-week Traditional, and Technology-assisted Courses Percentages of Non-completion

<table>
<thead>
<tr>
<th></th>
<th>FA</th>
<th>DP</th>
<th>DF</th>
<th>DR</th>
<th>W</th>
<th>WP</th>
<th>WF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>272</td>
<td>82</td>
<td>13</td>
<td>434</td>
<td>87</td>
<td>13</td>
<td>7</td>
<td>908</td>
</tr>
<tr>
<td>Total 9-week</td>
<td>31</td>
<td>11</td>
<td>9</td>
<td>56</td>
<td>44</td>
<td>9</td>
<td>2</td>
<td>162</td>
</tr>
<tr>
<td>Total Technology</td>
<td>135</td>
<td>32</td>
<td>25</td>
<td>263</td>
<td>130</td>
<td>25</td>
<td>25</td>
<td>635</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 18-weeks</td>
<td>0.03580</td>
<td>0.01079</td>
<td>0.00171</td>
<td>0.05713</td>
<td>0.01145</td>
<td>0.00171</td>
<td>0.00092</td>
<td>0.11952</td>
</tr>
<tr>
<td>Total 9-week</td>
<td>0.01529</td>
<td>0.00543</td>
<td>0.00444</td>
<td>0.02763</td>
<td>0.02171</td>
<td>0.00444</td>
<td>0.00099</td>
<td>0.07992</td>
</tr>
<tr>
<td>Total Technology</td>
<td>0.02734</td>
<td>0.00648</td>
<td>0.00506</td>
<td>0.05326</td>
<td>0.02633</td>
<td>0.00506</td>
<td>0.00506</td>
<td>0.12859</td>
</tr>
<tr>
<td>Z-score 18-W and TA</td>
<td>2.61260</td>
<td>2.48568</td>
<td>-3.33513</td>
<td>0.92325</td>
<td>-6.23883</td>
<td>-3.33513</td>
<td>-4.48973</td>
<td>-1.51085</td>
</tr>
<tr>
<td>Z-score 9-W and TA</td>
<td>-2.99371</td>
<td>-0.50991</td>
<td>-0.33870</td>
<td>-4.64829</td>
<td>-1.12206</td>
<td>-0.33870</td>
<td>-2.48662</td>
<td>-5.79635</td>
</tr>
</tbody>
</table>
In the proportion test, the assumption is that there will be no significant difference in the proportions of a specific characteristic of the samples. In the case of both the 18-week traditional course and the 9-week traditional course there were significant differences in the proportions of grades used for non-completion obtained and those of technology-assisted courses, indicating a difference in course retention. The 18-week traditional courses did not have a significantly different overall proportion of non-completion grades than those in the technology-assisted courses; however, the 9-week traditional courses had significant differences in the overall proportion of non-completing students and were significantly higher in the technology-assisted courses.

Figure 6. 18-week traditional, 9-week traditional, and technology-assisted courses percentages of non-completion.
CHAPTER 5

DISCUSSION, IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

Introduction

This chapter will include a summary of the results and findings of this study as presented in Chapter 4, including discussion of the results and conclusions. It will also include possible implications of this research and recommendations for further research.

Summary of the Study

This study was a quantitative study that used student end-of-course grades in a general studies mathematics course, Pre-Calculus Algebra from Fall 2007 to Fall 2012. The purpose of this study was to determine what effect methods of course delivery had in the areas of achievement, grade distribution, and retention rate. Specifically, traditional delivery methods were analyzed along with technology-assisted course delivery methods to determine if there were any significant differences.

Discussion

The first area analyzed by this study was the area of achievement. Achievement can be defined in multiple ways, and is often difficult to quantify. The idea of student achievement can mean successfully completing a course (passing) or could be measured by student performance on a standardized test. Because achievement is generally connected to performance, the use of student grades to determine achievement level is appropriate. To determine the level of student
achievement, the grades assigned in each course were totaled, giving a total number of A’s, B’s, C’s, D’s, and F’s assigned for a given semester. By taking the proportion of these grades to the total number of students in the course and using standard weights of A = 4.0, B = 3.0, C = 2.0, D = 1.0, and F = 0.0, the overall grade point average for a given semester/term was obtained.

