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An Investigation of Students' Media Preferences in Learning Mathematical Concepts

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ABSTRACT

AN INVESTIGATION OF STUDENTS' MEDIA PREFERENCES IN LEARNING MATHEMATICAL CONCEPTS
by
Ming Hang Yun Her

Besides the traditional face-to-face learning medium, online media are now available for students in various learning environments. The delivery of coursework through online media is on the increase in colleges and universities. However, research on the use of online learning media in beginning collegiate level foundational mathematics courses for non-mathematics and non-science majors is limited. Therefore, the purpose of this study was to investigate, within a foundational mathematics course, connections between media used for instruction in hybrid and online enhanced face-to-face learning environments and students' media preferences.

The online Web Course Tools (WebCT) Vista template used in this study was designed by the researcher and her colleague as a part of the hybrid fellowship project for a two-year college. Applying transactional distance theory and engagement theory, designers carefully analyzed each concept and determined which concepts would be delivered most effectively in each learning medium.

This study was quantitative in nature. During Fall 2005, thirty-eight students in the Introduction to Mathematical Modeling course at a community college in the southeast participated in the final study. Students in the hybrid sections comprised the treatment group while students in the online face-to-face section comprised the control

group. Throughout the semester, all students were asked to respond to questions on the following instruments: Assignment Feedback, Quiz Feedback, Test Feedback, and Project Feedback.

Chi-Square analysis showed that significant differences were found in the majority of items on the Test Feedback instrument related to the linear and quadratic modules. In general, the treatment group preferred online learning at least half of the time and believed online resources provide the basic resources for learning the subject matter. Students' written responses from the treatment group indicated that both online learner-content interactions, and in-class learner-instructor interactions supplemented the learning of mathematics. The control group preferred predominantly face-to-face learning and believed that learning primarily took place in a physical setting. The findings showed that the proportion of students who completed the course using the hybrid and face-to-face learning environments was not significantly different. Therefore, the data showed the success rate for both learning environments was about the same.

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by
Ming Hang Yun Her

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CHAPTER 1

INTRODUCTION

This study addressed a current trend in higher education, which shows how computers and the Internet have become increasingly important in education. In particular, this study was to investigate students' media preferences in a general education mathematics course (core mathematics course) for freshman college students in a hybrid learning environment and in a face-to-face classroom environment with online supplement. A hybrid learning environment is a combination of the face-to-face traditional classroom learning environment and the online learning environment. The online portion of the course used Web Course Tools (WebCT) Vista. The researcher of this study and her colleague developed the content of this course within WebCT Vista as a part of a college initiative to expand the offering of hybrid courses to students.

This study examined learner-content interaction as described in Transactional Distance Theory. Students in two different learning environments were involved in this research. In a hybrid-learning environment, the web-based portion of the course replaced half of the face-to-face classroom time when compared to a traditional face-to-face course. Students' learning media preferences were surveyed in the hybrid learning environment and in the face-to-face environment with online enhancement.

This chapter first examines the research problem and the rationale for this study. The following sections present the theoretical framework and address the design of the hybrid course in WebCT Vista.

Background of the Study

Computer and Internet access have become important components in education in the United States. They affect how students obtain class information, complete course requirements, or even obtain a higher education degree. The number of personal computers in use in America rose from 154.7 million in 1999 to 209.22 million in 2003. This number is projected to reach 260.55 million by 2007. According to the Computer Industry Almanac Inc., there were 110 million people using the Internet in the United States in 1999. Internet users will rise to 229.5 million by 2007. The Internet user ratio per 1,000 people was 2:5 in 1999. This number is expected to grow and reach 3:4 by 2007 (Juliussen, 2003).

Distance education in institutions of higher education uses computers and Internet connections, which students access either at work or at their household, thus adding a new dimension to the medium of course delivery. This new dimension is called online learning. Similar to other distance learning delivery methods, but unlike traditional face-to-face classroom instruction, online learning does not always require learners and teachers to interact simultaneously. Online classes have now become the dominant mode of delivery in the distance education arena. The percent of distance learning courses has increased from 33% in 1995 to 56% in 2001. From 2000-2001, 56% of degree granting institutions offered distance learning courses. Among those, 53% offered between one and thirty courses The projected percentage will reach 68% in 2004 (National Center for Education Statistics, 1997, 1999, 2003).

> The spread of contemporary Internet technology stimulated new ways of organizing distance teaching. This has been the case in established single-mode open universities and corresponding schools. Changes have been more significant perhaps in dual-mode [hybrid] institutions and those institutions that never before

> considered distance education but are now converting to dual-mode [hybrid] status. (Moore, 2003, p.6-7)

Many colleges and universities are expanding their distance courses to campus facilities via hybrid learning. Students enrolled in hybrid courses can use computer and Internet connections alongside the traditional face-to-face meeting format as a means of becoming more fully engaged learners.

Terminology

Definitions of some of the key terms used in the study are given below:

Traditional setting. A group of learners meet with an instructor face-to-face at a specific meeting time in a physical classroom. The total meeting hours in a week are equivalent to the credit hours of the course.

Distance education. The contact between the learners and instructor in an environment other than the traditional setting, usually involving computers, does not include face-to-face classroom contact.

Online setting. Online setting is one that uses the World Wide Web as a medium of learner-content interaction, learner-instructor interaction and learner-learner interaction.

Online course. An online course is the total use of the online setting to replace the traditional setting, that is, the online course will not meet in a traditional setting at all.

Online enhanced course. Learners and instructor meet in a traditional setting. An online component enhances the outside classroom work.

Hybrid course. Uses a combination of the traditional setting and the online setting. Approximately fifty percent of the instructional hours are in a traditional setting and the other fifty percent of the instructional hours will be in an online setting. Table 1 below illustrates the difference between a traditional, an online enhanced, a hybrid, and an online course using a three-credit-hour course as an example.

Table 1

Time Allocation for Different Learning Environments

	Instructional Hours		Independent Work Hours		
Learning Environment	Web	Physical Classroom	With Web	Without Web	Total hours
Traditional	0	45	0	135	180
Online enhanced	0	45	135	0	180
Hybrid	22.5	22.5	135	0	180
Online	45	0	135	0	180

WebCT. WebCT is a course management system that enhances the creation of online learning.

The Problem

Online learning and traditional face-to-face learning have different strengths and weaknesses. From a pedagogical point of view, many researchers show that some activities will be better delivered online and other activities will be more beneficial if conducted in a face-to-face classroom setting (Young, 2002a). Joseph (2005), research associate at the University of Chicago’s Center for School Improvement, sums up the unique characteristics of a hybrid course in the following way:

> Hybrid course design is often employed to take advantage of the best aspects of the face-to-face and online environments. The online portion of the course can extend classroom discussion beyond the class period, and the face-to-face meetings can provide some of the social aspects of learning that the online courses sometimes lack. But perhaps the greatest advantage of the hybrid model is the ability to maintain some of the structure of the F2F [face-to-face] classroom

> while enabling students to approach the course content based on their own learning objects and interests. (Joseph, 2005, p.6)

The present is fortuitous for hybrid course within institutions of higher education. Computer and Internet technology allow students to engage in college education without traveling to campuses as often as previously determined necessary. In fact, current technology can entirely eliminate the need to travel to classroom sites. With the growing student population in the United States, many higher education administrators face difficult decisions. Preserving the traditional course-delivery paradigm, class sizes are limited by the physical spaces and the number of sections offered are limited by classroom availability. Hybrid courses require fewer physical resources. Offering hybrid course options will allow higher education institutions to maintain an optimal class size while simultaneously expanding course offerings and accommodating the growing student population.

With the hope of better-quality education and more effective use of resources, many higher education institutions are encouraging their faculty to develop and to offer hybrid courses in each discipline and at each level. In spring 2003, one of the largest community colleges in the southeast started to explore the possibility of offering hybrid courses on an overcrowded campus of the college. At first, this creative solution was intended to resolve the issue of inadequate classroom space. In summer 2003, the college expanded the hybrid course offerings to six of its different locations to prepare for the future growth of the entire college. The first group of hybrid fellows was selected in summer 2003. This group of faculty was charged with developing and delivering high quality courses in a hybrid setting. Each hybrid course needed to meet the college's Exemplary Hybrid Course guidelines (Hybrid Department, 2004). The completed course guidelines would then be reviewed by the Center for Distance Learning and Education Technologies for technical quality. In November 2004, this Hybrid Fellowship Project was selected from 75 total submissions to receive the Best Practices Award in Academic Affairs of the State among all public colleges and universities (Board of Regents, 2004).

Rationale

Sunal, Sunal, Sundberg, and Staples (2002) identified 25 research studies that related to the use of the Internet in distance education and that addressed learning outcomes from 1997 to 2000 from 400 citations related to online learning. After careful analysis, they summarized as follows:

> Despite the large volume of research published, most reports sampled included little discussion of research design, data collection instruments or findings based on data gathered from course outcomes. Primarily descriptive in nature, the literature explains the creation of one or more courses, problems encountered, means of addressing problems and plans for continuing revision of courses and development of new courses. (p.110-111).

In addition, recent findings that involved the use of online learning compared to the traditional face-to-face learning model varied from one situation to another. The evidence was almost uniformly consistent in indicating that some online learning components are better than total traditional face-to-face learning in some aspects for some students.

Leh (2002) investigated graduate students' opinions toward hybrid courses and examined the impact of using different learner-instructor and learner-learner communication strategies. Data were collected from three campuses in six quarters from 1999 to 2001 with a pilot study in Fall 1999. Students in these hybrid courses were in-service teachers and worked full time. Participants of the study were Masters of

Instructional Technology students who took courses in a hybrid setting with little previous hybrid learning experience. The hybrid course was developed and implemented by the researcher in the study through a university grant. During the last face-to-face meeting, a 10-question Likert scale (1-4) and open-ended questions was used to collect data from the participants. Different communication strategies were used in each quarter during 1999-2001. Among the different types of communication strategies used, students favored average-duty moderating the most. This allowed students to take control of their learning without "information overload". Regardless of the communication strategies, the overall results indicated that both the students and the instructor favored the hybrid course. Using synchronous and asynchronous communication alternately could enhance online communities, and moderating strategies with thoughtful design and organization worked well in graduate level hybrid courses. According to this study, participants expressed that hybrid courses provided them with the options of choosing their best learning conditions and gave them opportunities to enrich their learning using recourses beyond boundaries of time and space.

Burden (2002) compared two sections of a multimedia approach in a sophomore level mathematics course at Youngstown State University, Ohio. Two of the thirteen sections were investigated during Spring 2002. Seventy-nine students in these two sections volunteered to participate in the study. This course was designed for non-mathematics and non-science majors. The purpose of this study was to seek a more comprehensive approach to teaching. One section was conducted in the traditional face-to-face environment; the other was conducted in the distance learning environment. Animated PowerPoint, synchronous tutoring via NetTutor (an online tutor through Link-

System International), online grades, and online quizzes from the publisher were used in both sections. The result of this study was that students from both types of environments responded favorably to the integration of multimedia technology in learning mathematics.

Parkinson, Greene, Kim and Marioni (2002) conducted a qualitative study of the teaching effectiveness on two groups of graduate students in the Master of Art Teaching Program. Fifty students were enrolled in either a traditional or a distance learning environment in four different courses. Video technology was utilized to deliver the content material to distance learners. All students in the traditional classroom setting indicated the teaching strategies affected their ability to process new knowledge. Twenty-six students in the distance learning environment pointed out that their learning styles affect the way they acquire knowledge. When considering the appropriate format of the course, fifty percent of the traditional students responded favorably. Twenty of the distance learners responded negatively to the format of the course, while twenty respond favorably. A few of these distance learners mentioned that they adjusted their learning style for the format of the class. This strongly suggested that students with physical distance between them and the instructor believe that learning style constitutes a major factor of their learning outcome.

Stokes (2001) attempted to locate predictors of student satisfaction in an online learning environment through an assessment of temperament, learning styles and demographics. Temperament data was collected using Keirsey Temperament Sorter II (Keirsy, 1998, 2000), which identifies four temperament types: guardian, artisan, idealist, and rationalist. Learning style information was collected using the Index of Learning Styles, which categorized participants into four dichotomous scales: sensory/intuitive, visual/verbal, active/reflective and sequential/global. In Spring 2001, 145 junior or senior students with a mean age of 21.7 years participated in the study. These students were enrolled in an online environment of two different education computer technology courses. The result strongly suggested that temperament and learning styles were not necessarily predictors of satisfaction in an online course. The study pointed out that the sample group selected to participate in this study might be biased. Students considering enrolling in courses that incorporate online learning may be reluctant to register because of perceived mismatches between their personal traits and the online environment. In addition, further research is needed in other levels and disciplines to accurately generalize the results.

Papanikolaou, Grigoriadou, Magoulas, & Kornilakis (2002) conducted a pilot study which involved online learning components in a computer architecture course. Multiple types of educational material and assessment tests were developed for each particular section, and each one was tailored to a specific instruction style such as interactive Java applets, streaming video, streaming audio and video of previously recorded classroom lectures and text-based explanations. The intended users of the courses were adults studying at a distance, as well as university students to whom access to the course material was a supplementary resource. The participants of this pilot study consisted of 10 sophomore students in Fall 2000 in Greece. This study showed that students preferred a hybrid-learning environment for their undergraduate studies, while for their postgraduate studies half of them preferred online learning.

Lee, Driscoll & Nelson (2004) used articles from four prominent distance education journals between 1997 and 2002 to identify research topics addressed. A total of 383 articles were involved. Three keywords were used to identify each article in the analysis. 213 key words were identified in 1997, 207 in 1998, 195 in 1999, 192 in 2000, 183 in 2001, and 159 in 2002. Learning media were not used as major key words among those articles.

The literature on students' medium preferences in online learning or hybrid learning has not been adequately addressed. Studies showed that students are ready to use different types of learning media besides traditional printed textbooks and face-to-face communication; for example, online tutoring (Burden, 2002), online discussion boards (Leh, 2002), Java applets (Papanikolaou, Grigoriadou, Magoulas, & Kornilakis, 2002), and video technologies (Papanikolaou, Grigoriadou, Magoulas, & Kornilakis, 2002; Parkinson, Greene, Kim, & Marioni, 2002). Most studies addressing the use of online learning components were geared to the graduate levels (Leh, 2002; Parkinson, Greene, Kim, & Marioni, 2002) or junior and senior level courses in undergraduate curricula (Stokes, 2001) wherein students perceived that technology oriented courses would directly benefit their college education and their future careers. Learning outcomes for students were not directly addressed in these studies. It is very difficult to predict the success of students involved in online learning environments (Papanikolaou, Grigoriadou, Magoulas, & Kornilakis, 2002; Stokes, 2001). Remaining as an open question is, "How students' medium preferences and learning outcomes, involving the use of online media in general education courses, in the beginning of their college education, affect their learning outcome?"

Significance of the Study

Hybrid courses which blend the online medium and face-to-face medium are growing in all disciplines and in all levels on traditional campuses. Information on students' medium preferences in their learning of subject concepts is lacking. This information will help instructors tailor courses to students' performances using online media. Faculty, counselors, and students need to correctly identify and match the potential candidates for online, hybrid or face-to-face courses. This guidance will be extremely crucial to freshmen who are new to the variety of options available in higher education settings. As a result, students will have a more positive and successful college experience. From the college administrators' point of view, successful students have a direct impact on the college's overall image as well as the school's passing, retention, graduation and transfer rates.

Purpose

The purpose of this quantitative study with open-ended questions is to investigate, within the foundational mathematics course, connections between media used for instruction and students' media preferences in learning mathematical concepts. Two learning environments are used in this research. They are hybrid learning environment and face-to-face learning environment with online enhancement. Online components were delivered through WebCT Vista. Students' media preferences are defined as the medium or media through which students learn best from their perspective.

Research Questions

In response to the general research question posed, “Is there any difference in preferred learning media between the students enrolled in the hybrid course and the students enrolled in the face-to-face course with online enhancement?” Students enrolled in the hybrid course would be the treatment group while students enrolled in the online enhanced course would be the control group. The following research sub-questions were constructed:

1. Are there any differences in students’ preferred learning media between the treatment and the control groups when engaged in doing homework assignments?
2. Are there any differences in students’ preferred learning media between the treatment and the control groups when engaged in taking quizzes?
3. Are there any differences in students’ preferred learning media between the treatment and the control groups when engaged in taking tests?
4. Are there any differences in students’ preferred learning media between the treatment and the control groups when engaged in doing projects?
5. Are there any differences in students’ preferred learning media between the treatment and the control groups for different mathematical concepts?
6. How do the students describe their choices of preferred learning media when completing mathematics projects?

Theoretical Framework

The theoretical framework that guides this study is a combination of transactional distance theory and engagement theory. Transactional distance theory describes how learning takes place through a psychological and communication gap. Engagement theory shows how students construct knowledge through collaborative, authentic learning with the use of technology. The following sections describe these theories in detail.

Transactional Distance Theory

Distance education theorist, Michael G. Moore (1972) first addressed his theory in 1972 without using the term transaction until 1980 (Moore, 1980). The concept of transaction is based on the work of Dewey and Bentley (1949). It “connotes the interplay among the environment, the individuals, and the patterns of behaviors in a situation” (Boyd, Apps, & Associates, 1980, p.5). Moore (1991, 1993a) points out that the most important separation between instructor and learner is not physical but psychological and communicative. Moore (1993b) believes that one of the key terminologies in this theory is “interaction.” There are three different types of interactions: learner-content interaction, learner-instructor interaction and learner-learner interaction.

The first type of interaction, learner-content interaction, is the main element in education. This interaction will result in changing a learner’s understanding, perspective and cognitive structure (Moore, 1993b). One of the powerful forms of media used to deliver content is text. Thus, the printed word has been relied upon for many centuries. Even in this technology saturated society, the majority of text is still delivered either in paper form or in electronic form. Moore (2001) points out that with the capability of high speed, broadband Internet access, audio and video are also becoming powerful media in the distance education environment.

Traditionally, learners interact with content through text. During the twentieth century, learners interacted with content through radio, television, audiotape, videotape, and computer software. However, the majority of distance learning courses offered by higher education institutions are still highly dependent on the printed form of text. In the field of mathematics, especially, many students have difficulty understanding printed textbooks. If learners cannot interact with the content successfully, that means learner-content interaction is challenging. To promote learner-content interaction, other types of content media need to be made available. With the capabilities of computer technology, different types of content such as text, streaming audio and streaming video can be easily synthesized.

The second type of interaction, learner-instructor interaction, remains in high demand by many learners (Moore, 1993b). An instructor's primary role is to engage students in learning the content most often through communication in a physical meeting. Traditionally, two-way learner-instructor interaction has taken place in the classroom. However, such communication has become possible through correspondence. With the help of technology, learner-instructor interaction can take place in an effective manner through telephone or video conferences, via email or discussion boards and in chat rooms.

The third type of interaction, learner-learner interaction, involves learners exchanging ideas in the class setting or in a group setting (Moore, 1993b). This technique is highly essential in modern society (Phillips, Santoro, & Kuehn, 1988). Learners can communicate with others through physical meetings, as well as within various online settings. With the help of computer technology, physical distance is no longer a barrier to instruction and learning.

These three types of interaction, as described by the transactional distance theory guide, provide the framework of the design for the hybrid course in this study. More than one form of media is used in each type of interaction to engage learners in this study's hybrid course. This is intended as a means of providing an active learner-centered environment. The emphasis of this study will be the learner-content interaction.

Engagement Theory

Engagement theory has emerged from teaching experiences in electronic and distance education environments (Kearsley, 1997; Kearsley & Shneiderman, 1998; Shneiderman, 1988, 1994; Shneiderman, Alavi, Norman, & Borkowski, 1995). Although this theory is not directly derived from constructivism, the idea is very similar to the constructivism principle. The primary idea of engagement theory is that students engage in meaningful activities through interaction with classmates in a technological environment. There are three basic components of engagement theory, which are summarized by Relate-Create-Donate.

The Relate component stresses group work that involves communication, planning, management, and acquisition or development of social skill. National Council of Teachers of Mathematics (NCTM) (1989, 2000) also strongly emphasizes the use of active learner-centered environments to engage learners in oral and written communication in mathematics. Heller, Keith, and Anderson (1997) reported that group solutions are significantly better than the best individual-in-the-group solution on matched problems. Therefore, the group solution is not just the solution offered by the best individual in the group. Social structure differentiates between group problem solving and individual problem solving (Vidakovic, 1997). Through active participation in classroom discussions, group meetings, electronic discussion boards and emails, students have the opportunity to exchange their ideas and to construct and reconstruct their understandings of mathematics and its applications.