These course grades were initially grouped into traditional courses and into technology-assisted courses, then later in the study the data were regrouped into 18-week traditional courses, 9-week traditional courses, and technology-assisted courses. The grade point averages were calculated for each semester/term and were then analyzed for average grade point average and standard deviation. Once these calculations were completed, a t test was run to determine if there was a significant difference in the course grade point averages of those students in traditional courses and those in technology-assisted courses. The average course grade point average for traditional courses was 2.13949 and the average grade point average for technology-assisted courses was 1.69526. At the 0.05 level of significance, there was a significant difference between the means of the two courses indicating that there was a difference in achievement among students in those courses. The traditional courses had a significantly higher overall course grade point average than the technology-assisted courses. The data were further analyzed when comparing the length of the course to student achievement, grade distribution, and retention rates. The length of the traditional courses was either 18-week semesters or 9-week terms; however, the length of each of the technology-assisted courses was 9 weeks. This change in the length of the course is an important factor and was studied to ensure that the differences observed were due to the course delivery method and not the length of the course. In order to determine what effect the length of course had on student achievement, the traditional courses were divided into two categories: the 18-week courses and the 9-week courses. The technology-assisted courses were grouped in the
same manner as they were previously. Upon regrouping the data, the average course grade point average of the 18-week traditional students was determined to be 2.01757, and the average course grade point average of the 9-week traditional students was determined to be 2.35383. These were compared to the technology-assisted course average of 1.69526 using a t test. In both the 18-week traditional and the 9-week traditional there were significant differences, indicating that the change in student achievement was not simply a result of the length of the course. In the 18-week traditional courses and the 9-week traditional courses, the overall course grade point average was significantly higher than the technology-assisted courses.

The second area analyzed in this study was that of grade distribution. The grade distribution for a given course was the number of each grade that was assigned to the students. Although there are several types of grades that can be assigned (A, B, C, D, F, FA, I, NG, P, AU, W, WP, WF, DR, DP, DF, IP, and Fl), the purpose of this portion of the study was to determine if there was a significant difference in the grade distributions of traditional and technology-assisted courses. Because some of these grades are no longer in use by the University, there were no grades in those categories. Additionally, grades such as NG, IP, AU, P, and I are not defined well enough to make any conclusions based on statistics obtained in those categories. Furthermore, grades of FA, W, WP, WF, DR, DP, and DF are all grades associated with failure to complete a course. These grades were analyzed later in the study.

To determine the effect the course delivery method has on grade distribution, the standard grades of A, B, C, D, and F were analyzed in the traditional courses and the technology-assisted courses. The proportions that these grades appeared in the courses was computed and a proportion test was used to determine if there was a significant difference in the number of A’s, B’s, C’s, D’s, and F’s given in the courses utilizing the different delivery methods. When
grouping all of the traditional courses together and all of the technology-assisted courses together, it was determined that there were z-scores of 12.42128 for the letter grade A and -14.2038 for the letter grade of F. This indicates that there is a significant difference in the proportion of the number of A’s and the proportion of the number of F’s, which indicates a difference in grade distribution between traditional courses and technology-assisted courses. The traditional courses had a significantly higher proportion of A’s in the grade distribution, and the technology-assisted courses had a significantly higher proportion of F’s. The data were then divided to determine if the length of course had any effect on the grade distribution and this was achieved by splitting the traditional courses into 18-week traditional courses and 9-week traditional courses. The technology-assisted courses were grouped as before.

The proportions of each of the grades were analyzed and, in the case of the 18-week traditional courses, the grades of A, C, and F had proportions that differed by significant amounts. The z-scores for these grades were 10.22323, 1.9949, and -12.5391, respectively. In the case of the 9-week traditional courses, the grades of A, B, D, and F had proportions that differed by significant amounts. The z-scores for these grades were 13.79957, 5.51933, -5.92802, and -10.7154, respectively. In both the case of the 18-week traditional courses and the 9-week traditional courses, there were significant differences in the proportions of the grades assigned. In the 18-week traditional courses there were significantly higher proportions of A’s and C’s. In the technology-assisted courses there were a significantly higher number of F’s. When comparing the 9-week traditional and the technology-assisted courses, the traditional courses had a higher proportion of A’s and B’s while the technology-assisted courses had a higher proportion of D’s and F’s. Because of these differences in both the 18-week traditional
course and the 9-week traditional course, the length of course is not the only factor causing the change.

The third area of study was that of student retention. In order to determine if a student completed a course using only end-of-course grades, the grades that indicate failure to finish the course were analyzed. In this study, those grades were FA, W, WF, WP, DR, DP, and DF. Although there are other grades possible (such as I-incomplete), they are not well defined and a student’s retention may not be apparent. For each of the FA, W, WF, WP, DR, DP, and DF grades, the student did not complete the course and therefore was not retained. The differences in the categories of these grades is primarily due to when the student decides to leave the course and what the student’s grade is at that time. These grades were divided into traditional courses and technology-assisted course, and a proportion test was performed to determine if there was a significant difference in the retention rates in the courses. The proportion test yielded z-scores that were significant for the grades of W, WF, WP, DP, and DF with values of -5.47475, -4.886, -2.79676, 1.971083, and -2.79676, respectively. This indicated a significant difference in the proportion of several of the non-completion grades. There were higher proportions of the grades of DP in the traditional courses and higher proportions of W, WF, WP, and DF in the technology-assisted courses.

The data were then regrouped to determine if length of course was a cause of the change in non-completion grades. The traditional courses were divided into the 18-week traditional and the 9-week traditional. The technology-assisted courses remained grouped in the same manner. The proportion tests were run for the grades of FA, W, WF, WP, DR, DP, and DF. In the 18-week traditional courses the FA, W, WF, WP, DP, and DF all were determined to have significant proportions with z-scores of 2.612604, $z = -6.23883$, $z = -4.48973$, -3.33513, 2.48568,
and -3.33513, respectively. The 9-week traditional course was determined to have significant differences in the proportions of FA, WF, and DR with z-scores of -2.99371, -2.48662, and -4.64829, respectively. This indicates that there are significant differences in the proportions of the grades associated with the retention rate. There were higher proportions of the grades of FA, WP, and DP in the 18-week traditional courses and higher proportions of W, WF, and DF in the technology-assisted courses. In the 9-week traditional courses, there were higher proportions of FA, WF, and DR. There were higher proportions of FA in the 9-week traditional courses, but higher proportions of WF and DR in the technology-assisted courses.

In addition to each individual non-completing grade distribution, the number of noncompeting grades for students was totaled and the proportion of non-completion grades was analyzed for the traditional and the technology-assisted courses. Because there are multiple manners in which a student can fail to complete a course, the total number of students who did not complete a course was analyzed. The result of this computation is valid regardless of when the withdrawal was processed or if the student was passing at that moment when they left the course. The first test performed was on the traditional courses and the technology-assisted courses and tested the null hypothesis “there will be no significant difference between the proportion of student who fail to complete the traditional course and those who fail to complete the technology-assisted course.” The z-score for this test of -3.094106 was beyond the critical z-value and thus the null hypothesis was rejected. The 18-week traditional courses did not have a significant difference in course completion. The 9-week traditional courses had a significant difference in the proportion of non-completion grades to the technology-assisted courses with the technology-assisted courses having a higher proportion of non-completion grades.
Like the other data, the course-retention results were also analyzed in a separate manner in order to determine if the course length was a factor in the proportions of student non-completion. The traditional group of students was divided into 18-week traditional, and 9-week traditional. The technology-assisted courses were grouped in the same manner they were previously. A proportion test was run on the 18-week traditional course compared with the technology-assisted course to determine if there were significant differences in the non-completion grades. The $z$-score yielded by this test was $z = -1.51085$, which is lower than the critical $z$-score at the 0.05 level of confidence; therefore, the null hypothesis was not rejected. A proportion test was also run on the 9-week traditional course compared with the technology-assisted course to determine if there were significant differences in the non-completion grades. The $z$-score yielded by this test was $z = -5.79635$, which is greater than the critical $z$-score at the 0.05 level of confidence; thus, the null hypothesis was rejected. Because the null hypothesis was not rejected for the 18-week traditional courses and was rejected for the 9-week traditional courses, there may be a connection between course length and retention rates between traditional courses and technology-assisted courses.