The Create component makes learning meaningful and creative. Students can apply what they learn to topics that interest them and their group members. In doing so, learners transfer what they discover in the classroom to realistic situations outside of the classroom (Blum, 1999). This process can improve students' mathematical exposition to strengthen understanding of mathematics and empower them to express what they have learned (Crannell, 1999).

The Donate component emphasizes the useful contribution students can make to the community while learning. Group projects, for instance, can be related to their job and career interests, civic concerns, and so forth. This helps students link mathematics to other related subjects of which students are more knowledgeable (Kenschaft, 1999). In the process of presenting solutions to problems, learners are reflecting upon their knowledge, re-presenting, and re-organizing their ideas from different mathematical concepts and various mathematics representations, thereby connecting different subjects to practical and realistic problems (Blum, 1999). Applying newly acquired knowledge helps learners to have a more holistic view of what the subject of mathematics is about and to integrate different concepts to solve problems that are interesting to them as well as beneficial to the community at large.

In this study, the project component of the course was designed to engage students in active problem solving using mathematics. By collecting data, investigating data properties, and analyzing data trends, students applied what they learned in the classroom directly in physical phenomena and in subjects that interested them.

Instructional Design of the Hybrid Course in WebCT Vista

The Introduction to Mathematical Modeling (Math 1101) course was developed as a part of a hybrid fellows program. The program charged faculty members to deliver high quality courses in a hybrid setting at one of the largest community colleges in the southeast. The Math 1101 course was a freshman course that satisfied the general education requirement toward an associate or a bachelor's degree for non-mathematics and non-science majors. The hybrid version of the Introduction to Mathematical Modeling course was designed to engage students in active learning using technology and to interact with students in varied-dimensions.

Media forms alone do not influence learning; however, media and methods are part of any instructional design in general (Kozma, 1994). Media must be carefully structured to assist the development of new methods that take appropriate advantage of each media's capabilities. The course designers strongly believed that the increase of learner-content interaction in the online setting would result in students obtaining better grasp of their subjects of study.

Streaming media, assessment tools and Interactive Java applets were heavily used in this course to provide learner-content interaction as well as to provide opportunities for the learner to discover mathematical knowledge. Streaming media was used to mimic the traditional classroom instruction time. Assessment tools were incorporated to give learners instant feedback for homework and quizzes. Interactive Java applets were used to provide opportunities for the learner to discover mathematics knowledge. These elements were provided inside WebCT Vista with "twenty-four, seven" availability. In addition to the unit tests, which assessed students' content knowledge, hands-on projects were used to assess students' ability to apply their mathematical knowledge to solve realistic problems.

The researcher and her colleague designed the Introduction to Mathematical Modeling hybrid course template used in this study. In designing this hybrid course, the designers followed the guidelines in the technology statement of the National Council of Teachers of Mathematics:

> When a curriculum is implemented, time and emphasis must be given to the use of technology to teach mathematical concepts, skills, and applications in the ways they are encountered in an age of ever-increasing access to more-powerful technology. (National Council of Teachers of Mathematics, 1998)

This hybrid course used the course management system adopted by the university system for all public colleges and universities in the state. The online component of this course consisted of four algebra investigations, twelve pre-recorded streaming video lectures, and five streaming video calculator lessons. The online assessment component of this course consisted of seventeen quizzes and three algebraic investigation assignments using Java applets on the Web. Four projects were also used in the course. Students can complete these projects individually or as a group. All of the online components were organized in WebCT Vista.

The algebraic investigations in this course used the World Wide Web resources. The Function Flyer Applet used in this study was developed by the Shodor Foundation and supported by the National Science Foundation. Each investigation consisted of an interactive applet and a worksheet. The students had the opportunity to gain first-hand experience with algebraic properties. Investigations in this course included the role of m and b in linear equations ($y = mx + b$) , the role of *a, h, and k,* in the vertex form of quadratic equations ($y = a(x-h)^2 + k$), the role of *a, b, and c*, in the standard from of quadratic equations ($y = ax^2 + bx + c$), and the role of *a* , *b*, *and c*, in exponential equations ($y = a \bullet b^x + c$). The investigation applets in this study supported the NTCM (2000) Principles and Standards for School Mathematics, which emphasize the proper use of technologies to facilitate higher order thinking skills.

> Electronic technologies-calculators and computers- are essential tools for teaching, learning, and doing mathematics. They furnish visual images of mathematical ideas, they facilitate organizing and analyzing data, and they compute efficiently and accurately. They can support investigation by students in every area of mathematics, including geometry, statistics, algebra, measurement, and number [theory]. When technological tools are available, students can focus on decision-making, reflection, reasoning, and problem solving. (p.24)

The calculator lessons in this course were invented and created by the course designers. They address the specific calculator technique required in the Introduction to Mathematical Modeling course. Each lesson was delivered through pre-recorded streaming media files, which could be accessed through WebCT Vista. When students viewed the files, the multimedia movies simultaneously displayed an animated calculator keyboard and calculator screen with audio step-by-step instruction. Students then followed the instructions to learn the calculator skills needed. In addition, students had the capability to pause and revisit the lesson anytime, anywhere as needed. Furthermore, handouts of the lesson were also available through WebCT Vista.

The hybrid course designers wrote all quizzes in this course. Each quiz consisted of five questions. The formats were mainly multiple-choice with a few short answer type questions. Both were automatically gradable by WebCT Vista. The course designer built a database for each quiz inside WebCT. Questions were selected according to the course designer’s specifications when students accessed quizzes. The question order and the choices were randomized. A quiz was designed for each topic covered in the course.

Students were able to access the quiz at anytime, from any location before the due date set by the instructor.

The hybrid course in this study was built on the notion of incorporating the advantages of computers and the advantages of expert consultation into one setting. The content delivered online was the basis for the face-to-face discussions and in-class mini-lectures. Students used the online content to refresh what they learned in the previous course, to explore new concepts, and to build new skills. Students used the online homework and quizzes to reinforce what they learned or to remedy any misunderstanding by getting immediate feedback. Instructors used the face-to-face time to clarify misunderstandings and discuss questions of concern by the students. In cooperative learning group meetings, students used what they learned to build mathematical models to solve realistic mathematics problems.

The organization of Math 1101 material is shown in Figure 1. General information obtained through the college’s Instructional Support Service (ISS) Lab and College Resource were linked to the course homepage for the convenience of students. Course Orientation contained general WebCT Vista Orientation and was created by the college; specific orientation about site navigation, general practice and specific course content were created by the researcher. The course syllabus was accessible via separate link on the homepage. All the tasks required in the course were organized in the three learning modules in chronological order. In addition, a link to the project component which consisted of four main projects of the course was also available on the homepage.

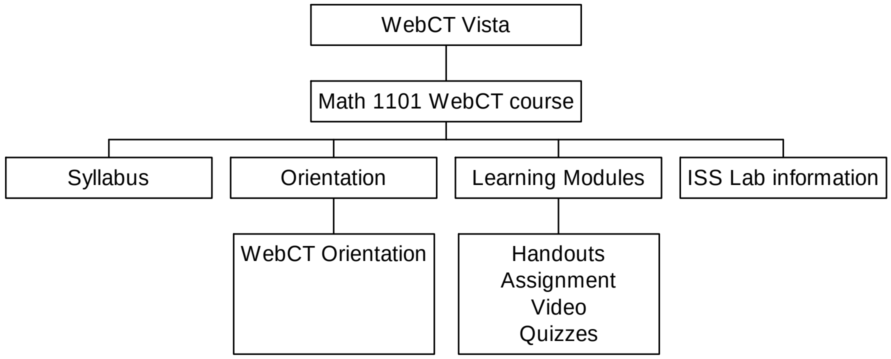

Figure 1. Visualization of the Math 1101 Course Structure

The following figure, Figure 2, shows the Math 1101 WebCT Vista course homepage at the end of the semester. The Exponential Model and Quadratic Model were not available at the beginning of the course. These two learning modules were made available when they were needed. Detailed content of each learning module can be found in Appendix C. Actual operation of the course will follow the Table of Contents in each learning module.

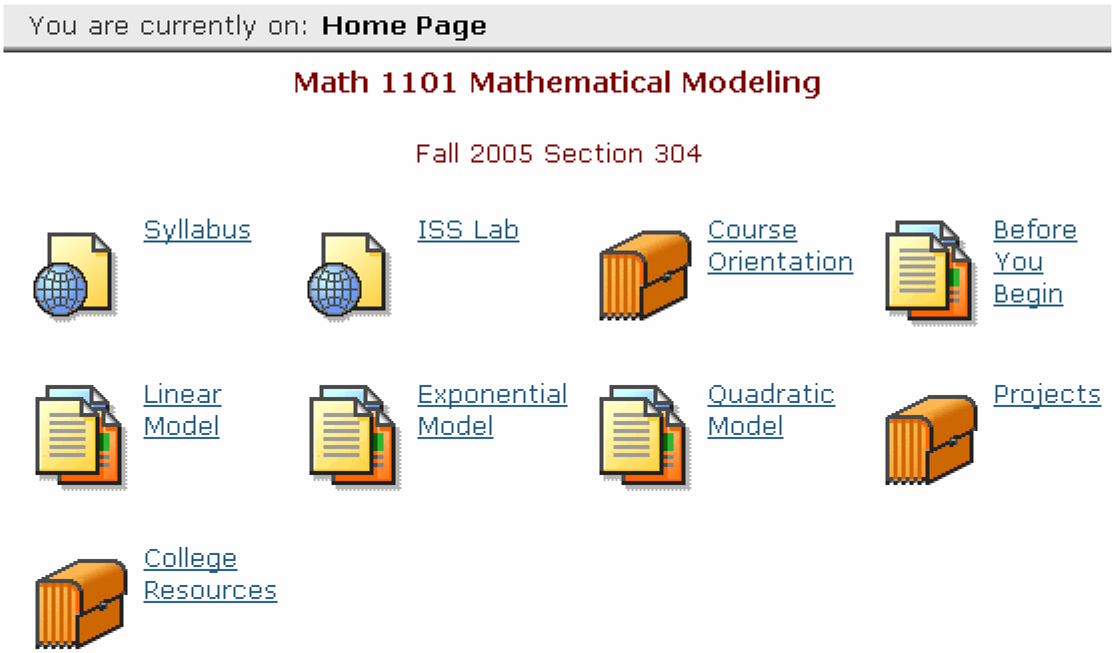

Figure 2. Math 1101 Course Homepage

Summary

The combination of computer and the Internet creates a dynamic and exciting new medium in higher education. Learner-content interaction, learner-learner interaction, and learner-instructor interaction are all possible in an online setting. Since higher education, especially the community college, faces the simultaneous challenge of increase in student population and budget cuts, hybrid courses, which combine the traditional setting and the online setting, seem an ideal administrative solution. Throughout the United States and abroad, hybrid courses are developing rapidly in each discipline and at each level.

Current research on the effectiveness of online learning (Burden, 2002; Gaensler, 2004; Leh, 2002; Parkinson, Greene, Kim, & Marioni, 2002; Stokes, 2001; Sunal, Sunal, Sundberg, & Staples, 2002) indicates that online learning is effective at some educational levels. There was little research available on the use of the online learning medium in the beginning collegiate level of foundational mathematics courses in the general education area for non-mathematics and non-science majors.

This study is focused on a Math 1101 online setting in WebCT Vista at one of the urban community colleges in the southeast. The intention of this study was to understand how students perceive learning when using a non-traditional medium. The hybrid-learning environment and the online enhanced environment addressed in this study used transactional distance theory and engagement theory. In addition to printed material, the instructor mainly used the web technology to increase learner-content interaction. The instructor also allotted in-class time for learner-to-learner interaction and learner-to-instructor interaction. In this study, the researcher investigated how learners described their learning experiences, which involved an online learning component, while engaged in an Introduction to Mathematical Modeling course. The subjects involved in the study, the methodology, and the procedures of the experiment will be discussed in Chapter 3.

CHAPTER 2

REVIEW OF LITERATURE

This review begins with the change of learning media in higher education. Research about learning mathematics and learning styles will be discussed in a subsequent section. Research areas related to the present study can be divided into three main categories: learning medium, learning mathematics, and learning preference.

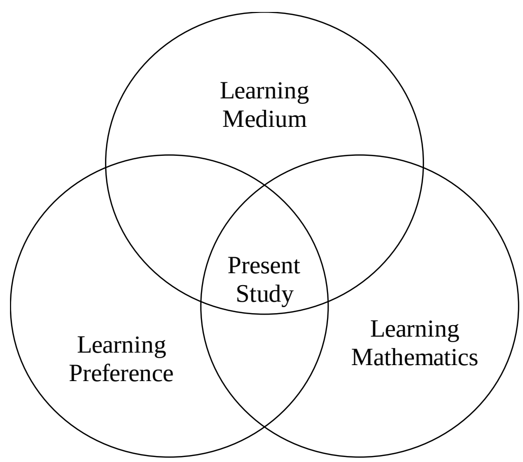

Figure 3. Research Areas Related to the Present Study

Learning Media

Trends of Learning Media in Higher Education

Distance Education has expanded quickly among higher education institutions, especially at two-year public colleges in the United States (National Center for Education Statistics, 1997, 1999, 2003). According to the National Center for Education Statistics (NCES), in Fall 1995, approximately 58% of public 2-year higher education institutions and 62% of four-year public higher education institutions offered distance education courses (National Center for Education Statistics, 1997). The percentage among private higher education institutions was very low. Overall, 33% of the American higher education institutions offered distance education courses.

Table 2

Higher Education Institutions Offering Distance Education (DE) in Fall 1995

Types of institutions	Percent currently Offering DE courses	Percent planning to offer DE courses within 3 years	Predicted Percent in 1998
Public, two-year	58	28	86
Public, four-year	62	23	85
Private, two-year	2	14	16
Private, four year	12	27	39
Overall	33	25	58

Note. From Distance Education at Postsecondary Education Institutions (p. 6), by Lewis, L., Alexander, D. and Farris, E., 1997, Washington D.C.: U.S. Department of Education. Copyright 1997 by NCES.

A similar report was published for the 1997-1998 school year (National Center for Education Statistics, 1999). For public institutions, the data indicated that nearly 62% of the two-year schools offered distance education courses and 78% of the four-year schools offered distance education courses. Although the data was lower for the predicted value in 1995, there was an increase among four different types of institutions.

Table 3

Higher Education Institutions Offering Distance Education (DE) Courses in 1997-1998

Types of institutions	Percent currently offering DE courses	Percent planning to offer DE courses within 3 years	Predicted Percent in 2000-2001
Public, two-year	62	20	82
Public, four-year	78	12	90
Private, two-year	5	20	25
Private, four year	19	22	41
Overall	34	22	56

Note. From Distance Education at Postsecondary Education Institutions: 1997-98 (p.18-19), by Lewis, L., Snow, K. and Levin, D., 1999, Washington D.C.: U.S. Department of Education. Copyright 1999 by NCES.

According to *Distance Education at Degree-Granting Postsecondary Institutions: 2000-2001* written by NCSE, approximately 90% of the public two-year institutions and 89% of the public four-year institutions offered distance education courses. A greater percentage of public two-year institutions offered distance education than did public learning courses.

Table 4

Higher Education Institutions Offering Distance Education (DE) Courses in 2000-2001

Types of institutions	Percent currently offering DE courses	Percent planning to offer DE courses within 3 years	Predicted Percent in 2003-2004
Public, two-year	90	5	95
Public, four-year	89	3	92
Private, two-year	16	23	39
Private, four year	40	16	56
Overall	56	12	68

Note. From Distance Education at Postsecondary Education Institutions: 200-2001 (p. 22), by Waits, T. and Lewis, L., 2003, Washington D.C.: U.S. Department of Education. Copyright 2003 by NCES.

In 1997-1998, the NCSE predicted the growth of distance education in a three-year period. The overall prediction in 1997-1998 was accurate when compared to the overall statistics reported in 2000-2001. The breakdown statistics showed that two-year public colleges exceeded the expected growth predicted in 1997-1998. However, in all other categories, the actual growth was lower than the expected growth. Table 5 shows the statistics of the actual percent of different types of higher institutions offering distance learning courses and the predicted percent from 1997-1998.

Table 5

Distance Education Courses in 2000-2001

Types of institutions	Actual Percent Offering DE courses In 2000-2001	Predicted Percent Offering DE courses from 1997-1998
Public, two-year	90	82
Public, four-year	89	90
Private, two-year	16	25
Private, four year	40	41
Overall	56	56

Note. The data in column 2 are from Distance Education at Postsecondary Education Institutions: 200-2001 (p. 22), by Waits, T. and Lewis, L., 2003, Washington D.C.: U.S. Department of Education. Copyright 2003 by NCES. The data in column 3 are from Distance Education at Postsecondary Education Institutions: 1997-98 (p.18-19), by Lewis, L., Snow, K. and Levin, D., 1999, Washington D.C.: U.S. Department of Education. Copyright 1999 by NCES.

In 1995 more institutions were planning to offer distance education courses within the next three years. The actual data in 1998 does not match the 1995 prediction. However, the data in 2000-2001 reflected the prediction quite well. If the trend continues as expected, more than 90% of public education institutions will be offering distance courses and approximately 70% of all the higher education institutions in the U.S. will offer distance education courses by 2003-2004.

Figure 4 shows the trend of course offerings in different types of higher education institutions. The number of course offerings has increased since 1995 in private two-year, private four-year, public four-year and public two-year institutions.

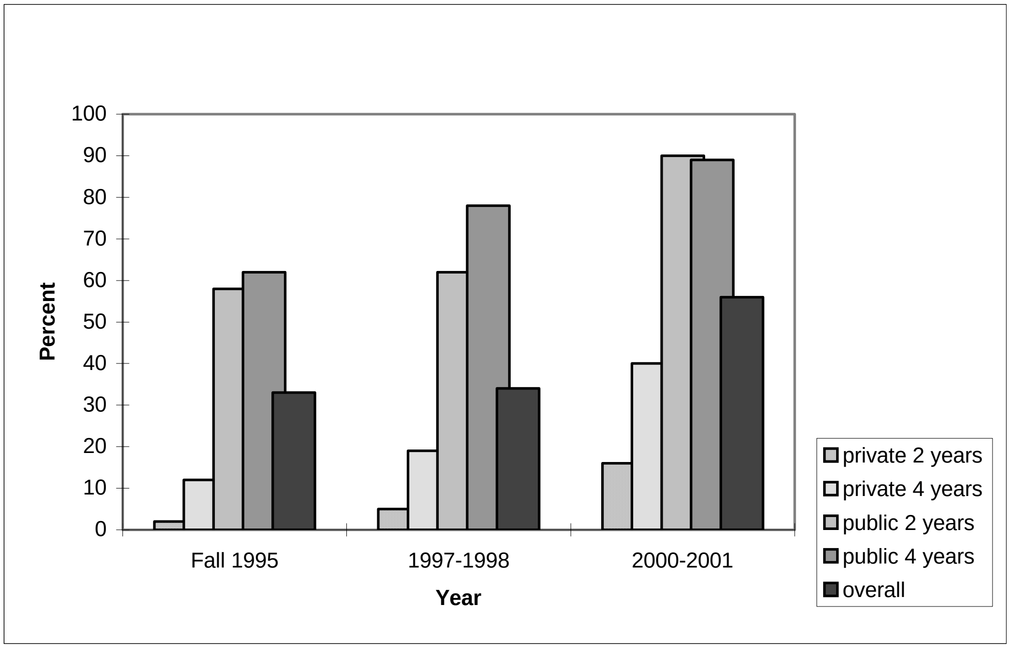

Figure 4. Trend in Higher Education Institutions Offering DE courses

Online Media in Education

The format of distance education has also changed drastically. In 1995, only 56% of higher education institutions had Internet access and 27% of these institutions offered some of their courses through the Internet (National Center for Education Statistics, 1997). However, in 2001, the major mode of instruction in distance education was asynchronous computer-based instruction through the Internet (90%). In addition, 88% of these institutions planned to expand their course offerings (National Center for Education Statistics, 1997). This new learning environment provided an option for students in continuing their studies, which would be impossible without Internet access.

Approximately one fifth of all college courses use some type of Internet-based course management system such as WebCT or Blackboard (Young, 2002b). Both software packages are template-based online course building and collaboration systems. The teacher can build syllabi, course calendars, and content modules. In addition, the course management software provides a wide range of communication tools such as email, discussion boards, and chat rooms. In most cases, the whole university will adopt one of the course management software packages. This course management system provides a similar look across disciplines.

Printed Media in Online Learning

Written material, either in printed form or electronic form, is the most familiar type of content in any educational environment. According to an international adult literacy study conducted from 1994 to1998, literacy is “the ability to understand and employ printed information in daily activities, at home, at work and in the community - to achieve one’s goals and to develop one’s knowledge and potential” (Tuijnman, 2000, p.9). This clearly indicates that being able to receive information in printed form is an essential skill for adults in this society. Written material exists in different forms, such as textbooks, course packages, course notes, and study guides. These materials may also appear in electronic form. In the digital world, most of the written material can be delivered easily on the World Wide Web using the Internet.

Publishing mathematics material on the web is not an easy task and is still developing (Moss, 2001). The representation of mathematics involves graphs, tables, formulas, function notation, and verbal descriptions. A dilemma especially pertinent to mathematics instructors is that the World Wide Web, which mainly uses hypertext mark-up language (HTML), does not support mathematical symbols. "The written symbol systems of mathematics are important factors affecting the learning experience of students" (Carter, 1995). In most word processors, for example, Microsoft Word, mathematical formulas are embedded into the document. This means that the formulae are foreign image objects in the document. Although the equation editor can make any mathematics formula, editing these objects is very troublesome (Majewski, 2000). Mathematics mark-up language (MathML) was developed to use mathematics tags to display mathematics formulas. However, special plug-ins need to be installed for the web browser to properly recognize these mathematics tags. Formulas and equations in MathML are not portable at present. This means that a user cannot copy the mathematics tag and paste it into other applications. Content MathML, which allows this capability is still developing (Ross & Rugh, 2003).

The Portable Document Format (PDF) can be seen everywhere on the web. More and more desktop publishing software has the ability to convert documents into PDF. Jakob Nielsen, the world's leading expert on website usability, states that "PDF is great for distributing documents that need to be printed (Nielsen, 2001, June 10)." Computer Algebra Systems (CAS), for example, Mathematica and Scientific Workplace, can create documents with complicated equations and graphics very easily and convert the documents into PDF form. Extra software is no longer needed to view documents containing equations and graphs.

Streaming Media in Online Learning

Streaming media technology allows playing audio, video, and multimedia files through the Internet in an effective way. In the past, video clips longer than 30 seconds were rarely used (Deal, 2003). These video files typically took a long time to download on the user end. With streaming technology, data is transmitted by a server application, and received and displayed by applications on the users' computer. These applications can start showing videos or playing audio as soon as enough data has been received and stored in the buffer on the viewers' computer. A streamed data file is simultaneously downloaded and viewed, but no physical file needs to be saved on the viewer's machine.

Streaming media technology puts virtually no limitations on the video clips used in an online learning environment. According to Maxwell at Western Kentucky University, the "live demonstration is an element missing in many online classes. Now I can take the classroom directly to the [online] students"("Spotlight on Dr. Marge Maxwell, Western Kentucky University", n.d.).

Boster, Meyer, Roberto, & Inge (2002) reported the effect of using streaming videos on educational performance. A database, which consists of an extensive collection of more than 1,500 videos and 15,000 chaptered clips of standards-based, core-curriculum educational video; teacher's guides; student activities; quizzes and teacher resources, was developed by United Learning. Teachers and students could access these videos clips through the Internet. The experimental-control study consisted of more than 1,400 elementary and middle school students in three Virginia school districts. Achievement results showed an average increase of 12.6% by students exposed to streaming technology compared to students who received classroom instruction alone.

Interactive Java Applets in Online Learning

Interactive Java Applets have been widely developed on the Internet. According to an online dictionary, Webopedia ("Applet", n.d.)

> An applet is a small Internet-based program written in Java, a programming language for the Web, which can be downloaded by any computer. The applet is also able to run in HTML. The applet is usually embedded in an HTML page on a Web site and can be executed from within a browser.

Applets are not tied to a specific software package or computational device. Students can access the applets through the Internet and a web-browser. Since applets can be very dynamic, the “what if” scenario can be illustrated instantaneously in front of students. Each interactive Java applet can be created for a specific purpose. Students will not be overwhelmed with keystrokes, but can focus on concepts. Using the Internet interactive investigation applet as an aid, many mathematical concepts can be presented in a more accurate and more efficient manner.

Heath (2002) reported the students’ feedback on the use of Java applets in a mathematics classroom at the United States Military Academy. Both the students and instructor agreed that the interactive features and the dynamic visualizations from Java applets significantly assisted students in conceptual understanding in the required freshman mathematics courses.

Reimer and Moyer (2005) conducted a study with third grade students using interactive Java applets, which they referred to as a virtual manipulative. The participants were comprised of nineteen third-grade students. Pre- and post-tests of conceptual knowledge and procedural knowledge were administered to this group of students before and after a two-week unit on fractions. Statistically significant improvement in students' post-test scores on a test of conceptual knowledge, and a significant relationship between students' scores on the post-tests of conceptual knowledge and procedural knowledge were observed. During the interview, students expressed that the virtual manipulative provided instant feedback and enjoyment while learning mathematics.

At Kennesaw State University, a group of faculty members expressed concern about the success rate of the traditional college level algebra course. Students had lost interest in the study of traditional college algebra. With a mission to make college algebra more interesting to the students, faculty members developed a mathematics course around application problems related to environmental issues. This course has officially been part of the curriculum since 1991 (Schaufele, Zumoff, Sims, & Sims, 1999). In 2001-02, the development of this course concentrated on Internet accessible computer Java applets which allow students to discover "what if" in dealing with mathematics equations (Szymanski & Duckworth, 2001).

Learning Mathematics

According to the American Mathematical Association of Two-Year Colleges (AMATYC), helping learners to discover the usefulness of mathematics within their life is the purpose, goal, and mission of the introductory mathematics course in college (AMATYC, 1995). Specific education outcomes in mathematics are listed for all students in all college programs as follows:

- exhibit perseverance, ability, and confidence to use mathematics to solve problems
- perform mental arithmetic and use proportional reasoning
- estimate and check answers to problems and determine the reasonableness of results
- use geometric concepts and representations in solving problems
- collect organize, analyze data and interpret various representations of data including graphs and tables
- use a variety or problem-solving strategies and exhibit logical thinking
- use basic linear, exponential, and other non-linear models appropriately
- communicate findings both in writing and orally using appropriate mathematical language and symbolism with supporting data and graphs
- work effectively with others to solve problems
- demonstrate an understanding and an appreciation of the positive role of mathematics in their lives (AMATYC, 2005, p.43)

The 2001 Mathematical Association of America (MAA) Guidelines for Programs and Departments in Undergraduate Mathematical Sciences recommendations affirm the important of understanding mathematics. The recommendations point out that:

> Mathematical Science departments should employ technology in ways that foster teaching and learning, increase the students' understanding of mathematical concepts, and prepare students for the use of technology in their careers or in their graduate study. (MAA, 2001)

Even for non-mathematics and non-science majors, a mathematics course is required in the core curriculum at all of the colleges and universities in the University System of Georgia (Board of Regents, 1997). In most institutions, the only required mathematics course is Introduction to Mathematical Modeling. Therefore, it is important that this course utilize technology that is both helpful in delivering mathematical concepts and in encouraging future learning using technology.

Mathematics not only involves abstract symbolic manipulation, but also realistic applications. Problem solving makes mathematics come alive. Memorizing theorem after theorem is not the purpose of studying mathematics. As Polya said in one of his interviews, "You cannot understand a theory unless you know how it was discovered" (Alexanderson, 1985, p. 251). There is a story behind each theory in mathematics, and the majority of them involve real life applications.

Mathematical modeling attempts to solve real world problems that involve mathematics. That is, mathematics is used as one of the tools in applying problem solving skills in realistic situations. Analytic skills, which involve making assumptions and translating real world situations into mathematical equations, are important in this process. Of course, a single number will not be a final answer. However, the interpretation of some numbers is often involved in the final solution. The solution is only a model, which is a capture of the real world setting (Michalewicz & Fogel, 2000).

One of the most influential books on problem solving is George Polya's How to Solve It. The preface of the book addresses the two faces of mathematics: rigorous science and experimental, inductive science. The second face is in the process of being invented and is new to both teachers and students (Polya, 1957). Obviously, Polya is referring the second face to problem solving as the new aspect of mathematics as he clearly indicated in the subtitle of his book.

"If there were any single event that could necessitate an updated approach to problem solving nearly 50 years after Polya's book, it would be the availability of powerful desktop computers at affordable prices" (Michalewicz & Fogel, 2000, p. vii). With the affordable technology of today's society, students can personally experience the real world phenomena described in the textbook. Students no longer only read information from books; often, they have seen, touched, and felt what they have read. This helps students truly understand the problems that they are investigating.

Traditionally, a mathematics curriculum, from elementary school and on, tends to decompose problems into smaller, simpler ones. Students with very realistic thinking always wonder about the need to solve problems in the ways described in textbooks. Under these circumstances, educators wonder why students cannot apply critical thinking and reasoning skills to the subject. Some students believe that mathematics is a myth and try their best to memorize rules and theorems without understanding. When it comes to textbook word problems, students have difficulty in applying mathematics to an unrealistic story.

Some educators foresee a serious erosion of mathematical ability in future generations. Various mathematics-related organizations encourage their members to overcome the difficulties in educating the next generation. In 1981, MAA recommended that students should incorporate real world mathematics modeling projects into the undergraduate curriculum (Committee on the Undergraduate Program in Mathematics, 1981). NCTM's Standards (1989) challenged schools to put more emphasis on problem solving skills, thereby giving meaningful experience in doing mathematics and connecting the study of mathematics to daily life. Compared to the past, the mathematics curriculum has more and more problem solving components. In addition, the American Mathematical Association of Two-Year Colleges (AMATYC) challenged two-year colleges to emphasize interactive learning, independent thinking, solving meaningful problems, and the use of multimedia technology in non-mathematics intensive major courses. The goals of the entry-level mathematics courses are to develop students' quantitative capabilities and logical thinking and to increase their reasoning skills (AMATYC, 1995). All of these mathematical education organizations suggest that the modeling of real world experiences should be a vital part of the curriculum and should start as early as possible.

As early as 1980, a non-profit organization named Consortium for Mathematics and its Applications (COMAP) took on this challenging mission. The purpose of this organization is to improve mathematics education for students of all ages through modeling real life issues in the world. To encourage the use of modeling in the existing curriculum for high school and undergraduate mathematics courses, COMAP created and published books and materials that cohere to the NCTM standards.

In addition, COMAP held the first Mathematical Contest in Modeling (MCM) in 1985. Teams from different parts of the world, and consisting of at most three members, worked either a continuous or a discrete modeling problem, on one of the designated weekends in February. The first Interdisciplinary Contest in Modeling (ICM) was held in

1999. The purpose of the contest was to develop and advance interdisciplinary problem-solving skills and written communication. The contest has been held at the same time as MCM each year since then (COMAP, 2000).

In 2001, COMAP also extended their goal to reach out to learning support students at the beginning of their college careers. COMAP developed two semester developmental mathematics programs (DevMap) for students entering college with weak mathematics backgrounds. A hands-on discovery approach is implemented throughout the program. The goal of this program is to enhance student learning by using applications from various fields (COMAP, 2001).

Learning Mathematics through Mathematical Modeling

Mathematics is a tool for answering vital social, scientific, and political questions with evidence (Abrams, 2001). Real world problems are usually not well defined. Modeling real world situations is indeed a cyclical process. During the modeling process, students will ideally begin to discern ways that mathematics is useful in the world around them. The mathematical modeling cycle is illustrated in the following diagram (p. 272):

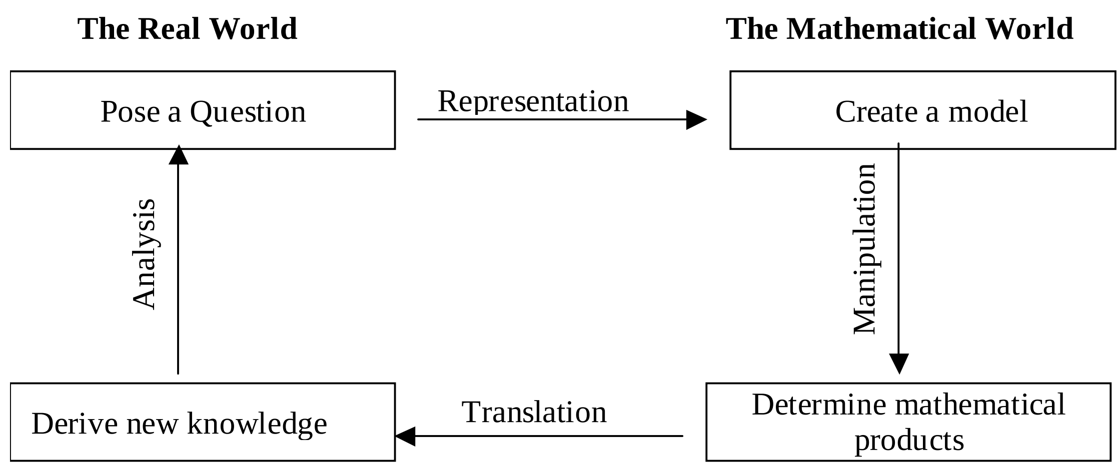

Figure 5. Mathematical Modeling Cycle

The mathematical modeling curriculum should allow students to "identify variables, simplify expressions, and choose mathematical abstractions that capture concrete ideas" (Abrams, 2001, p. 273). Through this process, students learn how to translate a real world problem into a well-formulated mathematics problem by using appropriate assumptions. After applying appropriate mathematics knowledge and technology to obtain a numeric answer, students need to interpret the answers in real world settings.

For students to grow, they need to learn through their own experience, not the teachers' experience (Ulmer, n.d.). Reproducing others' knowledge and algorithms represent a low level of understanding. This type of learning is truly captured by a Chinese proverbs, "Parrot learns to speak." The parrot can only replicate what its teacher says. The learning has not been internalized. As a teacher in a classroom, it is very easy to act as an expert in problem solving using mathematical knowledge. Rote explanations and flattening of multi-dimensional mathematical concepts does not promote active and engaged learning. It is very easy to fall into this style of teaching, as given by the following testimony:

> In the past, I primarily lectured to my students, presenting mathematics as a collection of facts and procedures to be memorized. I simply felt trapped into this style of teaching. I was given a textbook and syllabus to follow. Both dictated that my job was to cover a wide range of procedures and algorithms. Due to the breadth of topics, I had to abandon depth (Chappell & Hardy, 1999, p. 1).

This common practice contradicts the goal of mathematics education stated in the Principles and Standards. That is, “a major goal of school mathematics programs is to create autonomous learners" (National Council of Teachers of Mathematics, 2000). Askew and Carnell (1998) believe that teachers should spend more time helping the process of individual learning and less time giving information. The teachers should use a question and answer method to solve the problems that the students have in mind rather than giving a direct answer to the question. This approach of teaching will enable the students to interact deeply through accessing their own thought.

With the technology available in this society, jobs which require individuals to replicate a certain task have diminished. Computers are more efficient in tedious algorithms and produce greater accuracy. To educate the future generation, educators need to create spaces wherein thinking and decision can take place. Apprenticeships, which allow students to directly connect with the associate knowledge and applications in learning, are necessary.

Learning Mathematics through Projects

The method of incorporating projects into learning originated in medical schools. It has slowly been adopted by the discipline of mathematics. For example, a Project-Based First-Year Finite Mathematics Course at Indiana University was funded by a National Science Foundations (NSF) grant for “Mathematics and Science Throughout the Undergraduate Curriculum." All the projects in the course are real world problems from different companies, industries and organizations. Since the mathematics involved will vary according to project, a standard textbook covering almost all topics in a traditional course is used. The result of the mathematics model will be communicated through oral and written reports for each project (Kochanowski & Shafii-Mousavi, 2000).

The same emphasis was stated in the *Crossroads in Mathematics* for courses intended for the non-mathematics intensive majors. The curriculum should emphasize interactive learning, independent thinking, solving meaningful problems and the use of multimedia technology. The goals of the course are to develop students' quantitative capabilities, logical thinking and to increase their reasoning skills (AMATYC, 1995).

Projects can play different roles in the teaching and learning of mathematics. In doing projects, students transfer what they learn in the classroom to realistic situations outside the classroom (Blum, 1999). Instructors can use projects to improve students' mathematical exposition, to introduce new systems of mathematics, to strengthen understanding of previously encountered mathematics, and to provide feedback from the student to the instructor (Crannell, 1999). Projects encourage students to explore ideas further and help them to seek deeper understanding in class discussions. In addition, students learn how to formulate ideas from discussion with classmates and teachers (Kenschaft, 1999).

The *Crossroads in Mathematics Executive Summary* (Cohen, 1995) published by AMATYC, pointed out the basic principles that guided the introductory courses in college mathematics. One of the principles was that "Mathematics must be taught as a laboratory discipline. Effective mathematics instruction should involve active student participation using in-depth projects" (p. 4). It also emphasized problem solving, technology, conceptual understanding and collaborative learning. Traditionally, as reported in the MAA summer meeting in 1997, approximately 50% of liberal arts majors are successful in a basic mathematics course. Such outcomes are contradictory to the mission which is shared by most of the educators: "Mathematics education must reach out to all students" (Cohen, 1995, p. 4).

At the University of South Carolina, Spartanburg, project-based instruction in an introductory mathematics course for Liberal Arts majors was adopted. The Mathematics faculty believed that this new approach, which required mathematical thinking, would correct and enhance the students' view of mathematics. Students entered the class with a perception of mathematics as a list of rules for memorization. This entire course was a combination of individual and group activities and projects with no required textbook, aside from a forty-plus page booklet written by M. B. Ulmer, one of the faculty members. This approach covered less content material but contained more usable knowledge and promoted better student attitudes towards mathematics. The success rate was overwhelming. With 36 sections, the median student success rate for this new approach was 75%, compared to the rate of 58% with 28 traditional sections. In addition, these students maintained their performance in the succeeding statistics course (Ulmer, n.d.). The more up-to-date data, including sections from summer 1994 to spring 2001, indicated that the median success rate was 75% compared with 53% (Ulmer, n.d.). Upon completion of the course, the students better appreciated the use of mathematics in the world around them. Projects helped students to see how mathematics was connected to their lives (Basinait, 1996).

Using projects components in the teaching and learning of mathematics helps instructors learn more about how students think. This is a new approach to the teaching of mathematics. Projects help students link mathematics to other mathematics-related subjects about which students are more knowledgeable (Kenschaft, 1999). In the process of writing a project, students are reflecting upon their knowledge, re-presenting, and re-organizing their ideas from different mathematical concepts and various mathematics representations, and connecting different subjects in practical and realistic problems. This helps students to have a more complete view of what mathematics is about and to integrate different concepts into one physical form, that is, the project. From the work of students, instructors know more about their thinking through analyzing a mathematical problem (Blum, 1999). This also provides a chance for instructors to catch misunderstandings about mathematical concepts (Kenschaft, 1999).

Projects can assess other elements in learning that traditional testing will not assess otherwise. NCTM supports the idea that assessment should enhance students' learning (National Council of Teachers of Mathematics, 2000). Without a doubt, projects strengthen problem solving, critical thinking, analytical thinking, and interpretative skills (Blum, 1999). In doing projects, students are called upon to translate English writing to mathematics and explain a mathematics solution in plain English in a real world setting (Crannell, 1999). Obviously, students spend more time involved in the thinking process for the project's writing components than they do when taking traditional tests (Blum, 1999). Projects reveal what students know while traditional tests reveal what they don't know (Kenschaft, 1999).

Learning Preferences

Students' learning preference means how students perceive the way they learn best. Oftentimes learning preferences are related to learning styles. Grasha (1996) defined learning styles as, "personal qualities that influence a student's ability to acquire information, to interact with peers and the teachers, and otherwise participate in learning experiences" (p.41). Learning style can be classified in many different ways. In general, there are two main categories: cognitive and social.

Diaz & Cartnal (1999) compared the social learning styles of one section of online health education classes with one section of the same class that met on campus. This study took place in a medium-sized (8,000-9,000 enrollment) community college on the West Coast. The Grasha-Riechman Students Learning Style Scale (GRSLSS) was used to determine the social learning style for each student in both sections. GRSLSS classified learning styles into six different categories listed below.

1. Independent learners prefer independent study, self-paced instruction, and would prefer to work alone.
2. Dependent learners need guidance and need the support of instructor and classmates.
3. Competitive learners perform better when their academic accomplishments are recognized by others.
4. Collaborative learners acquire knowledge by sharing and by cooperating with instructors and classmates.
5. Avoidant learners are not stimulated by class attendance or classroom activities.
6. Participant learners are involved in classroom activities and discussion.