Findings Related to the Literature

This study showed that there are significant differences in student achievement for students enrolled in a traditional course to those that are enrolled in a technology-assisted course. This would support the position found in *Going the Distance in Online Education* (Larreamendy-Joerns & Leinhardt, 2006). In this article, the authors contended that although there is academic value to courses taught online, the level at which the students learn is inferior to other methods. While there are other studies that have shown differing results (Barbour & Mulcahy, 2008), the
data gathered in this study would support the position that students are learning in the technology-assisted classroom, but not at the same level as their traditional counterparts.

There are many studies in which students in an online classroom have higher achievement levels than their traditional counterparts, and there are other studies where the opposite relationship is present. One reason behind this difference may be the support of the students in the classroom. If students have a difficult time navigating the online environment, then their academic performance may suffer as well (Muilenburg & Berge, 2005). The technology-assisted courses in this study utilized MyMathLab, which is a proprietary course shell created by Pearson Education. While having a course shell is beneficial, it may have been an obstacle in this study. Additionally, the students in the technology-assisted courses in this study had all of their assessments online and these assessments were automatically graded. There is a significant challenge in grading mathematics problems due to syntax and format. Although computers have come a long way, there are still issues when it comes to mathematical symbols (Loch & McDonald, 2007).

Many mathematics solutions can be expressed in alternative forms that are equivalent. It is the lack of versatility that Naismith and Sangwin (2004) addressed with their Computer Algebra Based Learning and Evaluation (CABLE) system. The use of electronic tests in a technology-assisted course rather than paper and pencil tests could also affect achievement levels. In addition to the course environment and grading mechanisms, students may have had issues with achievement stemming from time management, course readiness, or course design as noted by Aragon and Johnson (2008).

The change in grade distribution between students in a traditional course and those in a technology-assisted course could also be attributed to course design issues, grading obstacles,
time management, and course readiness. While a student who enrolled in the traditional course would need to have the same prerequisite courses or placement as a student in the technology-assisted courses, the students may not become aware of their deficiencies as quickly and may not be able to remediate themselves in the time allotted. While online remediation tools exist and are often successful (Biesinger & Crippen, 2008) students may not know what areas need to be addressed and may have trouble locating the resources online. The students in the technology-assisted courses in this study showed a significant change in grade distribution. Because the grades in the study were end-of-course grades, these reflect the average of the student performance for the entire course. The grades in each of the courses studied were an average of the formative and summative assessments taken throughout the course. The difference in grade distribution, as well as student achievement, may stem from a problem noted by the U.S. Department of Education (2005). In this report, the NAEP noted that the computer grading of the constructed-response questions did not agree with the human grading. Additionally, it is difficult once a question has been developed to develop benchmarks for partial credit. Finally, the NAEP found that the electronic device used to take the assessments, whether school computer or NAEP provided laptop, affected the outcomes of the assessment. Because students in technology-assisted courses are assessed in an all-online format, differences in the assessments, grading, and the device the students use to access the course may all attribute to the change in grade distribution.

In addition to changes in achievement and grade distribution, there were significant differences in retention rates among the traditional courses and the technology-assisted courses. Students in both traditional courses and technology-assisted courses have trouble with time management, motivation, course design, and communication, but these issues are more distinct
in an online setting (Aragon & Johnson, 2008). Among the grades that indicate non-completion of a course there were several that showed significant differences, and between the 9-week traditional and the technology-assisted courses there was a significantly higher number of total non-completers than in the technology-assisted courses. The magnification of the issues that lead to student non-completion could have caused the changes in the proportion among non-completion grades and the change in totals among these courses.

**Surprises**

The biggest surprise of this study was a change in the grade distribution in the technology-assisted courses in the Fall of 2010. Prior to Fall 2010, the average percentage of A’s in the technology-assisted courses was 0.187754. Courses taught during Fall 2010 and after had a percentage of A’s in technology-assisted courses of 0.047931. This difference of 0.139823 is significant and is seen in each term after Fall 2010. The causes of the shift in grade distribution is not covered in the scope of this study, but due to the markedly different values, the courses before and after the change were analyzed to determine the effect on the results of the study. The courses were divided into courses taught prior to Fall 2010 and courses taught Fall 2010 and after. Once again, because course length can be a factor, the courses were grouped into three categories: 18-week traditional, 9-week traditional, and technology-assisted. For grade distribution the grades of A, B, C, D, and F were analyzed using the proportion test. The null hypotheses are that “There will be no significant difference in the grade distributions of 18-week traditional courses and technology-assisted courses taught prior to Fall 2010,” and “There will be no significant difference in the grade distributions of 9-week traditional courses and technology-assisted courses taught prior to Fall 2010.”
The data were grouped into 18-week traditional, 9-week traditional, and technology-assisted over the semesters from Fall 2007 to Summer 2010 and each assigned grade was analyzed at the 0.05 level of significance to determine if there was a significant difference in the proportion of the grades assigned. The proportion test yielded the following $z$-scores for the 18-week traditional course compared to the technology-assisted course: the grade of A, $z = 3.207987$; the grade of B, $z = -0.4693$; the grade of C, $z = 3.3004$; the grade of D, $z = 1.344729$; and the grade of F, $z = -9.88356$. At the 0.05 level of significance, the critical $z$-score was 1.95996. At the 0.05 level of significance for the grades of A, C, and F the null hypothesis was rejected. This indicates that the proportions of the grades A, C, and F are significantly different, with the 18-week traditional courses having a higher proportion of A’s and C’s. The technology-assisted courses had a higher level of F’s. At the 0.05 level of significance for the grades of B, and D, the null hypothesis was not rejected.

The proportion test yielded the following $z$-scores for the 9-week traditional course taught prior to Fall 2010 compared to the technology-assisted course: the grade of A, $z = 6.921865$; the grade of B, $z = 4.70587$; the grade of C, $z = 1.964$; the grade of D, $z = -3.4498$; and the grade of F, $z = -10.0951$. At the 0.05 level of significance, the critical $z$-score was 1.95996. At the 0.05 level of significance for the grades of A, B, D, and F, the null hypothesis was rejected. This indicates that the proportions of the grades A, B, D and F are significantly different, with the 9-week traditional courses having a higher proportion of A’s and B’s. The technology-assisted courses had a higher level of D’s and F’s. At the 0.05 level of significance for the grade of C, the null hypothesis was not rejected. The grade distributions for courses taught Fall 2010 and after were also analyzed and the grades of A, B, C, D, and F were analyzed using the proportion test. The null hypotheses are that “There will be no significant difference in the grade
distributions of 18-week traditional courses and technology-assisted courses taught Fall 2010 and after,” and “There will be no significant difference in the grade distributions of 9-week traditional courses and technology-assisted courses taught Fall 2010 and after.”