Sixty-eight students in the online section and forty students in the on-campus section participated in the study. Students in the online section were significantly more independent than students in the on-campus section ($p<0.1$). Students in the on-campus section were significantly more dependent than the online section ($p <0.1$). Therefore, independence was clearly less of a learning preference for face-to-face students. Additional analysis revealed that face-to-face students displayed collaborative tendencies. Online students responded well to collaborative activities only if clear structure and guidance were provided. Both groups were less favorable to Avoidant and Competitive learning styles.

Ford and Chen (2001) conducted an empirical study that explored the relationship between matching and mismatching instructional presentation style with students' cognitive style in a computer-based learning environment. Matched or mismatched instructions on students’ cognitive styles were given to seventy-three postgraduate students on how to create Web pages using HTML. Based on performance measured on a multiple-choice test of conceptual knowledge, significant statistical differences were found for students learning in matched and mismatched conditions. Students performance was significantly better in matched conditions than mismatched conditions. No significant difference was found on the practical test. These findings provide support for the notion that matching and mismatching can have significant effects on learning outcomes.

Lee, Cheng, Rai, & Depickere (2005) studied the effect of cognitive learning styles and three learning dimensions. Cognitive learning styles can be classified as either field dependent or field independent. Field dependent learners are individuals who prefer to be guided in their learning processes and employ less analytic approaches to learning. Field independent learners welcome less restricted guidance and enjoy an analytical and autonomous approach to learning. Learning dimensions included using non-linear learning approaches (use online learning component), learning controls and multiple tools. The sample was comprised of 217 students from Murdoch University, Australia; who were enrolled in a first-year Information Technology course in their undergraduate study. A survey was carried out every other semester over a period of 3 years (1999–2001). The class met two hours per week for the traditional regular lecture and one hour per week for tutorials. WebCT was used in the course to provide lecture notes for students and also to facilitate interchange between students and instructors with the use of email and bulletin boards. Tree-Based regression was used to analyze the interaction between the learning dimensions and the effect on students' cognitive style. The research findings indicated that non-linear learning is the primary dimension that determines students' cognitive learning styles. This was subsequently followed by multiple tools and learner control dimensions. The results also confirmed that background information has effects on students’ cognitive learning style. The overall findings suggested that students' preference of learning, level of learner control and the range of multiple tools must be taken into consideration in order to enhance education quality for individuals.

Terrell (2005) studied the effect of cognitive learning styles in the attrition rate of a doctoral program at a large, private, metropolitan university in southeastern Florida, which widely used the distance education format in their academic program. When students were off-campus, the class interacted using various synchronous and asynchronous tools. Data was collected from 216 students who began a doctoral program between 1993 and 1998. At the time of analysis, all students involved had either graduated or left the program by early 2003. The Kolb Learning Style Inventory determined the learning style of these students. This learning style instrument classified learners into four types of learning styles: Diverging, Assimilating, Converging, and Accommodating. The majority of students (167 or 77.3%) fell into either the Converger or the Assimilator category; of these, 37.1% (i.e., 62) graduated. Of the 49 students falling into the Diverger or Accommodator categories, 20 (i.e., 40.8%) graduated. The overall comparison of graduation rate (38%) by learning style was not statistically significant ($F(3, N = 216) = 3.074, p = .380$). According to this longitudinal study, learning style was not a factor for attrition rate in a graduate program that involved distance learning components. Terrell also pointed out that this might not be true for undergraduate, secondary education for adult learners. In addition, compared to the national average, this doctoral program has a higher attrition rate.

Student-to-student interaction and student-to-instructor interaction occurs differently in the online learning environment than it does in a traditional learning environment. Students in a hybrid-learning environment meet face-to-face once a week in a classroom. Communication can take place in an online setting and in a classroom setting. Therefore, social learning preference may not be a main factor between hybrid and face-to-face students.

Summary

Learning medium, learning mathematics, and learning preference are the three main areas related to the present study. Using an online learning component is becoming more and more common among higher education institutions (National Center for

Education Statistics, 1997, 1999, 2003). In a hybrid-learning environment, learning media are extended from traditional printed textbooks to include another medium using the World Wide Web. These media include text and graphic web pages, streaming media, and interactive investigation applets. Mathematics can now be presented with more speed and accuracy, thanks to these technologies. Students can access these resources through computers with Internet connection without time limitations. Resources delivered through Internet helped students to increase conceptual understanding and subject knowledge (Boster, Meyer, Roberto, & Inge, 2002; Heath, 2002; Reimer & Moyer., 2005).

Learning mathematics is not learning how to manipulate mathematics symbols. Learning mathematics is learning how to solve problems with the help of mathematics, constructing mathematical modeling, and revising mathematics ideas.

Examination of learning styles can be approached in two different categories – cognitive learning styles and social learning styles. Research (Diaz & Cartnal, 1999; Ford & Chen, 2001; C. H. M. Lee, Cheng, Rai, & Depickere, 2005) supported the notion that learning styles influence students’ performance. Cognitive learning styles were not determining factors in students’ attrition rate in a distance learning program (Terrell, 2005). Differences in social learning styles were studied between face-to-face and online students (Diaz & Cartnal, 1999; Ford & Chen, 2001; C. H. M. Lee, Cheng, Rai, & Depickere, 2005). Since hybrid students are not completely physically isolated to the degree that online students are, social learning styles might not be a major factor in learning among face-to-face and hybrid students.

Literature on the students’ medium preferences in online learning or hybrid learning is rarely addressed. Studies addressing the use of online learning are mostly geared to the graduate level (Parkinson, Greene, Kim, & Marioni, 2002) or junior and senior level courses in the undergraduate curriculum (Stokes, 2001) in which students perceived that such courses have effects on their professional or post-graduate education prospects. Further research is needed in the general education courses taken in the freshman or sophomore year. Whether students' medium preferences involving the use of online media in the general education courses in the beginning of their college education affects their learning is still an open question.

CHAPTER 3

METHODOLOGY

The major research question of this study is: Is there any difference in preferred learning media between the students enrolled in the hybrid course and the students enrolled in the face-to-face course with online enhancement? This study was quantitative in nature with open-ended survey questions. This chapter presents the results of the pilot study, the research methodology used, and the subjects involved in the study. Procedures involved in conducting the experiment are addressed. The instruments used are presented and may be found in Appendix A. The method of data analysis and the assumptions of the study are reviewed.

Pilot Study

Before commencing the current research, a pilot study was conducted. This pilot contributed to the refinement of the research instruments, further identified the subjects being studied, and aided the fine-tuning of the data collection processes in the final study.

During Summer 2005, at one of the urban community colleges in the southeast, a pilot study was conducted to determine students' preference of media in a hybrid course. This study was mainly qualitative in nature. Open-ended survey questions were used to gain more understanding of the student's choice of media preference. The pilot study was guided by the research question: What is the preferred learning media of students who enrolled in the hybrid course?

Subjects of this study were students enrolled in a hybrid Introduction to Mathematical Modeling course in Summer 2005. This course was eleven weeks long. The online learning component was delivered through WebCT Vista 2.0. There were twenty-five students registered for the course. Thirteen students participated in the first class meeting and twelve students took the final exam and completed the course.

Data collection was ongoing. Students filled out survey instruments after completing homework assignments, projects, quizzes and tests. These survey instruments asked students to indicate their preferred media of learning while completing their homework assignments, quizzes, and tests. Students were given the choice of online, face-to-face or both. Upon finishing the projects, students were asked to give their feedback by mathematical concepts as to which approach to learning was most useful to them. In addition to the available choices (online, face-to-face or both) students were also asked to give reasons for their media choice.

To conduct this pilot study, the first step was to gain approval for research involving human subjects from the Institutional Review Boards, both at the two-year college where the research took place and at Georgia State University, the doctoral-granting institution. Analysis of data then followed. All quantitative data was coded using an EXCEL spreadsheet. All answers from the open-ended questions were read.

Codes 1, 2, 3, were used to indicate students preferred medium in the hybrid mathematics course. Code 1 represented the students who picked “face-to-face”. Code 2 represented the students who indicated “both”. Code 3 represented the students who selected “online”. A possible average score for each item is from one to three. Dividing this scale into three categories, a score of 1.00 to 1.67 represented a preference of the face-to-face learning environment; a score of 1.67 to 2.33 represented a preference of the hybrid-learning environment; and a score of 2.33 to 3.00 represented a preference of the online environment. The following table represents the average score in the pilot study for each student in the area of quizzes, tests and final exam.

Table 6

Average Responses for Each Individual Student

Subject	Quizzes Average	Test Average	Final Exam
A	1.02	1.00	1.00
B	1.00	1.00	1.00
C	1.00	1.00	1.00
D	1.13	1.20	1.27
E	1.18	1.97	2.86
F	1.25	1.00	1.32
G	1.34	1.00	2.00
H	1.52	1.83	2.00
I	1.94	2.00	2.00
J	1.94	2.00	2.00
K	2.00	2.00	2.00
L	2.12	2.10	2.14

Using the aforementioned categories of averages, it might be said that eight out of twelve students preferred the face-to-face learning environment when asked to complete quizzes while four out of twelve students preferred hybrid learning. No student indicated a preference for an online learning environment. When they were asked to complete the end-of-module tests, six students preferred the face-to-face learning environment while six students preferred the hybrid-learning environment. Again, no student indicated a preference for an online learning environment. When taking the final exam, five students indicated their preferred learning environment was face-to-face and six students indicated their preferred learning environment was hybrid. From the instrument given during the final exam, one student preferred the online learning environment.

The quantitative results indicated that approximately half of the students preferred face-to-face learning and half of the students preferred the hybrid form when engaged in projects. Students who preferred the face-to-face learning environment were consistent with their choices across all aspects of every survey instrument. The qualitative data gathered through projects showed that the majority of the students preferred a face-to-face learning environment. Two themes emerged as reasons for choosing face-to-face learning media: (1) immediate feedback and (2) human contact.

The pilot study imformed the methodology of the research in four different areas: (1) the refinement of survey instruments, (2) reduction of tedious data collection especially through the assignments, (3) the need for demographic data and (4) the need to have a control group.

In the pilot study, the research instrument only allowed students to indicate if they preferred learning face-to-face, online, or both. It did not allow students to choose a combination that emphasized one of these preferences. Since the face-to-face learning environment and the online learning environment are extreme cases in this study, a combination of different degrees of the face-to-face and the online environment might be useful. The idea of a continuum of learning environment was attempted in the final study.

The modified research instruments provide a scale for students to indicate their preference. The research instruments used the scale from one to five where one indicates a preference of exclusively the face-to-face session, two indicates a preference of the combination of mainly face-to-face session and some online resources, three indicates a preference of equally important between face-to-face session and online resources, four indicates a preference of the combination of mainly online resources and some face-to-face session, and five indicates a preference of exclusively online resources.

The initial plan of the pilot study was to collect data twice for each question from every assignment, in order to capture the effect of face-to-face meeting in a hybrid class. The first time, data was collected before the class discussion session and the second time, data was collected after the class discussion session in the face-to-face meeting. The pre- and post- survey regarding the homework asked students to tell their confidence level when doing the homework exercise. Not only was this process very time-consuming, but students also felt the process was very tedious. Since the result from the pilot study showed that students strongly believed in their choices throughout the entire semester, in the final study, data would need to be collected once for each assignment and students would be asked their preferred learning media for the entire assignment. In addition, the survey instrument had choices similar to the quizzes, tests and project. That is, five choices were available for students to indicate their media preference.

The pilot study indicated that approximately half of the students preferred face-to-face learning media. Demographic data was needed to find out who these people were, their comfort with using computers and Internet and their WebCT experience. A demographic survey was added to the research study in Fall 2005.

Although students in the pilot study were self-selected into this hybrid-learning environment, the data show half of the students preferred face-to-face. The researcher was interested in knowing the preferred learning media for the face-to-face students in an online enhanced class. A control group was added to the study in Fall 2005. The control group was made up of students enrolled in a face-to-face section with online enhancement of the same course.

Research Methodology

This study was quantitative in nature, using a treatment group and a control group. As a supplement, open-ended survey questions were used to gain more understanding of the subjects. Questionnaires regarding preferred learning media were collected through homework, online quizzes, paper-and-pencil tests, and projects. The treatment group consisted of the students who enrolled in the hybrid Math 1101 in Fall 2005, which met once a week for one hour and fifteen minutes. The control group was comprised of students who enrolled in the face-to-face Math 1101 in Fall 2005, which met twice a week for one hour and fifteen minutes each session. Convenience sampling was used in this study. In general, a quasi-experimental design was used (Huck, Cormier, & Bounds, 1974). A code was assigned to each student who enrolled in the course in the beginning of the semester. All instruments were administrated to both the treatment and control groups throughout the entire semester. Data were collected in four different categories, (1) homework and quizzes, (2) tests, (3) projects, and (4) final exam. Through these categories, data were collected about students’ preferred medium of learning on each topic addressed in the course.

Subjects

The subjects in the study were students in a large, public, multi-campus two-year college in the Southeastern part of the United States. The enrollment at the participating campus was approximately 2,180 with 70.6% female and 29.4% male. The mean age was 27 years and the median age was 23 years. Approximately 79.3% identified themselves as African American and 9.4% identified themselves as Caucasians. Roughly 85.8% of the new students were classified as Learning Support students and 25.1% of the new students were classified as freshman. Convenience samples were used throughout the study. Students enrolled in the Introduction to Mathematical Modeling course in Fall 2005 during the day, were the subjects of this research. The same instructor taught all sections. Students self-selected into the treatment group or the control group. The treatment group consisted of students who were enrolled in the Math 1101 hybrid section. The control group consisted of students who were enrolled in the Math 1101 face-to-face section. These two types of learning media were clearly indicated in the "Schedule book" in the school website. A description such as the one below was used in the class schedule website:

> Above section (MATH 1101-XXX) is a HYBRID COURSE. The class meets on Wednesdays 9:30 - 10:45am in the classroom and the rest of the instruction each week will be delivered online. This is a class with WEB-BASED components. You will need access to a COMPUTER and the INTERNET, and EXPERIENCE using them. For more information about minimal requirements, visit http://www.xxx.edu/~dl/webct/student/computer_requirements.htm. If you would like to know more about hybrid courses, please visit http://www.xxx.edu/~xxxhyb/. Contact your instructor for additional information.

Therefore, students enrolled in the hybrid course knew that this course had online learning components. The class met once a week for seventy-five minutes on campus in a classroom. Students were expected to logon to WebCT Vista to access course material.

However, there was no indication whether online enhancement was involved in the face-to-face section. The face-to-face section in this study used online enhancement through WebCT throughout the semester. Students enrolled in the face-to-face section were the control group. Students from the treatment and the control groups had access to a WebCT Vista 3.0. The face-to-face section met in a classroom two times a week and each class meeting was seventy-five minutes. In addition, this face-to-face section used online enhancement throughout the semester. Sections in the treatment group and in the control group met weekdays at 9:30 a.m. The researcher was also the instructor for both courses.

Structure of the Hybrid Course

The Introduction to Mathematical Modeling hybrid course is a 3-hour beginning level mathematics course. Students in this course met once a week during the 15-week semester. Each face-to-face class meeting was seventy-five minutes. The class took place in a classroom equipped with a computer, a data projector, a SMART board (an interactive whiteboard), and a document camera.

Students in the treatment group were required to logon to WebCT to access the web-based portion of the course each week. Students were required to log on to the course at least twice a week. Streaming video lectures, video graphing calculator demonstrations, Java applet web-based investigation, handouts, homework assignments, homework assignment suggested solutions, and group projects were available to all students twenty-four hours a day. The material was organized into three modules: linear models, exponential models, and quadratic models. Inside each module, the material was organized in chronological order according to the class schedule. Students also were able to access the quizzes through the modules. Table of Contents for the learning modules are available in Appendix C.

All seventeen quizzes were completed outside the face-to-face class meeting. Students needed to access the quizzes inside WebCT Vista. Most of the quizzes were in multiple-choice format. There were a few questions using matching or short answer format. The purpose of the quizzes was to confirm what the students had learned. Three paper and pencil tests were conducted in-class during the face-to-face meeting. Four group projects were used to assess students' abilities to apply their mathematics knowledge to real-world settings. Each group submitted a written report in Microsoft Word format with all the TI-83 calculator screen shots showing how the answers were deduced. This file needed to be submitted inside WebCT as an attachment before a specified deadline.

On the WebCT Vista 3.0 course homepage, students found the course syllabus, class schedule, orientation folder, the "Before you Begin" learning module, and three course content modules. Inside the orientation folder, students found a few short video demonstrations on how to navigate through the WebCT Vista website for this course. The "Before You Begin" learning module consisted of a link to the college WebCT guide, a link to an orientation folder and an orientation quiz. The orientation quiz covered general information about WebCT Vista and also gave students the opportunity to experience taking an online quiz. The three main course content modules of the course were displayed to the students when they were needed.

Implementation of the Hybrid Course

After students registered for the hybrid course, they were encouraged to visit the WebCT link from the official school homepage. On the first day of the semester, students were able to get their WebCT identification code and WebCT password from the school website by using their school identification number and birth date. Using this information, they were able to logon to WebCT and access the course. From this point on, they had access to the course materials and were able to see the structure of the course. Course syllabus and the tentative class schedule were available within WebCT Vista. A copy of these documents is also located in Appendix C. The main content of the course was organized into three different modules, Linear Model (LM), Exponential Model (EM) and Quadratic Model (QM). In the beginning of the semester, students were able to view only the LM module on the WebCT Vista. Other learning modules were available when needed, according to the course schedule.

The class schedule clearly indicated materials that were introduced in class and course materials that were each student's responsibility. The instructor discussed the detailed operations of the course during the first two weeks of class.

During the first face-to-face meeting, the researcher-instructor gave an overview of the process of logging on to WebCT. Orientation to the course included a brief explanation of the course syllabus, the organization of the WebCT, expectations for quizzes, assignments and group/individual projects. Also, informed consent forms and student information sheets were given to each student. The completed forms were collected from each individual before the end of the class. All quizzes were done online and due on the specified dates at 11:59 p.m. in WebCT. All assignments were available inside WebCT in PDF file format. They were expected to complete those assignments on paper and show the solution process. Some assignments involved the use of Interactive Java applets on the web. The Table of Contents of all modules can be found in Appendix C. The rest of the class time was used to discuss the class material under LM Topic 2: Visualizing Two Variable Data inside the WebCT Vista.

Before each class meeting, students were expected to complete all assignments and quizzes as noted on the syllabus. They were expected to complete Topic 3: Introduction to Function and Topic 4: Function Notation on their own with the online resources such as class handouts, and streaming videos. In addition, they had to read and complete all assignments that were available for each topic. The instructor did not expect students to find the answers to all problems; however, the instructor expected students to attempt to critically think through the assignments. Without this, students could not engage in their learning. Students needed to turn in selected assignments for the next class period. Students were encouraged to bring the difficult problems to the face-to-face meeting for discussion. Assignments not required to be turned in would have solutions available on WebCT during the next class meeting and students were able to check if they understood those concepts. Figure 6 below shows the schedule for the first few weeks of class in a hybrid section.

Dates	In Class	Online	Quiz Due (Tuesday)	Turn In at Next Class
Wednesday 8/24/05 and the week thereafter	Intro, WebCT, LM 2	LM 3, 4	Q1	A1, A3
Wednesday 8/31/05 and the week thereafter	LM 5	LM 6, 7	Q2, Q3	A6
Wednesday 9/7/05 and the week thereafter	LM 8	LM 9	Q4	A8
Wednesday 9/14/05 and the week thereafter	LM 10	LM 11	Q5, Q6	A 9, A10
Wednesday 9/21/05 and the week thereafter	LM 12	LM 13	Q7	A 11, Project One
Wednesday 9/28/05 and the week thereafter	TEST ONE	EM 2		A 12

Figure 6. Partial Schedule of a Math 1101 Course

The second face-to-face meeting involved collecting Assignment 1 and Assignment 3, and answering questions regarding all assignments. Then the class would move on to Topic 5: Average Rate of Change in the LM. In like manner, the “In Class” and “Online” format was alternated for the rest of the semester.

Structure of the Face-to-Face Course

The Introduction to Mathematical Modeling Face-to-Face course is a 3-hour course. Students in this course met twice a week for seventy-five minutes during the 15-week semester. The class took place in a classroom equipped with a computer, a data projector, a SMART board (an interactive whiteboard), and a document camera.

Students in this face-to-face course, with online enhancement, were the control group. Each student had access to the WebCT course, which was based on the exact template of the hybrid course. Therefore, students had access to streaming video lecture, video graphing calculator demonstrations, Java applet web-based investigations, handouts, homework assignments, homework assignment suggested solutions, and individual or group projects. Although students in this course were not required to logon to the WebCT for a specific number of times, students were expected to complete quizzes online, and print out assignments and projects. All course material was explained and discussed in class thoroughly.