The data were grouped into 18-week traditional, 9-week traditional, and technology-assisted groups over the semesters from Fall 2010 to Fall 2012 and each assigned grade was analyzed to determine if there was a significant difference at the 0.05 level of significance in the proportion of the grades assigned. The proportion test yielded the following z-scores for the 18-week traditional course compared to the technology-assisted course: the grade of A, $z = 13.54087$; the grade of B, $z = 0.78898$; the grade of C, $z = -0.671$; the grade of D, $z = -0.08431$; and the grade of F, $z = -9.11327$. At the 0.05 level of significance, the critical z-score was 1.95996. At the 0.05 level of significance for the grades of A and F, the null hypothesis was rejected. At the 0.05 level of significance for the grades of B, C, and D, the null hypothesis was not rejected. The proportion test yielded the following z-scores for the 9-week traditional course taught Fall 2010 and after compared to the technology-assisted course: the grade of A, $z = 14.92489$; the grade of B, $z = 2.41145$; the grade of C, $z = -1.662$; the grade of D, $z = -4.77245$; and the grade of F, $z = -4.31679$. At the 0.05 level of significance, the critical z-score was that of 1.95996. At the 0.05 level of significance for the grades of A, B, D, and F, the null hypothesis was rejected. At the 0.05 level of significance for the grade of C, the null hypothesis was not rejected. These results are summarized in Table 6, Figure 7, and Figure 8.
Table 6

*Grade Distribution for Courses before Fall 2010*

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
</tr>
</thead>
<tbody>
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<td><strong>Totals before Fall 2010</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Total 18-week Traditional</td>
<td>882</td>
<td>911</td>
<td>916</td>
<td>382</td>
<td>470</td>
</tr>
<tr>
<td>Total 9-week Traditional</td>
<td>374</td>
<td>392</td>
<td>293</td>
<td>73</td>
<td>97</td>
</tr>
<tr>
<td>Total Technology-Assisted</td>
<td>555</td>
<td>675</td>
<td>576</td>
<td>252</td>
<td>575</td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 18-week Traditional</td>
<td>0.216814159</td>
<td>0.22394297</td>
<td>0.225172075</td>
<td>0.0939036</td>
<td>0.11553589</td>
</tr>
<tr>
<td>Total 9-week Traditional</td>
<td>0.282051282</td>
<td>0.295625943</td>
<td>0.220965309</td>
<td>0.0550528</td>
<td>0.07315234</td>
</tr>
<tr>
<td>Total Technology-Assisted</td>
<td>0.187753721</td>
<td>0.22834912</td>
<td>0.194857916</td>
<td>0.0852503</td>
<td>0.19451962</td>
</tr>
<tr>
<td><strong>Z-score 18-W and TA</strong></td>
<td>3.207986955</td>
<td>-0.469284632</td>
<td>3.30041216</td>
<td>1.3447293</td>
<td>-9.8835595</td>
</tr>
<tr>
<td><strong>Z-score 9-W and TA</strong></td>
<td>6.921865141</td>
<td>4.705871672</td>
<td>1.963960661</td>
<td>-3.4498029</td>
<td>-10.095102</td>
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<tr>
<td><strong>Totals Fall 2010 and after</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 18-week Traditional</td>
<td>657</td>
<td>717</td>
<td>969</td>
<td>460</td>
<td>479</td>
</tr>
<tr>
<td>Total 9-week Traditional</td>
<td>171</td>
<td>157</td>
<td>164</td>
<td>41</td>
<td>101</td>
</tr>
<tr>
<td>Total Technology-Assisted</td>
<td>95</td>
<td>361</td>
<td>527</td>
<td>244</td>
<td>436</td>
</tr>
<tr>
<td><strong>Percentage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 18-week Traditional</td>
<td>0.174734043</td>
<td>0.190691489</td>
<td>0.257712766</td>
<td>0.1223404</td>
<td>0.12739362</td>
</tr>
<tr>
<td>Total 9-week Traditional</td>
<td>0.243937233</td>
<td>0.223965763</td>
<td>0.23951498</td>
<td>0.0584879</td>
<td>0.14407989</td>
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<tr>
<td>Total Technology-Assisted</td>
<td>0.047931382</td>
<td>0.182139253</td>
<td>0.265893037</td>
<td>0.123108</td>
<td>0.21997982</td>
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<td><strong>Z-score 18-W and TA</strong></td>
<td>13.54086826</td>
<td>0.788984318</td>
<td>-0.671412251</td>
<td>-0.0843075</td>
<td>-9.1132736</td>
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<tr>
<td><strong>Z-score 9-W and TA</strong></td>
<td>14.92488731</td>
<td>2.411453922</td>
<td>-1.662238448</td>
<td>-4.7724541</td>
<td>-4.3167864</td>
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</table>
**Figure 7.** Grade distribution of courses before Fall 2010.