Instrumentation

In this research, the main instruments used were as follows: Assignment Feedback (AF), Project Feedback (PF), Quiz Feedback (QF) and Test Feedback (TF). The research instruments are listed in Appendix A.

AF asked for students' feedback about their experience with their assignments. The survey asked the student to identify his/her preferred media of learning directly related to the student's ability to complete the specific assignment as a whole. A scale of one to five was used in this instrument. Choice 1 indicated that the student primarily preferred face-to-face learning in completing the specific assignment. Choice 5 indicated that the student primarily preferred online learning in completing the specific assignment. The choices 2, 3, 4 indicated the different degree of combining the face-to-face learning and the online learning in completing the specific assignment. Choice 2 indicated face-to-face learning was a dominant factor and online-learning was a minor factor in the ability to complete the assignment. Choice 3 indicated both face-to-face and online learning were equally important in their ability to complete the specific assignment. Choice 4 indicated online learning was a dominant factor and face-to-face learning was a minor factor in completing the assignment. This survey was used on selected assignments in the course. All the mathematical concepts of the course were rated by students' preferred medium preference, assessed either by AF or QF.

PF was a three-question survey asking student's feedback after completing the individual/group projects. Students had the choice of completing the project as an individual or within a group. However, each individual responded to PF according to his/her own experience. The first question the PF asked the student was to indicate the related topic to complete the project. The second question asked the student to indicate which learning medium was best for him/her. The third question asked the student to explain why he/she selected his/her answer in question two. PF was used for project 1, project 2, project 3, and the semester project. They were labeled as PF1, PF2, PF3, and PFS.

QF was a survey asking for individual feedback about his/her learning experience while completing an online quiz. The format was similar to AF. Choices 1 to 5 were available. QF was used for each online quiz. Students indicated their preference of learning media once for each quiz as a whole. All the concepts of the course were rated by students as to their preferred medium preference either by AF or QF.

TF was a survey asking students' feedback about their learning experience while completing the paper-and-pencil end-of-modules tests and the final exam. The format was similar to AF. Choices 1 to 5 were available. Students indicated their preference of learning media for each test item. Each test item was related to a concept of the course content. TF was used for test 1, test 2, test 3 and the final exam. Each item in test 1, test 2 and test 3 addressed different concepts of the course. The final exam addressed all the concepts in the entire course.

These research instruments were used to answer the research sub questions as follows:

Table 7

Relation of Research Instruments and Research Sub Questions

Research Sub Question	Instrument used
Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in doing homework assignments?	AF
Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in taking quizzes?	QF
Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in taking tests?	TF
Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in doing projects?	PF
Are there any differences in students' preferred learning media between the treatment and the control groups for different mathematical concepts?	AF, QF, TF, PF
How do the students describe their choices of preferred learning media when completing mathematics projects?	PF

Note. AF = Assignment Feedback; QF = Quiz Feedback; TF = Test Feedback; PF = Project Feedback.

Data Collection Procedure

Data were collected from the individual through verbal and written forms throughout the entire semester. Observations were conducted each week during the face-to-face class meeting. All research instruments are provided in Appendix A.

During the 15-week semester, all students were asked to participate in the AF and QF while completing their assignments and quizzes respectively every week. At the end of each learning module, surveys were taken through PF1, PF2, PF3 and TF1, TF2, TF3, while students were completing their project and test respectively. At the end of the semester, students completed PFS while completing the semester project. During the final exam day, student completed TFF. Figure 7 shows the data collection procedure.

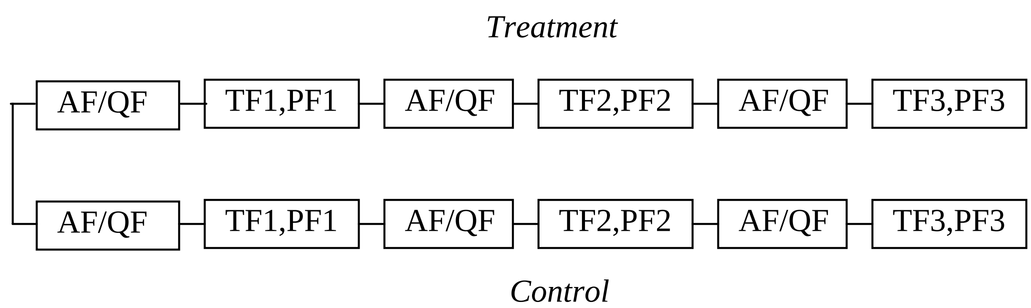

Figure 7. Procedure Flow Charts

Assumptions

This research assumed that:

1. The technical performance of the WebCT Vista 3.0 during the semester did not affect the students' choices of preference of studying mathematics.
2. Students adapted to the computer technique required in both the treatment and control groups during the semester.
3. The day of the week on which the course was taught is not a major factor.
4. Assignment Feedback (AF) measured the preference of learning media in completing the assignments in both the treatment and control group.
5. Quiz Feedback (QF) measured the preference of learning media in completing the quizzes in both the treatment and control group.

6. Test Feedback (TF) measured the preference of learning media in completing the tests and final exam in both the treatment and control group.

7. Project Feedback (PF) measured the preference of learning media in completing the projects in both the treatment and control group.

8. The students in the treatment and control group appeared to be the same as far as ability in mathematics is concerned.

9. The students in the treatment and control group appeared to be the same as far as ability in WebCT experience is concerned.

10. Subjects in this study are those who began and who completed the course. That is, only students who took the final exam in the course were included in the statistical analysis of the research.

11. Convenience sampling was used; therefore, the generalizations of the results from this study are limited to a group similar to the subjects used in this research. Other generalization may or may not apply.

Limitations

This research was constrained by the following:

1. The subjects who enrolled in the three designated sections of the Math 1101 course.

2. The number of students who selected to enroll in either the treatment group or the control group (self-selection).

3. The number of students who participated in the final exam. This is the students used in the statistical part of the study.

4. The number of students who turned in the research instruments.

Analysis

Data collected through WebCT Vista was retrieved and coded in an EXCEL spreadsheet. In addition, all the data from paper surveys were coded in the same EXCEL spreadsheet. Chi-Square contingency tables were used to analyze the data and compare responses from students in the treatment and the control groups.

All open-ended surveys were read. Characters were chosen according to the preferred learning media in order to get a more detailed understanding of the choice of learning media.

Summary

This study was quantitative in nature with some open-ended questions to understand the students' choices of preferred media learning preference. The study involved students enrolled in three sections of an Introduction to Mathematics Modeling course. Two sections were hybrid and one section was face-to-face with online enhancement. Data were collected through electronic survey and paper-and-pencil surveys. Chi-Square contingency tables were the major statistical analysis used in the study.

CHAPTER 4

RESULTS

This chapter reports the results of the study. The subjects from the treatment and the control groups were compared. Statistical analyses for research sub questions one to five are provided. Discussions of the research sub questions are given. Students' responses to the opened-ended questions are also presented.

Subjects

Initially, fifty students were enrolled in three sections of the Math 1101 course during Fall 2005. Thirty-one students were initially enrolled in the hybrid section, the treatment group, and nineteen students were initially enrolled in the face-to-face section with online enhancement, the control group. A total of thirty-five students took the final exam and completed the course, of which twenty students belonged to the hybrid section, the treatment group, and fifteen students were in the face-to-face section, the control group (See Table 9). There is not a significant difference between the treatment and the control groups as to the proportion of students who completed the course (Ho: $p_t = p_c$, $z = -1.08$, $p = .28$). The majority of the participants were female (See Table 10). There is not a significant difference between the treatment and the control groups as to the proportion of women who completed the course (H_0: $p_t = p_c$, $z = .893$, $p = .37$). Almost all of the participants identified themselves to be African American (See Table 11). There is not a significant difference between the treatment and the control groups as to the proportion of

African Americans (H_0: $p_t = p_c$, z = -.349, p = .73). A little more than half were younger than 22 (See Table 12). There is not a significant difference between the treatment and the control groups as to the proportion of students under 22 years of age (H_0: $p_t = p_c$, z = -.697, p = .49). The majority of the students did not have previous WebCT experience (See Table 13). There is not a significant difference between the treatment and the control groups as to the proportion of students' with no previous WebCT experience (H_0: $p_t = p_c$, z = .540, p = .59).

Table 8

Participants Distribution

Group	Enrolled	Completed
Treatment	31	20
Control	19	15
Total	50	35

Table 9

Gender Distributions of the Subjects

Group	Female	Male	Total
Treatment	16	4	20
Control	10	5	15
Total	26	9	35

Table 10

Race Distributions of the Subjects

Group	African	Caucasian	Others	Total
Treatment	18	1	1	20
Control	14	0	1	15
Total	32	1	2	35

Table 11

Age Distributions of the Subjects

Group	<22	22-35	>35	Total
Treatment	11	5	4	20
Control	10	3	2	15
Total	21	8	6	35

Table 12

Distributions of the Subjects' WebCT Experience

	Previous WebCT Experience		
Group	No	Yes	Total
Treatment	15	5	20
Control	10	5	15
Total	25	10	35

There seems to be no differences in the demographics of the treatment and the control groups. In addition, each group had the same instructor. Since there is a placement process in place, students may not enroll in this course unless they meet the placement criteria; therefore, the mathematical backgrounds of the students were approximately the same in each group. The statistical analysis of the research questions included responses from these thirty-five students who completed the course.

Research Questions

At the completion of the semester, data were transcribed into EXCEL. A copy of the data is in Appendix D. The statistical method of choice for Research Questions 1, 2, 3, and 4 is Chi-Square Contingency Tables to determine if there are differences in the distributions of responses between the treatment and the control groups. Since for a Chi-Square model, the expectation for each cell must be greater than or equal to 5 and the number of participants for the treatment and control group is twenty and fifteen respectively, the Likert scale needed to collapse as follows: "1" which represented exclusively face-to-face preference and "2" which represented mainly face-to-face and some online preference were collapsed to represent predominantly face-to-face style while "3" which represented both face-to-face and online are equally important, "4" which represented mainly online and some face-to-face preference and "5" which represented exclusively online preference were collapsed to represent at least half of the time online.

Research Sub Question 1

Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in doing homework assignments?

For this question, each assignment feedback (AF) was collapsed into two categories according to the above description, predominantly face-to-face and at least half of the time online. The count of the number of responses in each of the collapsed categories for the treatment and the control groups was placed in an EXCEL spreadsheet. Chi-Square values were calculated using TI-83 and the expected value of each cell was checked to determine if the matrix met the assumption, expected value in each cell must be at least 5.

Statistical Hypothesis 1.

There are no differences in the distribution of responses between the treatment and the control groups as far as homework assignments.

Table 13 shows the Chi-Square values and the p-values for the comparison of the distribution of responses between the two groups (treatment and control) and for each AF item from the data. There is insufficient evidence to reject Statistical Hypothesis 1. The results show that there is no significant difference between the treatment and control group among all the AF. Item A19 could not be used since the expectation values were too low.

Table 13

χ^2 Table of AF

Assignment	χ^2	p-value
A1	.27	.61
A3	.78	.38
A9	3.39	.06
A16	1.09	.29
A17	.35	.55
A19	4.07	.04[a]
A22	.01	.91
A25	1.97	.16

[a]Expected values were less than 5. E=4.29 and E=4.7.

Discussion of Research Sub Question 1

There is no difference between the treatment and the control groups according to the Chi-Square statistics. The data from the treatment and the control groups were combined for summary reporting. Table 14 shows the students' preference from the combined group. The top two choices from the students were exclusively face-to-face and equally important between face-to-face and online. The least likely choices are mainly online and some face-to-face and exclusively online.

Table 14

Distribution of AF for the Combined Group

Assignment	F	Fo	OF	Of	O	Total
A1	11	4	11	3	2	31
A3	10	5	11	3	2	31
A9	9	6	12	2	1	30
A16	7	7	15	1	0	30
A17	9	6	14	0	0	29
A19	7	2	11	1	0	21
A22	9	7	8	2	2	28
A25	9	4	7	3	0	23

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Research Sub Question 2

Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in taking quizzes?

For research sub question 2, each quiz feedback was collapsed into two categories according to the above description, predominantly face-to-face and at least half of the time online. The count of the number of responses in each of the collapsed categories for the treatment and the control groups was placed in an EXCEL spreadsheet. Chi-Square values were calculated using TI-83 and the expected value of each cell was checked to determine if the matrix met the assumption, expected value in each cell must be at least 5.

Statistical Hypothesis 2.

There are no differences in the distribution of responses between the treatment and the control groups as far as quizzes.

Table 15 provides the Chi-Square values and the p-values for each QF from the data. Significant differences were found in the distribution of responses in Q5. The treatment group preferred at least half of the time online and the non-treatment group preferred predominantly face-to-face style in Q5. There is sufficient evidence to reject the null hypothesis for quiz 5. All other distributions of responses in QF are not significantly different; that is, there is no significant difference between the treatment and the control groups.

Table 15

χ^2 Table of QF

Quiz Item	χ^2	p-value
Q1	2.61	.11
Q2	.01	.90
Q3	.14	.71
Q4	2.33	.13
Q5	4.37	.04[*]
Q6	2.79	.09
Q7	.12	.73
Q8	.06	.80
Q9	1.23	.26
Q10	.09	.76
Q11	1.64	.20
Q12	3.8	.05
Q13	1.89	.17
Q14	.36	.55
Q15	1.22	.27
Q16	.55	.46[a]
Q17	.09	.76

[a]Expected value was less than 5. E=3.9.

[*]$p<.05$.

Discussion of Research Sub Question 2

One should note that by chance alone, with 17 different Chi-Square test, one such evaluation will be significant. The significance level on the one significant result below is not high, indicating that this set of responses on quiz 5 might be attributed to chance and not a real difference between the two groups. Therefore, in general, there does not seem to be a real difference between the treatment and control groups when quizzes are involved. Table 16 shows the distribution of students' media preferences from the combined group. Most students chose exclusively face-to-face and an equal combination of face-to-face and online. Besides the above two choices, students preferred the mainly face-to-face and some online learning environment. Very few students chose mainly online and some face-to-face category. Only one student chose exclusively online.

Table 16

Distribution of QF for the Combined Group

Quiz item	F	Fo	OF	Of	O	Total
Q1	11	4	14	2	0	31
Q2	10	10	13	1	0	34
Q3	9	10	10	4	0	33
Q4	11	7	13	1	0	32
Q5	10	11	13	1	0	35
Q6	12	6	13	2	0	33
Q7	11	8	13	1	0	33
Q8	16	5	10	3	0	34
Q9	12	6	13	2	1	34
Q10	12	5	12	2	0	31
Q11	10	11	12	0	0	33
Q12	10	8	12	1	1	32
Q13	9	6	16	0	1	32
Q14	10	5	13	1	0	29
Q15	9	8	11	2	0	30
Q16	11	12	8	0	1	32
Q17	10	9	11	0	0	30

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Research Sub Question 3

Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in taking tests?

For this question, each test question from each end-of-module test and the final exam was collapsed into two categories as described previously, predominantly face-to-face and at least half of the time online. The count of the number of responses in each of the collapsed categories for the treatment and the control groups was placed in EXCEL spreadsheet. Chi-Square values were calculated using TI-83 and the expected value of each cell was checked to determine if the matrix met the assumption, expected value in each cell must be at least 5.

Statistical Hypothesis 3a.

There are no differences in the distribution of responses between the treatment and the control groups as far as each test item in test 1.

Table 17 records the Chi-Square values and the p-values for each TF from the Test 1. There is sufficient evidence to reject the null hypothesis for the significant Chi-Square Value. Significant differences were found in T1-1, T1-2, T1-3, T1-4, T1-6, T1-8, and T1-9.

Table 17

χ^2 Table of TF from Test 1

Test Item	χ^2	p-value
T1-1	3.86	.049*
T1-2	8.81	.003*
T1-3	10.59	.0011*
T1-4	5.66	.02*
T1-5	2.79	.094
T1-6	5.66	.02*
T1-7	2.34	.13
T1-8	8.81	.003*
T1-9	5.12	.02*
T1-10	1.91	.17

*$p < .05$.

Discussion of Research Sub Question 3a

Since seven of the ten sets of responses were significant, it seems clear that there is a real difference between the two groups as to the items on Test 1. In general, the treatment group preferred at least half of the time online and the control group preferred predominantly face-to-face style in all the above test items. Chi-Square Contingency Table of these items can be found in Appendix B. Table 18 shows that the treatment group favored the choice of equally important between the face-to-face and online while the control group favored the exclusively face-to-face choice.

Table 18

Distribution of TF for the Significant Items in T1

Test Item	F	Fo	OF	Of	O	Total
T1-1						
Treatment	4	3	11	0	1	19
Control	8	2	1	2	1	14
T1-2						
Treatment	3	2	12	1	1	19
Control	9	2	2	1	0	14
T1-3						
Treatment	4	3	11	0	1	19
Control	8	5	0	1	0	14
T1-4						
Treatment	3	4	10	0	2	19
Control	8	3	1	2	0	14
T1-6						
Treatment	4	3	11	0	1	19
Control	9	2	2	1	0	14
T1-8						
Treatment	3	2	13	0	1	19
Control	9	2	1	2	0	14
T1-9						
Treatment	5	1	11	1	1	19
Control	9	1	3	1	0	14

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

The null hypotheses were not rejected for item T1-5, T1-7, and T1-10. The distribution for the choice of media preferences of the combined groups is shown in Table 19. The top two choices of the media preferences were exclusively face-to-face and equally important between face-to-face and online. Some students preferred mainly face-to-face and some online. Very few preferred mainly online and some face-to-face, and exclusively online.

Table 19

Distribution of TF for the Combined Group for the Non Significant Items in T1

Test Item	F	Fo	OF	Of	O	Total
T1-5	11	7	11	3	1	33
T1-7	13	8	9	1	2	33
T1-10	15	4	9	4	1	33

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Statistical Hypothesis 3b

There are no differences in the distribution of responses between the treatment and the control groups as far as each test item in test 2.

Table 20 lists the Chi-Square values and the p-values for each TF from Test 2. No significant difference was found in any of the items between the treatment and the control groups. Therefore, there is insufficient evidence to reject the null hypothesis. T2-2 and T2-8 could not be used since the expectation values were too low.

Table 20

χ^2 Table of TF from Test 2

Test Item	χ^2	p-value
T2-1	2.56	.11
T2-2	.68	.41[a]
T2-3	1.94	.16
T2-4	1.94	.16
T2-5	3.8	.051
T2-6	1.51	.22
T2-7	2.79	.09
T2-8	1.17	.28[b]

[a]Expected value was less than 5. E=4.06. [b]Expected value was less than 5. E=4.4

Discussion of Research Sub Question 3b

Since the null hypotheses were not rejected for all the test items in Test 2, there does not seems to be a difference between the treatment and the control groups regarding Test 2. So, the data from both groups were combined. The combined distribution of students' media preference is shown in Table 21. Students favored the exclusively face-to-face learning environment the most. The second common choice was equally important between face-to-face and online. The third choice was mainly face-to-face and some online. The fourth choice was mainly online and some face-to-face. Only one student chose exclusively online in some items.

Table 21

Distribution of TF for Test 2 for the Combined Group

Test Item	F	Fo	OF	Of	O	Total
T2-1	17	5	8	1	1	32
T2-2	14	8	9	1	0	32
T2-3	16	4	9	3	0	32
T2-4	16	4	10	2	0	32
T2-5	13	5	13	1	0	32
T2-6	12	6	12	2	0	32
T2-7	15	4	13	0	0	32
T2-8	15	4	9	1	1	32

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Statistical Hypothesis 3c

There are no differences in the distribution of responses between the treatment and the control groups as far as each test item in test 3.

Table 22 shows the Chi-Square value and the p-value of each TF from the Test 3. Significant differences were found in T3-1, T3-2, T3-3, T3-4, T3-5a, T3-5c, and T3-5e. Therefore, the null hypothesis was rejected for each significant value. The Chi-Square Contingency Table of these items can be found in Appendix B.

Table 22

χ^2 Table of TF from Test 3

Test Item	χ^2	p-value
T3-1	5.6	.02*
T3-2	8.58	.003*
T3-3	6.37	.011*
T3-4	13.05	.0003*
T3-5a	4.38	.036*
T3-5b	3.3	.07
T3-5c	4.38	.036*
T3-5d	3.3	.07
T3-5e	4.38	.036*
T3-6	2.81	.09

*$p < .05$.

Discussion of Research Sub Question 3c

Seven out of ten sets of responses were significant indicating a real difference between the two groups. The treatment group preferred at least half of the time online and the control group preferred predominantly face-to-face style in all the above test items. The treatment group favored the choice of equally important between the face-to-face and online while the control group favored the exclusively face-to-face choice.

Table 23

Distribution of TF for the Significant Items in Test 3

Test Item	F	Fo	OF	Of	O	Total
T3-1						
Treatment	5	3	7	3	2	20
Control	11	1	2	1	0	15
T3-2						
Treatment	4	2	9	4	1	20
Control	10	2	1	1	1	15
T3-3						
Treatment	6	3	8	2	1	20
Control	11	2	2	0	0	15
T3-4						
Treatment	3	2	12	3	0	20
Control	11	2	1	0	1	15
T3-5a						
Treatment	5	4	7	4	0	20
Control	11	1	2	0	1	15
T3-5c						
Treatment	5	4	6	4	1	20
Control	9	3	3	0	0	15
T3-5e						
Treatment	6	3	8	2	1	20
Control	10	2	3	0	0	15

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

There is insufficient evidence to reject the null hypotheses for item T3-5b, T3-5d, and T3-6. Table 24 shows the choice of preferred learning media in the combined group for test 3. The top two choices of the media preferences for the combined group were exclusively face-to-face and equally important between face-to-face and online. Some students preferred mainly face-to-face and some online. Very few preferred mainly online and some face-to-face, and exclusively online.

Table 24

Distribution of TF for the Combined Group for the Non Significant Items in Test 3

Test Item	F	Fo	OF	Of	O	Total
T3-5b	15	7	9	3	1	35
T3-5d	18	4	9	3	1	35
T3-6	14	6	11	2	2	35

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Statistical Hypothesis 3d

There are no differences in the distribution of responses between the treatment and the control groups as far as each test item in the final exam.

Table 26 gives the Chi-Square values and the p-values for each TF from the final exam. Significant differences were found in FE7 and FE8. Therefore, the null hypothesis was rejected for these two. Chi-Square Contingency Tables for these items can be found in Appendix B.

Table 25

χ^2 Table of TF from Final Exam

Final Exam Item	χ^2	p-value
FE1a	.16	.69
FE1b	1.35	.24[a]
FE2	.01	.92
FE3	1.23	.26
FE4	.97	.32
FE5	.97	.32
FE6	3.84	.0501
FE7	4.64	.03*
FE8	5.04	.025*
FE9	3.84	.0501
FE10	3.84	.0501
FE11a	1.62	.20
FE11b,c	1.62	.20
FE12	.67	.41
FE13a	.01	.92
FE13b	.01	.92
FE13c	.01	.92
FE14a	.97	.32
FE14b	.97	.32
FE14c	.97	.32

[a]Expected value was less than 5. E=4.58.

*$p < .05$.

Discussion of Research Sub Question 3d

The distribution of students' preferred learning media is reported in Table 26. The treatment group generally preferred at least half of the time online and the control group preferred predominantly face-to-face style in FE7 and FE8. There is no difference between the treatment and the control groups. More specifically, most preferred learning media for the treatment group was equally important between the face-to-face and online learning environment. The most preferred learning media for the control group was exclusively face-to-face.

Table 26

Distribution of TF for the Significant Items in the Final Exam

Final Exam Item	F	Fo	OF	Of	O	Total
FE-7						
Treatment	3	3	10	2	2	20
Control	9	1	5	0	0	15
FE-8						
Treatment	4	3	8	3	2	20
Control	8	3	4	0	0	15

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Table 27 shows the distribution of the preferred learning media from the combined group. The most common two choices are exclusively face-to-face and equally important between face-to-face and online. Besides these two choices, the rest of the students preferred mainly face-to-face with some online learning environment. Very seldom, student chose exclusively online learning environment.

Table 27

Distribution of TF for the Combined Group for the Non Significant Items in the Final Exam

Final Exam Item	F	Fo	OF	Of	O	Total
FE1a	14	8	10	2	1	35
FE1b	14	11	8	1	1	35
FE2	11	12	12	0	0	35
FE3	13	9	11	2	0	35
FE4	13	7	13	2	0	35
FE5	13	7	11	3	1	35
FE6	12	7	13	2	1	35
FE9	13	6	13	2	1	35
FE10	12	7	12	3	1	35
FE11a	13	6	14	2	0	35
FE11b,c	11	8	14	2	0	35
FE12	11	12	10	2	0	35
FE13a	14	9	10	2	0	35
FE13b	17	6	10	2	0	35
FE13c	17	6	10	2	0	35
FE14a	16	4	13	2	0	35
FE14b	15	5	13	2	0	35
FE14c	15	5	13	2	0	35

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Research Sub Question 4

Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in projects?

For this question, each project feedback was collapsed into two categories according to the previous description, predominantly face-to-face and at least half of the time online. The count of the number of responses in each of the collapsed categories for the treatment and the control groups was placed in EXCEL spreadsheet. Chi-Square values were calculated using TI-83 and the expected value of each cell was checked to determine if the matrix met the assumption, expected value in each cell must be at least 5.

Statistical Hypothesis 4

There are no differences in the distribution of responses between the treatment and the control groups as far as projects.

Table 28 shows the Chi-Square value and the p-value of each PF. No significant difference was found in all the items between the treatment and the control groups Therefore, there is insufficient evidence to reject the null hypothesis.

Table 28

χ^2 Table of PF

Project Feedback	χ^2	p-value
PF1	2.89	.09
PF2	2.73	.10
PF3	.19	.66
PFS	.03	.85

Discussion of Research Sub Question 4

According to the Chi-Square statistics, the treatment and the control groups had no differences in their choice of learning environments when engaged in projects. These two groups of data were combined. The distributions of the students' choices are shown in Table 29. Among the five choices, students preferred the exclusively face-to-face learning environment and equally important between the face-to-face and online learning environment.

Table 29

Distribution of PF for the Combined Group

Project Feedback	F	Fo	OF	Of	O	Total
PF1	15	10	11	3	0	29
PF2	10	6	11	1	0	28
PF3	9	7	12	0	0	28
PFS	9	7	14	1	0	31

Note. F = exclusively Face-to-Face. Fo = mainly Face-to-Face and some online. OF = Online and Face-to-Face being equally important. Of = mainly Online and some Face-to-Face. O = exclusively Online.

Research Sub Question 5

Are there any differences in students' preferred learning media between the treatment and the control groups for different mathematical concepts?

For this question, mathematical concepts used in each learning module were matched to different tasks: homework assignments, quizzes, and tests. The relation between each task and the concept taught is shown in Table 30. LM2-LM11 represents concepts taught in the Linear Module. The Symbol LM stands for linear module and the number represents the section in the Table of Contents for the Linear Model. The Table of Contents for the Linear Model is listed in Appendix C. EM4-EM10 represents concepts taught in the Exponential Model. The symbol EM indicates these concepts came from the Exponential Model. The proceeding number represents the section in the Table of Contents for the Exponential Module. The Table of Contents for the Exponential Model is listed in Appendix C. QM3-QM10 represents concepts taught in the Quadratic Model. The symbol QM indicates that these concepts came from the Quadratic Model. The number represents the section in the Table of Contents for the Quadratic Model. The Table of Contents for the Quadratic Model is also listed in Appendix C.

Table 30

Concepts Taught in the Course

Concept Label	Concepts	AF	QF	TF
LM2	Visualizing Two Variable Data	A1		T1-1, FE1a
LM3	Identify Function		Q1	T1-3, FE2
LM4	Function Notation	A3		T1-2, T1-4, FE2, FE1b
LM5	Average Rate of Change		Q2	T1-5
LM6	Slope Intercept Form		Q3	T1-7, FE11a
LM8	Interpret Initial Value and Average Rate of Change		Q4	T1-6, FE11b
LM9	Graph of Linear Function		Q5	T1-8, FE9
LM10 LM12	Finding Linear Model from Data	A9	Q7	T1-10, FE14a
LM11	Find Points of Intersection		Q6	T1-9, FE 11c
EM4	Basic Properties about Exponents		Q8	T2-1
EM5	Graph of Exponential Function		Q9	T2-2, FE10
EM6	Finding Exponential Equation from Two Given Points	A16	Q10	T2-3, FE4
EM7	Interpret Initial Value and Percent o Change	A17	Q11	T2-5
EM8	Solve Exponential Function with Unknown Exponents		Q12	T2-4
EM9	Finding Exponential Model from Data	A19		T2-8, FE14b
EM10	Finding Accumulate Value After t Years Finding Time for Doubling		Q13	T2-7
QM3	Identify Vertex and Line of Symmetry from the Graph	A22		T3-4
QM4	Finding Quadratic Equation in Vertex Form from a Given Graph			T3-4, FE6
QM5	Graph of Quadratics Function		Q14	T3-1, FE8
QM6	Convert Vertex Form to Standard Form		Q15	T3-2, FE7
QM7	Finding Quadratic Model from Data	A25		T3-6, FE14c
QM8	Finding x-Intercepts, Max/Min, Intersections		Q16	T3-5, FE12a, b,c
QM9	Graph Quadratic Equation with an Appropriate Window		Q17	T3-3

Statistical Hypothesis 5a

There are no differences in the distribution of responses between the treatment and the control groups as far as each mathematical concept taught in the Linear Model.

The Chi-Square statistics for AF, QF and TF from the previous sections were reorganized and grouped into mathematical concepts. Table 31 shows the Chi-Square values and the p-values for each concept taught in the Linear Model. Significances were found in test items related to concepts LM2, LM3, LM4, LM8, LM9, and LM11 in TF for test one. Therefore the null hypotheses are rejected for these items. No significant differences were found on the same math concepts when using AF, QF or TF for the final exam. For concepts LM5, LM7, and LM10/LM12, all research instruments consistently show no significant difference. Therefore, there is insufficient evidence to reject the null hypothesis.

Table 31

χ^2 Table of Linear Module Grouped by Concepts

Instruments	χ^2	p-value
LM2		
A1	.27	.61
T1-1	3.86	.049*
FE1a	.16	.69
LM3		
Q1	2.61	.11
T1-3	10.59	.0011*
FE2	.01	.92
LM4		
A3	.78	.38
T1-2	8.81	.003*
T1-4	5.66	.02*
FE1b	1.35	.24
FE3	1.23	.26
LM5		
Q2	.01	.90
T1-5	2.79	.09
LM6		
Q3	.14	.71
T1-7	2.34	.13
FE11a	1.62	.20
LM8		
Q4	2.33	.13
T1-6	5.66	.02*
FE11b	1.62	.20
LM9		
Q5	4.37	.04
T1-8	8.81	.003*
FE9	3.84	.0501

Table 31 (continued)

χ^2 Table of Linear Module Grouped by Concepts

Instruments	χ^2	p-value
LM10 or LM12		
Q7	.12	.73
A9	3.39	.06
T1-10	1.91	.17
FE14a	.97	.32
LM11		
Q6	2.79	.09
T1-9	5.12	.02*
FE11c	1.62	.20

[a] Expected value was less than 5. E=4.58.

*$p < .05$.

Discussion of Research Sub Question 5a

Six out of nine measured concepts have some significant differences in some instruments. For each of these concepts, approximately 33% to 40% of the Chi-Square statistics show significant differences. These are not strong evidences to conclude that preferred learning media are dependant on mathematical concepts taught in the linear module.

Statistical Hypothesis 5b

There are no differences in the distribution of responses between the treatment and the control groups as far as mathematical concepts taught in the Exponential Model.

Table 32 shows the Chi-Square value and the p-value for each concept taught in the Exponential Model. No significant differences were found for any of these items, representing concepts taught in the Exponential Model. Therefore, there is insufficient evidence to reject this null hypothesis in all concepts taught in the Exponential Module.

Table 32

χ^2 Table of Exponential Module Grouped by Concepts

Instruments	χ^2	p-value
EM4		
Q8	.06	.8
T2-1	2.56	.11
EM5		
Q9	1.23	.26
T2-2	.68	.41[a]
FE10	3.84	.0501
EM6		
Q10	.09	.76
A16	1.09	.29
T2-3	1.94	.16
FE4	.97	.32
EM7		
Q11	1.64	.2
A17	.35	.55
T2-5	3.8	.051
EM8		
A19	4.07	.04[b]
T2-8	1.17	.28[c]
FE14b	.97	.32
EM9		
Q12	3.8	.051
T2-4	1.94	.16
EM10		
Q13	1.89	.17
T2-6	1.51	.22
T2-7	2.79	.09
FE12	.67	.41

[a]Expected value was less than 5. E=4.06. [b]Expected value was less than 5. E=4.29.

[c]Expected value was less than 5. E=4.4.

Discussion of Research Sub Question 5b

All the Chi-Square Models used in the exponential modules show no significant differences. Therefore, one can conclude that there are no differences in the distribution of responses between the treatment and control group regarding the concepts taught in the exponential module.

Statistical Hypothesis 5c

There are no differences in the distribution of responses between the treatment and the control groups as far as mathematical concepts taught in the Quadratic Model.

Table 33 shows the Chi-Square value and the p-value of each concept taught in the Quadratic Module. Significant differences were found in both test item and final exam item on QM5 and QM6. Significant differences were only found in test item related to concepts QM3/QM4, QM8, and QM9. No significant differences were found on the same item in the final exam. In addition, no significant differences were found in QM7 across all instruments. Therefore, the null hypothesis was rejected for significant concepts as indicated.

Table 33

χ^2 Table of Quadratic Module Grouped by Concepts

Instruments	χ^2	p-value
QM3		
A22	.01	.91
QM4		
T3-4	13.05	.0003*
FE6	3.84	.0501
QM5		
Q14	.36	.55
T3-1	5.60	.02*
FE8	5.04	.025*
QM6		
Q15	1.22	.27
T3-2	8.58	.003*
FE7	4.64	.03*
QM7		
A25	1.97	.16
T3-6	2.81	.09
FE14c	.97	.32
QM8		
Q16	.55	.46 [a]
T3-5a	4.38	.036*
T3-5b	3.30	.07
T3-5c	4.38	.036*
T3-5d	3.30	.07
T3-5e	4.38	.036*
FE13a	.01	.92
FE13b	.01	.92
FE13c	.01	.92
QM9		
Q17	.09	.76
T3-3	6.37	.011*

[a] Expected value was less than 5. E=3.9.

Discussion of Research Sub Question 5c

For concepts QM5 and QM6, two out of three Chi-Square values are significant. In the hybrid format of this course, students were responsible to learn these two sections using the online resources. These two sections were not designed to be a part of the face-to-face in-class materials. Concepts taught in these two sections were Graph of Quadratic Function and Converting Vertex to Standard Form.

For concepts QM3/4, QM7, QM8, and QM9, approximately 30% of the Chi-Square statistics show significant differences. For concept QM7, none of the Chi-Square statistics show a significant difference. Therefore, there are no differences in students' preferred learning media between the treatment and the control groups for different mathematical concepts in the Quadratic Model.

Research Sub Question 6

How do the students describe their choices of preferred learning media when completing mathematics projects?

All the completed research instruments were read. The results are presented in the following five different sections.

Voices from Those Not Completing the Course

There were four different out-of-class projects assigned during the semester. It was each student's prerogative to complete each project as an individual or with a group. After completing each project, each student was required to complete the project feedback form individually.

Three students who did not complete the course had submitted some of the project feedback forms. All three students were female. These students' data were not included in the statistical analysis in the previous questions. A code was used to report students' feedback for the open-ended questions. The prefix ST represents a student in the treatment group – the hybrid course. The prefix SC represents a student in the control group – the face-to-face course with online enhancement. The proceeding number is a random number assigned within each group.

SC02 is an African American female between the ages of 17-22. She is single, without any children, and works 20 hours per week. She had some previous WebCT experience and was comfortable using WebCT on her own. She had a computer with dial-up Internet service at home, however she did not have any experience using mathematics software in studying mathematics. SC02 always sat towards the back of the room with people surrounding her. She was an attentive student, but when called on to answer questions in class, she was not very self-confident. Sometimes, she would respond by asking questions to clarify the original question. Her thoughts were very logical. However, she never volunteered to answer any question in class. On the first project feedback, she wrote:

> Algebra is a particularly challenging course for me. I have to actually view the instructions and have immediate assistance, if I encounter a problem. For this project, as well as other assignments, I had to visit the ISS lab. There, I received face-to-face instructions on how to finish the task. Exclusive face-to-face learning is the best choice for me.

On the second project feedback, she wrote:

> Algebra is a hard course; therefore, I need face-to-face support. Because I was absent one week, it damaged my grade. I need extra help; I will see you later.

She never came back to class after turning in the second project.

SC08 is an African American female, single, without any children. She was not working when she started the semester. She had no previous WebCT experience but believed that she could handle the computer portion of the course. She had a computer at home and DSL Internet connection. She had not used any computer software to study mathematics before. SC08 sat in the middle of the classroom by herself. If her seat was taken, she would choose an unoccupied table close by. She was very shy and quiet. On the first project feedback, she wrote:

> I prefer face-to-face learning environment because the lesson is explained more thoroughly and more in depth. I am really not someone who is technology advance so face-to-face is my preference.

ST16 is an African American female; her age was between 17 and 22. She was single without any children, and worked 40 hours per week. She had no previous WebCT experience. ST16 had a computer with DSL Internet connection at home and did not have any experience with using math software to study mathematics. She chose to take the hybrid course because she wanted to have a better understanding of the course material in addition to saving time and gas. She was frequently absent from the class meetings. However, she was consistent in sending an email during the first two months. If there were any assignments that needed to be turned in while she was absent, then her email would indicate that the assignment was on its way to my office. She kept her promise; her assignment always found their way to my office, even on the days that she was absent from class. She completed 15 of the 17 online quizzes. On the second project feedback, she wrote:

> I prefer mainly face-to-face and some online because it give me a chance to learn the information on my own and then it gives me a chance to ask questions and get a better understanding of what I learned on my own. It also allows me to learn and ask question on all the things that I could not figure out by myself.

Voices from Those Who Consistently Chose Predominantly Face-to-Face Learning Style

Among the thirty-five students who completed the course, seven students consistently indicated that they preferred either an “exclusively face-to-face” learning environment or a “mainly face-to-face with some online” learning environment. More than ninety-five percent of the responses fell into these two categories. In the earlier statistical analysis, these two types were collapsed to indicate predominantly face-to-face learning style. Two of these students were in the treatment group and five of these students were in the control group.

ST10 is an African American female between the ages of 17 to 22; she was single without any children. She did not have computer and Internet access at home. She had no experience with WebCT. She was also not working. ST10 was a very vocal person in class. She did not give a reason as to why she chose to take the hybrid course. When asked directly about her choice in registering for the hybrid course, she acknowledged that she was not aware of the hybrid format of the course until the first day of class. However, if there were something she did not understand, she always got the instructor’s attention. She sat in the front row of the classroom where the instructor had easy access to her and could see her work. During the third week of class, she even found out the meeting time and classroom of the face-to-face section of this course. She came to the face-to-face class and sat at the back of the room. When the instructor noticed her sitting in another class, she admitted that she needed more class time to digest the material, especially those materials that she was held accountable for online. The class, however, did not go over the online class material as she had expected. She wrote on her project feedbacks:

PF1: I can learn better by talking to someone face-to-face.

PF2: Face-to-face cause I can learn better face-to-face.

PF3: I am a visual learner so I need exclusively face-to-face

PFS: I can learn, and understand face-to-face better than online are any other way.

ST01 is a single African American female between the ages of 17 to 22 without any children. She had previous experience with WebCT and was very comfortable using it. She had a computer with DSL Internet access at home. She was not working. She did not write down her reason for choosing the hybrid course. She was a very verbal person in class, and liked to answer questions. She sat in the middle of the front row. If the instructor stood in front of the classroom, she was the first person that would be seen. A week before the first test, she began going to the instructor's office every Friday. She brought her homework or project in to either ask question or to make sure that her work was correct. She wrote on her project feedback:

PF1: I am a visual learner and I learn best when I am face-to-face, because if I have any question, I can get them answered instead of waiting.

PF2: I prefer exclusively face-to-face because I am a visual learner and need to speak to the professor.

PF3: I am a visual learner so I need exclusively face-to-face.

PFS: I am a visual learner so I need face-to-face. I learn better when I speak to an Instructor.