**Figure 8.** Grade distribution of courses in Fall 2010 and after.

The apparent change in the distribution of A’s in the Fall 2010 is an area where more study is warranted; however, when considering the distributions before and after this change, there are still significant differences in grade distributions between the traditional courses and the technology-assisted courses.
Conclusions

The conclusions of this study are that at this University, there are significant differences in the areas of achievement, grade distributions, and course retention between students enrolled in both the traditional and technology-assisted courses for Pre-Calculus Algebra between Fall 2007 and Fall 2010. In the area of achievement, the students in the traditional courses scored at a significantly higher level than those students in the technology-assisted courses. The students in the traditional courses had an average course grade point average of 2.13949479 and the students in the technology-assisted courses had an average course grade point average of 1.695255794. This indicates that the students enrolled in the traditional course are developing a greater understanding of the material presented than their counterparts in technology-assisted classes.

The grade distributions showed significant differences particularly in the number of A’s and F’s that the students received. The total percentage of A’s in the traditional courses was 0.216541978, where the total percentage of A’s in the technology-assisted courses was 0.13163224. This difference in percentage affected the grades below, but the most noted change was in the number of F’s. The total percentage of F’s in the traditional courses was 0.116791355 and the total percentage of F’s in the technology-assisted courses was 0.204738761. There was a significantly higher number of A’s in the traditional courses and a significantly higher number of F’s in the technology-assisted courses.

The retention rates had significant differences between the traditional courses and the technology-assisted courses. While there are significant differences in the distribution of the grades for non-completion, some of these differences can be attributed to a given instructor’s use of a particular grade as opposed to differences in the student retention. In order to remove the bias from these grade distributions, the total of the non-completion grades was analyzed with the
...traditional courses having a non-completion rate of 0.111180382 and the technology-assisted courses having a non-completion rate of 0.128594573. These data showed that there is a significant increase in the number of non-completing students in a technology-assisted course versus a traditional course. This difference in the number of non-completing students was not significant when considering the 18-week traditional course and the technology-assisted course. The change in course retention was most notable between the 9-week traditional courses and the technology-assisted courses.

Other than in the area of course retention, the differences in traditional courses and technology-assisted courses were consistent regardless of course length. This indicates that the differences in student achievement and student grade distribution that are highlighted in this study are the cause of something other than time in a course.

Implications for Action

Much of the research done prior to this study indicates that students in a technology-assisted course can perform at a level consistent with or even higher than the students in a traditional course. This study, however, showed considerable differences between the two groups with the traditional courses having a higher level of achievement and a better grade distribution. Because of the differences between prior research and this study, the root cause of the differences must be analyzed. Prior research indicates that in many cases when students in a technology-assisted course delivery method fail to perform as well as students in a traditional course, the course design or assessment methods may be the cause. Students in the technology-assisted courses in this study are not performing as well as the students in the traditional courses and because of the scope of this study both in sample size and time, the cause is most likely not
due to some external factor such as time management. The use of computerized testing methods for all of the student assessments and the policies regarding student engagement in a course may need to be changed, in order for the achievement levels to rise and the grade distributions to more accurately mirror the population.

Theoretical Framework

The Cognitive Theory of Multimedia Learning and Transactional Distance theory are the theories on which this study on technology-assisted mathematics education was centered. The Cognitive Theory of Multimedia Learning states that if a particular concept is delivered using multiple mediums a student should have better understanding. This increase in comprehension is due to the brain processing this information in multiple manners (Moreno & Mayer, 1999). The achievement and grade distributions that were seen in this study are not consistent with an increase in student comprehension. The lack of an increase in this study, however, does not contradict the theory. Although there were many multimedia tools available to the students in the technology-assisted courses, their use was not required. Students could take the course and finish the assessments without having to access the multimedia resources. Because students could choose not to utilize the multimedia tools, they may not have experienced the potential benefits.