Voices from Those Who Consistently Chose At Least Half of the Time Online

SC05 is a middle-age African American female. She is married and has two children. She had no previous experience using WebCT. She had a computer at home and had dial-up Internet service. She always dressed professionally, with matching hat. During the first week of class, she always came late and sat at the back of the room. She was intimidated by the forms of technology used in the class, and was not very confident in her mathematics skills. She attempted to drop the class after the add-drop period. The office of Academic Counseling recommended her to speak to the instructor and face the problem. At the end of second week, she followed up the recommendation. After that, she sat in the middle towards the front of the classroom. Even when she was late, SC05 would walk to the front and sit there, listening attentively. She was very studious, and she began to ask questions after class, and later, during class. She tried her very best to strive for success in the class. Her written responses are as follows:

> PF1: The reason for choosing both face-to-face and online is because I am not quite yet comfortable with using the computer. I have to admit the more I use it the more I like it. But I also like being able to ask a person questions if I need to do so that they can show me how they derive with the answer to the problem that I am having a challenge with.
>
> PF2: It works better for me when I have someone to explain the problem to show me how to do it then I can work on my own on the computer.
>
> PF3: The more I use the computer online, the more comfortable I become but it still does not take place of a face-to-face learning experience for me. I still need someone to explain and demonstrate for me.
>
> PFS: I need both and it worked for me.
>
> .

Emerging Themes for the Predominantly Face-to-Face Learning Style Students

There are three themes that emerged from the students who preferred predominantly face-to-face learning style. First, students believe that learning primarily took place in a physical setting.

> ST10: I can learn better by talking to someone face-to-face.
>
> SC03: I believe in the face-to-face education, especially math because I like to ask questions and write it down.
>
> SC09: I like face-to-face better. I learn a lot better with you explaining face-to-face. I understand better.
>
> SC10: I'm more comfortable learning face-to-face. I feel I learn better when I'm being taught face-to-face rather to learn on my own. When I learn face-to-face it gives me a better understanding on the subject and if I have any questions someone is there to answer. I also understand more on the subject if someone is there to show me step-by-step how to do a problem.
>
> SC12: I would much rather do everything face-to-face. Doing things face-to-face gives me a better understanding of the assignment, because it would allow me to ask questions.
>
> SC15: As I stated earlier, math is not one of my strong subjects. It can be very frustrating at times because it usually takes me longer to learn math than most students. One way, I am sure to learn and comprehend math is if I know there is someone directly in front of me in case I need to ask question. This way there is some on there to break down the assignment when I need help.

Secondly, learner-content interaction came from learner-instructor interaction and learner-tutor interaction. Human contact made learning take place.

> SC01: I truly feel comfortable if the professor shows me how to work the problems.
>
> SC03: I like hearing the explanation from the Professor; that helps me understand the problems better.
>
> SC09: I like face-to-face better. I learn a lot better with you explaining face-to-face. I understand better.

> SC15: Math is not one of my best subjects. Therefore, it takes me longer to learn math than others. I benefit more when there is someone there to break it down in ways I can understand. This is something I gained from going to the ISS lab. I also learn well in class as long as I ask questions when I am confused.

Thirdly, online material was used as a reference or backup resource. Students express themselves in the following ways:

> SC07: Everything on Quadratic was pretty straight forward, so there was no need to use online work. Most of the issues that I had were dealt with in the class.

> SC07: Throughout the semester, I have been consistent in achieving the necessary methods to make this class a success. Mainly face-to-face but a few things I was doubtful about, I seek to obtain the information on the Internet.

> SC17: The face-to-face is very helpful but the online material adds an extra touch.

Emerging Themes for the At Least Half of the Time Online Learning Style Students

There are four themes that emerged from students who preferred at least half of the time online. First, online material provided the basic resource for the subject matter that they studied.

> ST06: Of all the options that I have had to explore in my Mathematical Modeling class, I really enjoyed the videos. They gave me a better opportunity to see the step by step process needed to analyze the word problems and also help me to understand the steps.

> ST07: Both ways were useful in doing this project. However, the online gives more information needed and the face-to-face help explain what was not very cleared.

> ST11: In doing this semester project both the face-to-face and the online material were both equally important. The online material was my guideline for the semester project. The face-to-face approach was beneficial because when some problems don't make sense to me, I can get it cleared up by asking questions in the face-to-face session and see the problem work out.

Secondly, the online material was available at anytime and anywhere, at the student's convenience. The following comments were made:

> ST06: The online lesson and exercises allow me to review the material as many times as I needed

> ST20: I would prefer a combination of face-to-face and online learning. As an adult, online learning has been very beneficial to me. It has allowed me to learn at home while also spending time at home with my children and husband. Online learning has given me the opportunity to learn the information presented online at my own pace. Face-to-face learning has also given me the opportunity to listen to the instructor to find a better solution to solving problems.

Thirdly, the online learner-content interaction and the in-class learner-instructor interaction went hand-in-hand in the understanding of mathematics.

> ST02: I believe that receiving help from both online materials and face-to-face aided me in completing this project. Due to the fact that I pay very close attention in class I was able to remember what I was taught and refer to the class discussion. Also if there was a problem that I did not understand I was able to go back and use the online notes and the notes I took in class to finish my assignment.

> ST05: I would have to say that learning this material was through face-to-face and online. The online help gave me the basic concept while the face-to-face gave me the break down of what to do.

> ST05: The online information gave me better understand of the concept that we went over while in class. The face-to-face work also helped me by Mrs. Her's explanation of the entire concepts.

> ST06: Of all the options that I have had to explore in my Mathematical Modeling class, I really enjoyed the videos. They gave me a better opportunity to see the step by step process needed to analyze the word problems and also helped me to understand the steps. Ms. Her's in class presentation gave me an opportunity to ask question and solidify what I learn.

> ST11: Both face-to-face and online materials were helpful to me. I can figure out a lot of the solutions by using the online material provided inside the WebCT. So if I have any problems that I can't get, that's when the face-to-face approach comes along and I can ask questions to clarify my problems.

> ST20: I find both very helpful in each unit. Online videos help to reinforce what I learned in class.

Lastly, learner-learner interaction also contributed to the understanding of mathematical concepts.

> ST02: This project was very easy. Having already known how to use quadratic equations and how to solve them, it helped me be able to understand how to figure out the problems. With the help of my notes and my friends I was able to accomplish this project. But I also used my own knowledge.
>
> ST05: Working in a group with my group members also gave me a better understanding of the concept.

Summary

This chapter contains the results and findings of the study by answering each of the research sub questions. When students engaged in tests, significant differences were found in the test on Linear Models and the test on Quadratic Models. Students enrolled in the hybrid learning environment preferred online learning at least half of the time. Students enrolled in the face-to-face learning environment preferred predominantly face-to-face learning. Through the distribution of the preferred learning environment, the majority of the students in the hybrid chose as equally important between face-to-face and online, while the majority of the face-to-face students chose exclusively face-to-face learning environment.

There were no significant differences in students' preferred learning media when engaged in homework assignments, online quizzes, and projects. There were no significant differences in students' preferred learning media for different mathematical concepts. Through the distribution of students' choice of learning media, the majority of the students chose either exclusively face-to-face or equally important between face-to-face and online. Rarely did students chose exclusively online learning environment.

In addition, students who consistently chose the predominantly face-to-face learning style, and at least half of the time online learning style, were presented. Emerging themes for the above learning styles were also discussed. The open-ended written responses provided some information on learning preference for some individuals who did not complete the course.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

This chapter summarizes the hybrid learning design and the research questions addressed in this study, the methodologies utilized to carry out the study, and the analysis of data. This chapter also provides the conclusions found along with a discussion of recommendations for further research in the area of hybrid learning at the college level.

Summary

The purpose of this study was to better understand students' preferred media learning in a beginning collegiate level mathematics course for non-mathematics and non-science majors. A pilot study was conducted to refine the research instruments, further identify the subjects being studied, and aid the fine-tuning of the data collection process in the final study.

The participants of the final study were enrolled in three different sections of Introduction to Mathematical Modeling in a two-year public college in the southeast. This research study was conducted at a predominantly African American campus. Two sections of Mathematical Modeling were taught in the hybrid environment, and one section was taught in the face-to-face environment with online enhancement. Both used the identical WebCT Vista template. The researcher taught all three of the sections. The theoretical framework underlying the present study focused on transactional distance theory and engagement theory.

Transactional distance theory suggests that three main interactions affect learning. They are learner-content interaction, learner-instructor interaction, and learner-learner interaction. The WebCT Vista template used in this study was designed to increase learner-content interaction through online learning media.

Engagement theory emphasizes the use of meaningful activities from the students' perspective. In designing this course, one of the goals was to help the non-mathematics and non-science majors apply the mathematics they learned to their disciplines. This course used group or individual projects to encourage students to connect mathematical phenomena to other subjects that may be of interest to them.

The WebCT Vista template used in this study is a product of the college hybrid fellowship project which earned the Board of Regents 2004 Best Practice Award in Academic Affairs. Both designers of the course were selected to be the hybrid fellows. The Math 1101 WebCT Vista course was designed to engage students' learning with the appropriate use of technologies in homework assignments, projects and quizzes. In addition to the printed material, the template also included streaming media files to increase student-content interaction. Students were required to complete quizzes online at their convenience but before a predetermined deadline. Students took tests and the final exam in a classroom environment using the paper-and-pencil format.

The main research question of this study was: Is there a difference in preferred learning media between the students enrolled in the hybrid course and the students enrolled in the face-to-face course with online enhancement? In addition to the main research question, six research sub-questions were developed:

1. Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in doing homework assignments?
2. Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in taking quizzes?
3. Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in taking tests?
4. Are there any differences in students' preferred learning media between the treatment and the control groups when engaged in doing projects?
5. Are there any differences in students' preferred learning media between the treatment and the control groups for different mathematical concepts?
6. How do the students describe their choices of preferred learning media when completing mathematics projects?

Quantitative research methodologies, mainly Chi-Square analyses, were utilized in the final study to analyze the data related to research questions one through five. The comparability between the treatment and the control groups were established by statistical tests through different factors such as completion rate, gender, ethnicities, age, and previous WebCT experience. Students' written responses to open-ended questions in project feedback were used to interpret the result for research sub-question six.

Conclusions

The research data show there are no differences in students' preferred learning media between the hybrid students and the face-to-face students when engaged in doing homework assignments, taking quizzes, or doing projects. The study also shows that no preference exists in learning a particular concept.

According to the data, significant differences between the students enrolled in the hybrid learning environment and the students enrolled in the face-to-face learning environment were found in the end-of-the-module tests on linear models and quadratic models. There were no differences found in the students' preferred learning media in these two groups for all other aspects examined. All significant difference items showed a consistent result. In this study, students selected their learning environment at the time of registration. Although the majority of the research instruments showed no significant difference, the results show that more hybrid students selected online and face-to-face learning as being equally important; and the face-to-face students selected exclusively face-to-face and mainly face-to-face with some online learning. That is, students enrolled in the hybrid learning environment preferred online learning at least half of the time, while students enrolled in the face-to-face learning environment preferred the predominantly face-to-face learning style.

Historically, the completion rate of solely online courses is always lower than the face-to-face course in this institution. However, this study found that while not all participating students knew their preferred learning media before entering into the course, there was no significant difference between the proportion of students who completed the course in the hybrid setting and in the face-to-face setting of the Introduction to Mathematical Modeling course. Compared to the face-to-face format of the course, the hybrid course met only half of the time on-campus. Students in the hybrid course used the same evaluation methods as the face-to-face course with online enhancement. So, the completion rate of this hybrid course and face-to-face course are similar. Therefore, this study suggests that institutions should consider offering hybrid courses instead of totally online courses in mathematics.

From the distribution of the students' preferred learning environments, students consistently gave preference to the exclusively face-to-face learning environment or the hybrid environment where online interactions replaced half of the face-to-face classroom interactions. In addition, for items showing significant differences between the treatment and control group, a majority of the students in the treatment group chose the hybrid environment where online interactions replaced half of the face-to-face classroom interactions, while the majority of the control group chose exclusively face-to-face. This indicated that students might already know which learning environment was best for them when they registered for the course. Therefore, they self-selected into a certain learning environment. According to the data, it seems that students do not believe that a freshman mathematics course could be learned in a completely online environment.

When grouping the Chi-Square statistics according to mathematical concepts taught in the class, no particular learning media was preferred for a particular concept. Two concepts showed significant differences in both the end-of-the module test and the final exam. They were QM5- Graph of Quadratic Functions and QM6- Converting Vertex Form to Standard Form. Other concepts in the end-of-the-module test indicated significant difference; however, there were no significant differences in the corresponding sections on the final exam. Therefore this study found that no particular concept is needed to be taught totally face-to-face or totally online. Each online lesson for the hybrid course was carefully chosen and presented by WebCT template designers with many years of teaching experience. This study also confirms that those mathematics concepts could be learned through online learning media.

The result of the exponential end-of-module test was different from the linear and quadratic end-of-module tests. Hybrid students preferred at least half of the time online and the face-to-face students preferred predominately face-to-face when completing the linear and quadratic tests. Over time, these differences did not uphold. Based on the final exam feedback on the similar test items, this preference no longer existed. According to the researcher’s experience, students at this level are more familiar with the content in the linear module and quadratic module. This might suggest that hybrid students initially preferred learning familiar topics through a mixture of face-to-face and online learning environments with online learning being at least half of the time. However, during the final phase of the course, these students preferred predominately face-to-face learning environment. This might suggest that students expected a more precise review of the entire course that is tailored to their individual need.

Through the project feedback from students, reasons for choosing predominantly face-to-face learning and online learning at least half of the time preference were analyzed. Students who preferred the predominantly face-to-face learning environment perceived that learning primarily took place in a physical setting. Excerpts taken from students' written responses indicated that learner-content interactions come from the learner-instructor and learner-tutor interactions. Online material was used as a reference or backup resource. Very few students mentioned that learner-learner interaction improved and sharpened their understanding in mathematics. This may be attributed to the students' learning experiences in environments where individual learning has been the norm.

According to transactional distance theory, students learn through interactions. Students who preferred an online learning environment at least half of the time believed that online resources provided basic information for the subject matter, which was available anytime and anywhere at their convenience. Students in this group viewed all components of transactional distance theory as important elements in their mathematics learning. These components are the online learner-content interaction, the in-class face-to-face learner-instructor interaction and learner-learner interaction. On the other hand, students who preferred predominately face-to-face did not distinguish among learner-content interaction with learner-instructor and learner-learner interactions.

This study was not intended to focus on African American students. However, the majority of the students in all three sections of Introduction to Mathematical Modeling were African American. Within current literature related to online learning environments, the research participants are primarily Caucasians (Burden, 2002; Hunhueon, 2002; May, 2002). Thus, the result of the study provides significant information on African American students' views on the use of educational technologies in learning mathematics.

Recommendations for Future Research

Technology has made a big impact in people's everyday lives. Even in the academic arena, technology has changed teaching and learning. At the campus on which this research took place, each classroom was equipped with at least one computer with

Internet accessibility. Technology does not change the knowledge, but it changes the way in which we acquire knowledge.

> Students' engagement with, and ownership of, abstract mathematical ideas can be fostered through technology. Technology enriches the range and quality of investigations by providing a means of viewing mathematical ideas from multiple perspectives. (NCTM, 2000, p.25)

The intent of this research study was to understand students' learning preference in reference to the learning environments in which they voluntarily enrolled. The following recommendations for future research were a result of this study:

1. The study was completed for only the face-to-face learning environment, with online enhancement, and the hybrid learning environment. A completely online learning environment was not included in the study. Further study should be implemented for all three learning environments that presently exist in college level mathematics courses.

2. The subjects of this study were predominantly African Americans; classes with students from diverse ethnic and racial backgrounds may be used in future studies. This study could serve to generalize learning preferences across different ethnicities.

3. The study was completed for one freshman mathematics course. Further studies should be implemented for different courses with different instructors. This study could serve to identify learning preferences across disciplines for collegiate freshman.

4. Time was not considered as a factor in this study. A time series analysis on students' learning preferences may be implemented in the future to investigate possible changes in students' learning preferences over prolonged time periods.

5. More sections of the Introduction to Mathematical Modeling course should be taught using the same WebCT Vista template in different learning environments. Increasing the number of participants would improve the statistical power of the tests that

are currently used in the study. In addition, with more participants, the data may be analyzed according to the five learning preferences as planned in the beginning of the study.

6. Overall performance of the course was not analyzed in this study because it was not included in the Intuitional Review Board (IRB) request. Course performance should be studied in the future because it is another important factor to be considered when comparing the two types of delivery for the course.

7. Time spent in the online environment from the treatment and control groups may be analyzed in the future. The actual time spent using WebCT might be a factor that influences students' preferred media choice.

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APPENDIXES

Appendix A

Survey of Media for Preferred Learning Mathematics
Assignment Feedback

After you complete each question in this assignment, indicate your preferred media for learning the mathematical concept for the entire assignment in the chart below. Circle **1**, **2**, **3**, **4**, or **5** in the feedback column. Use the guide below for **1**, **2**, **3**, **4**, or **5** to indicate your preferences.

1. Exclusively the **face-to-face** sessions were most useful in helping me to understand the mathematics content on this assignment.
2. Mainly the face-to-face session and some online material were useful in helping me to understand the mathematics content on this assignment.
3. The face-to-face session and the online material are equally importance in helping me to understand the mathematics content on this assignment.
4. Mainly the online material and some face-to-face session were useful in helping me to understand the mathematics content on this assignment..
5. Exclusively the **online** material was most useful in helping me to understand the mathematics content on this assignment.

	Feedback				
Entire Assignment	1	2	3	4	5

Survey of Media for Preferred Learning Mathematics

Quiz Feedback

After you complete each quiz question, indicate your preferred media for learning the mathematical concept for the entire quiz the chart below. Circle **1**, **2**, **3**, **4**, or **5** in the feedback column. Use the guide below for **1**, **2**, **3**, **4**, or **5** to indicate your preferences.

1. Exclusively the **face-to-face** sessions were most useful in helping me to understand the mathematics content on this quiz.
2. Mainly the face-to-face session and some online material were useful in helping me to understand the mathematics content on this quiz..
3. The face-to-face session and the online material are equally importance in helping me to understand the mathematics content on this quiz.
4. Mainly the online material and some face-to-face session were useful in helping me to understand the mathematics content on this quiz..
5. Exclusively the **online** material was most useful in helping me to understand the mathematics content on this quiz.

			Feedback		
Entire Quiz	1	2	3	4	5

Survey of Media for Preferred Learning Mathematics

Test 1 Feedback

After you complete each test question, indicate your preferred media for learning the mathematical concept for each test item in the chart below. Circle **1**, **2**, **3**, **4**, or **5** in the feedback column. Use the guide below for **1**, **2**, **3**, **4**, or **5** to indicate your preferences.

1. Exclusively the **face-to-face** sessions were most useful in helping me to understand the mathematics content for this question on the test.
2. Mainly the face-to-face session and some online material were useful in helping me to understand the mathematics content for this question on the test.
3. The face-to-face session and the online material are equally importance in helping me to understand the mathematics content for this question on the test
4. Mainly the online material and some face-to-face session were useful in helping me to understand the mathematics content for this question on the test.
5. Exclusively the **online** material was most useful in helping me to understand the mathematics content for this question on the test.

Question Number	Feedback				
Question 1	1	2	3	4	5
Question 2	1	2	3	4	5
Question 3	1	2	3	4	5
Question 4	1	2	3	4	5
Question 5	1	2	3	4	5
Question 6	1	2	3	4	5
Question 7	1	2	3	4	5
Question 8	1	2	3	4	5
Question 9	1	2	3	4	5
Question 10	1	2	3	4	5

Survey of Media for Preferred Learning Mathematics

Test 2 Feedback

After you complete each test question, indicate your preferred media for learning the mathematical concept for each test item in the chart below. Circle **1**, **2**, **3**, **4**, or **5** in the feedback column. Use the guide below for **1**, **2**, **3**, **4**, or **5** to indicate your preferences.

1. Exclusively the **face-to-face** sessions were most useful in helping me to understand the mathematics content for this question on the test.
2. Mainly the face-to-face session and some online material were useful in helping me to understand the mathematics content for this question on the test.
3. The face-to-face session and the online material are equally importance in helping me to understand the mathematics content for this question on the test
4. Mainly the online material and some face-to-face session were useful in helping me to understand the mathematics content for this question on the test.
5. Exclusively the **online** material was most useful in helping me to understand the mathematics content for this question on the test.

Question Number	Feedback				
Question 1	1	2	3	4	5
Question 2	1	2	3	4	5
Question 3	1	2	3	4	5
Question 4	1	2	3	4	5
Question 5	1	2	3	4	5
Question 6	1	2	3	4	5
Question 7	1	2	3	4	5
Question 8	1	2	3	4	5

Survey of Media for Preferred Learning Mathematics

Test 3 Feedback

After you complete each test question, indicate your preferred media for learning the mathematical concept for each test item in the chart below. Circle **1**, **2**, **3**, **4**, or **5** in the feedback column. Use the guide below for **1**, **2**, **3**, **4**, or **5** to indicate your preferences.