In Transactional Distance Theory, the key constructs are the educator, the learner, and communication (Kang & Gyorde, 2008). In a traditional classroom, there is a considerable amount of interaction between the student and the teacher. In a technology-assisted course, there is significantly less interaction. The technology-assisted courses in the study had no requirement for interaction between the instructors and the students. A student could work through the course
without communicating with the instructor. Because the course did not require any type of educational “transaction,” students in the technology-assisted classroom may have missed valuable learning opportunities.

This study revealed deficiencies in the technology-assisted courses when compared to the traditional courses. The Cognitive Theory of Multimedia Learning and Transactional Distance Theory offer possible rationales for these differences.

Recommendations for Further Research

Because the data in this study yielded results that were significant and challenging to some of the other research that has been done in this area, it is important that further research is conducted into the grading practices both in the traditional courses and the technology-assisted courses to determine if any incongruities exist. Since the technology-assisted courses in this study did not have multimedia learning module requirements or any requirement for communication between the students and the instructor, other technology-assisted PreCalculus courses should be analyzed where these are part of the course requirement. Additionally, it is important to look at not only end-of-course grades, but also student grades throughout the course to determine if the changes are localized or consistent. This research should be repeated on other courses in the mathematics curriculum including courses that are prerequisites and subsequent courses to determine if the differences noted in this study are evident in other courses as well. Finally, research should be conducted with students who take more than one mathematics course to determine how traditional and technology-assisted courses prepare students for subsequent courses.
Concluding Remarks

Technology is both fantastic and dangerous. Technology gives a person the ability to interact and learn in ways that are incredible. A person can take a virtual tour of a famous museum or watch a video of some difficult concept all from the comfort of their home. Technology is dangerous because if not properly implemented it can be a burden rather than a tool. Administrators, educators, and students must look at not only what the technology can do, but also how the technology is being implemented. In addition, it is imperative that we learn the limitations that are inherent in each piece of technology so potential problems can be addressed. Properly implemented technology can make a tremendous difference on the entire learning experience and provide educational experiences that are incredibly worthwhile. It is imperative that those responsible ensure it is used correctly.
REFERENCES


APPENDIX A

IRB EXEMPTION APPROVAL FOR TROY UNIVERSITY
April 24, 2013

Mr. Robert Vilardi
Mathematics Lecturer
Troy University: Montgomery

Dear Mr. Vilardi,

The Institutional Review Board has reviewed your project 201304068-Vilardi: Mathematics Achievement: Traditional Instruction and Technology Assisted Course Delivery Methods and has determined it falls into the exempt category, meaning your research does not require IRB approval. However, if there are changes with your protocol placing participants at risk, you are responsible for immediately informing the IRB of these changes.

Please let me know if you have questions or if I can be of additional assistance.

Sincerely,

Gina Maresco, Ph.D., Chair
APPENDIX B

IRB EXEMPTION APPROVAL FOR THE UNIVERSITY OF ALABAMA
May 6, 2013

Robert Vilardi
ELPTS
College of Education
The University of Alabama

Re: IRB # EX-13-CM-051 “Mathematics Achievement: Traditional Instruction and Technology Assisted Course Delivery Methods”

Dear Mr. Vilardi:

The University of Alabama Institutional Review Board has granted approval for your proposed research.

Your protocol has been given exempt approval according to 45 CFR part 46.101(b)(4) as outlined below:

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

This approval expires on May 5, 2014. You will receive a notice of expiration 90 days in advance. If the study continues beyond that date, you must complete the appropriate portion of FORM: IRB Renewal Application. If you modify the application, please complete FORM: Modification of an Approved Protocol. Changes in this study cannot be initiated without IRB approval, except when necessary to eliminate apparent immediate hazards to participants. When the study closes, please complete FORM: Request for Study Closure.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,

Caroline T. Myles, MSM, CBM
Director & Research Compliance Officer
Office for Research Compliance
The University of Alabama