1. Exclusively the **face-to-face** sessions were most useful in helping me to understand the mathematics content for this question on the test.
2. Mainly the face-to-face session and some online material were useful in helping me to understand the mathematics content for this question on the test.
3. The face-to-face session and the online material are equally importance in helping me to understand the mathematics content for this question on the test
4. Mainly the online material and some face-to-face session were useful in helping me to understand the mathematics content for this question on the test.
5. Exclusively the **online** material was most useful in helping me to understand the mathematics content for this question on the test.

Question Number	Feedback				
Question 1	1	2	3	4	5
Question 2	1	2	3	4	5
Question 3	1	2	3	4	5
Question 4 a-d	1	2	3	4	5
Question 5a	1	2	3	4	5
Question 5b	1	2	3	4	5
Question 5c	1	2	3	4	5
Question 5d	1	2	3	4	5
Question 5e	1	2	3	4	5
Question 6	1	2	3	4	5

Final Exam Feedback

After you complete each test question, indicate your preferred media for learning the mathematical concept for each test item in the chart below. Circle **1**, **2**, **3**, **4**, or **5** in the feedback column. Use the guide below for **1**, **2**, **3**, **4**, or **5** to indicate your preferences.

1. Exclusively the **face-to-face** sessions were most useful in helping me to understand the mathematics content for this question on the test.
2. Mainly the face-to-face session and some online material were useful in helping me to understand the mathematics content for this question on the test.
3. The face-to-face session and the online material are equally importance in helping me to understand the mathematics content for this question on the test
4. Mainly the online material and some face-to-face session were useful in helping me to understand the mathematics content for this question on the test.
5. Exclusively the **online** material was most useful in helping me to understand the mathematics content for this question on the test.

Question Number			Feedback		
Question 1a	1	2	3	4	5
Question 1b	1	2	3	4	5
Question 2	1	2	3	4	5
Question 3	1	2	3	4	5
Question 4	1	2	3	4	5
Question 5	1	2	3	4	5
Question 6	1	2	3	4	5
Question 7	1	2	3	4	5
Question 8	1	2	3	4	5
Question 9	1	2	3	4	5
Question 10	1	2	3	4	5
Question 11a	1	2	3	4	5
Question 11b, c	1	2	3	4	5
Question 12 a-c	1	2	3	4	5
Question 13a	1	2	3	4	5
Question 13b	1	2	3	4	5
Question 13c	1	2	3	4	5
Question 14a	1	2	3	4	5
Question 14b	1	2	3	4	5
Question 14c	1	2	3	4	5

Project One Feedback

1. **Place a check beside each concept in the course that you used in developing and completing your project.**

________ Visualizing Two Variable Data
________ Identify Function
________ Function Notation
________ Average Rate of Change
________ Slope Intercept Form
________ Interpret Initial Value and Average Rate of Change
________ Graph of Linear Function
________ Writing Linear equation from word problems
________ Finding Points of Intersection
________ Finding Linear Model from Data

2. **Which approach to learning the concepts was most useful to you? Check one.**

__	Exclusively Face-to-face	__	Mainly Face-to-face and some online	__	Equally Important between Face-to-Face and Online	__	Mainly online and some Face-to-face	__	Exclusively Online

3. **Write a brief paragraph explaining your answer to question 2 above.**

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Project Two Feedback

1. **Place a check beside each concept in the course that you used in developing and completing your project.**

________	Basic Properties about Exponents
________	Graph of Exponential Function
________	Forms of Exponential Equations
________	Finding exponential equation from two given points
________	Writing Exponential equation from word problems
________	Identify Initial Value and Percent of Change
________	Solve Exponential Function with unknown exponents
________	Finding accumulate value in after t years
________	Finding time for doubling
________	Finding Exponential Model from Data

2. **Which approach to learning the concepts was most useful to you? Check one.**

__	Exclusively Face-to-face	__	Mainly Face-to-face and some online	__	Equally Important between Face-to-Face and Online	__	Mainly online and some Face-to-face	__	Exclusively Online

3. **Write a brief paragraph explaining your answer to question 2 above.**

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Project Three Feedback

1. Place a check beside each concept in the course that you used in developing and completing your project.

________	Identify Vertex and line of symmetry from the graph
________	Graph of Quadratic Function
	Convert vertex form to standard form
________	Finding quadratic equation from a given graph
________	Writing Quadratic Equation from word problems
________	Finding an Appropriate Window
________	Finding x-intercept
________	Finding max/min
_______	Finding intersection
_______	Finding Quadratic Model from Data

2. **Which approach to learning the concepts was most useful to you? Check one.**

__	Exclusively Face-to-face	__	Mainly Face-to-face and some online	__	Equally Important between Face-to-Face and Online	__	Mainly online and some Face-to-face	__	Exclusively Online

3. **Write a brief paragraph explaining your answer to question 2 above.**

Semester Project Feedback

1. **Place a check beside each concept in the course that you used in developing and completing your project.**

______	Visualizing Two Variable Data	_____	Identify Initial Value and Percent of Change
______	Identify Function	_____	Solve Exponential Function with unknown exponents
______	Function Notation	_____	Finding accumulate value in after t years
______	Average Rate of Change	_____	Finding time for doubling
______	Slope Intercept Form	_____	Finding Exponential Model from Data
______	Interpret Initial Value and Average Rate of Change	_____	Identify Vertex and line of symmetry from the graph
______	Graph of Linear Function	_____	Graph of Quadratic Function
______	Writing Linear equation from word problems	_____	Convert vertex form to standard form
______	Finding Points of Intersection	_____	Finding quadratic equation from a given graph
______	Finding Linear Model from Data	_____	Writing Quadratic Equation from word problems
______	Basic Properties about Exponents	_____	Graph quadratic equation with an appropriate window
______	Graph of Exponential Function	_____	Finding x-intercept
______	Forms of Exponential Equations	_____	Finding max/min
______	Finding exponential equation from two given points	_____	Finding intersection
______	Writing Exponential equation from word problems	_____	Finding Quadratic Model from Data

2. **Which approach to learning the concepts was most useful to you? Check one or both**.

__	Exclusively Face-to-face	__	Mainly Face-to-face and some online	__	Equally Important between Face-to-Face and Online	__	Mainly online and some Face-to-face	__	Exclusively Online

Please go to next page

3. Write a brief paragraph explaining your answer to question 2.

Appendix B

Chi Square Contingency Table for Quiz 5 on the QF

	Primarily Face-to-Face	At Least Half Online
Treatment	9	11
Control	12	3

Note. $\chi^2 = 4.37$, df = 1, p = .04.

Chi Square Contingency Table for Question 1 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	7	12
Control	10	4

Note. $\chi^2 = 3.86$, df = 1, p = .049.

Chi Square Contingency Table for Question 2 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	5	14
Control	11	3

Note. $\chi^2 = 8.81$, df = 1, p = .003.

Chi Square Contingency Table for Question 3 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	7	12
Control	13	1

Note. $\chi^2 = 10.59$, df = 1, p = .0011.

Chi Square Contingency Table for Question 4 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	7	12
Control	11	3

Note. χ^2 = 5.66, df = 1, p = .02.

Chi Square Contingency Table for Question 6 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	7	12
Control	11	3

Note. χ^2 = 5.66, df = 1, p = .02.

Chi Square Contingency Table for Question 2 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	5	14
Control	11	3

Note. χ^2 = 8.81, df = 1, p = .003.

Chi Square Contingency Table for Question 9 on the TF1

	Primarily Face-to-Face	At Least Half Online
Treatment	6	13
Control	10	4

Note. χ^2 = 5.12, df = 1, p = .17.

Chi Square Contingency Table for Question 1 on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	8	12
Control	12	3

Note. $\chi^2 = 5.6$, df = 1, p = .02.

Chi Square Contingency Table for Question 2 on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	6	14
Control	12	3

Note. $\chi^2 = 8.58$, df = 1, p = .003.

Chi Square Contingency Table for Question 3 on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	9	11
Control	13	2

Note. $\chi^2 = 6.37$, df = 1, p = .011.

Chi Square Contingency Table for Question 4 on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	5	15
Control	13	2

Note. $\chi^2 = 13.05$, df = 1, p = .0003.

Chi Square Contingency Table for Question 5a on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	9	11
Control	12	3

Note. χ^2 = 4.38, df = 1, p = .036.

Chi Square Contingency Table for Question 5c on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	9	11
Control	12	3

Note. χ^2 = 4.38, df = 1, p = .036.

Chi Square Contingency Table for Question 5e on the TF3

	Primarily Face-to-Face	At Least Half Online
Treatment	9	11
Control	12	3

Note. χ^2 = 4.38, df = 1, p = .036.

Chi Square Contingency Table for Question 7 on the TFFE

	Primarily Face-to-Face	At Least Half Online
Treatment	6	14
Control	10	5

Note. χ^2 = 4.64, df = 1, p = .03.

Chi Square Contingency Table for Question 8 on the TFFE

	Primarily Face-to-Face	At Least Half Online
Treatment	7	13
Control	11	4

Note. $\chi^2 = 5.04$, df = 1, p = .025.

Appendix C

Math 1101 Hybrid Course Syllabus

Course Information

Course Title: Math 1101 - 304 - Intro. to Mathematical Modeling - Fall 2005

Instructor: Ming-Hang Her

Office: SB-1252

Class Time: W 9:30a.m. - 10:45a.m.

Room: SB 2140

Phone: (XXX) XXX-XXXX (office)   (XXX) XXX-XXXX (secretary)

E-mail mher@gpc.edu

Website: http://www.xxx.edu/~mher/Math1101Hybrid
Please check this website for specific information on Hybrid Course.

Office Hours: MW: 8:00a.m. – 9:30a.m. 11:00a.m. – 12:00p.m.
TR: 8:00a.m. - 9:30a.m.; 12:45p.m. - 1:30p.m.
F: 9:00a.m. - 11:00a.m.
Other office hours by appointment. Please call or drop by anytime.

Prerequisite: Placement into college-level mathematics

Materials:

- Text: Connally, et atl. Functions Modeling Change: A Preparation for Calculus, 2nd Edition. Wiley
- WebCT Vista account and password,
- TI-83 (plus) graphing calculator
- Notebook with paper, pencils, graph paper, ruler

Supplemental Materials: Student Solutions Manual, tutors, and printed practice materials are resources available in the ISS Lab, SB 1110.

Course Descriptions: This course uses graphical, numerical, symbolic, and verbal techniques to describe and explore real-world data and phenomena. Emphasis is on the use of elementary functions (linear, quadratic, exponential, and logarithmic) to investigate and analyze applied problems and questions, supported by the use of appropriate technology, and on the effective communication of quantitative concepts and result. Functions introduced through applications are the main focus of the course. This course is intended for non-science majors.

Course Objectives: To provide the non-mathematics, non-science major with an understanding of the role of mathematics in today's society.

Course Policies

Attendance: Students should attend ALL classes to maximize their chances for success. Missing more than one class period may result in your becoming hopelessly behind. Further, the majority of the material on the test will come directly from class lectures, so it is to your benefit to attend all classes. We abide by the official absence policy, which states: Regular class attendance is an important part of learning therefore; students are expected to attend every class. You are responsible for knowing about announcements/assignments made in class, whether you are there or not.

WebCT Online presence includes but is not limited to viewing notes, submitting assignments, taking quizzes, participating in on-line discussions, or asking questions via email. Students are required to **login at least twice a week.** This figure is considered the minimum and it is anticipated that student will be online more often. **Failure of a student to have an online presence for each week will be equivalent to one absence.**
Hybrid Course Orientation

Assignments: There will be homework assignments on topics discussed in class and online. To succeed in this course you will need to do each of these assignments. Assignment will be pick up for grade on completeness and/or on accuracy. Generally chapter test & quizzes question will come from the homework. You MUST turn in your notebook during the Final Exam.

Quizzes

- The quiz will come form homework assignment , class discussion. or online lecture.
- Quizzes will be available through WebCT Vista
- Deadline for each quizzes will be strictly observed.
- To qualify for second attempt of the quiz, one must complete the online quiz one week before the due date AND turn in a referral to my office 24 hours before the cut-off time inside the WebCT.

Withdrawal: Students, who official withdraw no later than October 14,2005 and withdraw themselves from the course will receive a W. After October 14, 2005 student initiating the withdrawal will receive a WF. Any student who fails to take the Final Exam will receive an F for the course.

Projects:

- 3 projects and 1 semester project will be assignment during the semester.
- Project One
- Project Two
- Project Three
- Semester Project
- All the projects can be done either in groups or individually and will be graded.
- Students are encouraged to discuss with the instructor about the projects PRIOR to the due date.
- Project due date: please refer to WebCT Vista calendar.
- 5 points will be deducted from the project for each day (including weekends and holidays) after the due date.

Tests: All the tests are weighted the same. Each test will be 50 points.

Make Up Policy: Students will complete all tests. If a student miss a test, 1/3 of the final exam grade will be used to replace one missing test.

Evaluation: The final grade will be based on the following:

Assignments ---------- 90 points Notebook Check ------ 30 points Quizzes ----------------- 130 points Projects----------------- 150 points Semester Projects---- 100 points Tests ------------------- 150 points Final Exam ------------ 150 points	A: 716--800 B: 636--715 C: 556--635 D: 476--555 F: 0--475 W = Withdrawal by mid-term WF = Student - initiated withdrawal after October 14, 2005

Dates	In Class	Online	Quiz Due (Tuesday)	Turn In at Next Class
Wednesday 8/24/05 and the week thereafter	Intro, WebCT, LM 2	LM 3, 4	Q1	A1, A3
Wednesday 8/31/05 and the week thereafter	LM 5	LM 6, 7	Q2, Q3	A6
Wednesday 9/7/05 and the week thereafter	LM 8	LM 9	Q4	A8
Wednesday 9/14/05 and the week thereafter	LM 10	LM 11	Q5, Q6	A 9, A10
Wednesday 9/21/05 and the week thereafter	LM 12	LM 13	Q7	A 11, Project One
Wednesday 9/28/05 and the week thereafter	TEST ONE	EM 2		A 12
Wednesday 10/5/05 and the week thereafter	EM 3	EM 4, 5	Q8, Q9	A 14
Wednesday 10/12/05 and the week thereafter	EM 6	EM 7	Q10, Q11	A16, A17
Wednesday 10/1905 and the week thereafter	EM 8	EM 9	Q12	A19
Wednesday 10/26/05 and the week thereafter	EM 10	EM 11	Q13	Project Two
Wednesday 11/2/05 and the week thereafter	TEST TWO	QM 2,3		A21, 22
Wednesday 11/9/05 and the week thereafter	QM 4	QM 5, 6	Q14,Q15	A 24, A25
Wednesday 11/16/05 and the week thereafter	QM 7	QM 8, 9	Q16, Q17	Project Three
Wednesday 11/30/05 and the week thereafter	TEST THREE	Semester Project		Semester Projector
Wednesday 12/7/05 and the week thereafter	Semester Project Presentation	Final Review		
THURSDAY 12/15		FINAL EXAM - 8:00 am – 10:00 am		

Assignments are collected during the first five (5) minutes of class.
If you are more than 5 minutes late, your assignment will be penalized by 25%.
No assignment will be accepted beyond the ending class time of the due date.

Department Policies

Cheating and Plagiarism: Please sees "Academic Honesty Policy"

Telephone and Paging Devices: Telephones and any paging devices must be switched off or set for an inaudible signal while in the classroom. No audible signal may sound while the student is in class. This policy also applies to devices with alarms. E.g. watches. Other faculty and staff nay not be requested to monitor a student's telephone or paging device.

Ban on food and drink: No eating or drinking in class.

XXX Policies

Americans with Disabilities Act (ADA) Statement: "If you are a student who is disabled as defined under the Americans with Disabilities Act (ADA) and require assistance or support services, please seek assistance through the Center for Disability Services (CDS). A CDS Counselor will coordinate those services."

Statement of Non-discrimination: XXXXXX College supports the Civil Rights Act of 1964, Executive Order #11246, Title IX of the Educational Amendments of 1972, Section 504 of the Rehabilitation Act of 1973, and the Americans with Disabilities Act. No person shall, on the basis of age, race, religion, color, gender, sexual orientation, national origin or disability, be excluded from participation in, or be denied the benefits of, or be subjected to discrimination under any program or activity of the college. Any individual with a grievance related to the enforcement of any of the above provisions should contact the Director of Human Resources, Ombudsperson.

Equal Opportunity Statement: No person shall, on the basis of age, race, religion, color, gender, sexual orientation, national origin or disability, be excluded from participation in, or be denied the benefits of, or be subjected to discrimination under any program or activity of XXXXXX

Affirmative Action Statement: XXXXXX College adheres to affirmative action policies to promote diversity and equal opportunity for all faculty and students.

Tentative Schedule for Math 1101 Section 302, Fall 2005 (Face-to-Face Section)

Dates	In Class	Dates	In Class	Quiz Due (Mon)
8/23/05	Intro, WebCT, LM 2 **Turn in Next Class A1**	8/25/05	LM 3,4 **Turn in Next Class A3**	Q1
8/30/05	LM 5	9/1/05	LM 6, 7 **Turn in Next Class A6**	Q2, Q3
9/6/05	LM 8	9/8/05	LM 9 **Turn in Next Class A8**	Q4
9/13/05	LM 10 **Turn in Next Class A9**	9/15/05	LM 11 **Turn in Next Class A10**	Q5, Q6
9/20/05	LM 12 **Turn in Next Class A11**	9/22/05	LM 13 **Turn in Next Class: Project One**	Q7
9/27/05	TEST ONE	9/26/05	EM 2 **Turn in Next Class A12**	
10/4/05	EM 3	10/6/05	EM 4, 5 **Turn in Next Class A14**	Q8, Q9
10/11/05	No Class	10/13/05	EM 6 **Turn in Next Class A16**	Q10
10/18/05	EM 7 **Turn in Next Class A17**	10/20/05	EM 8	Q11,Q12
10/25/05	EM 9 **Turn in Next Class A19**	10/27/05	EM 10	Q13
11/1/05	EM 11 **Turn in Next Class: Project Two**	11/3/05	TEST TWO	
11/8/05	QM 2,3 **Turn in Next Class A21, A22**	11/10/05	QM 4,5	Q14,Q15
11/15/05	QM 6,7 **Turn in Next Class A24, A25**	11/17/05	QM 8	Q15,Q16
11/22/05	QM 9,10 **Turn in Next Class: Project Three**	11/24/05	No Class	Q17
11/29/05	TEST THREE	12/1/05	Semester Project	
12/6/05	Semester Project Presentation	12/8/05	Final Review	
TUESDAY 12/13/05			FINAL EXAM - 10:30 am – 12:30 pm	

Assignments are collected during the first five (5) minutes of class.
If you are more than 5 minutes late, your assignment will be penalized by 25%.
No assignment will be accepted beyond the ending class time of the due date.

Table of Contents for Linear Model

12.2. Graphing Calculator Handout – Linear Model
12.3. Assignment 11: Finding Linear Model from Data with Graphing Calculator
12.4. Quiz 7: Plot Data in TI
13. Test Review – Linear Model

Table of Content for Exponential Model

11. Test Review – Exponential Model

Table of Content for Quadratic Model

Appendix D

Data from Fall 2005

	Group	*Gender*	*Q1*	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*	*Q11*	*Q12*	*Q13*
SC01	N	F	2	3	3	2	2	2	2	1	1	1	1	2	2
SC02*	N	F	1	1	1	-	1	1	1	1	1	1	1	1	1
SC03	N	F	1	1	1	1	1	1	1	1	1	1	1	1	1
SC04	N	F	-	2	2	-	1	1	1	1	1	3	2	2	-
SC05	N	F	3	3	3	3	3	3	3	3	3	3	3	3	3
SC06	N	M	3	3	1	3	2	2	3	1	1	1	2	2	2
SC07	N	M	1	1	1	1	1	1	1	1	1	1	1	1	2
SC08*	N	F	1	1	1	1	1	1	1	-	2	-	-	-	3
SC09	N	M	-	1	-	1	2	-	-	-	-	-	-	2	-
SC10	N	F	1	1	2	1	1	1	1	1	1	1	1	1	1
SC11	N	F	1	2	-	1	2	2	2	3	2	1	1	1	1
SC12	N	M	1	1	1	1	1	1	-	1	1	-	2	-	1
SC13	N	M	3	3	3	3	3	3	3	3	3	3	3	2	3
SC14	N	F	3	3	4	2	1	3	3	4	5	-	-	-	3
SC15	N	F	1	1	1	1	1	1	1	1	1	1	1	1	1
SC16	N	F	-	3	3	3	4	3	3	3	3	3	3	3	3
SC17	N	F	2	1	1	2	2	1	3	1	3	3	2	3	3
ST01	T	F	1	1	1	1	1	1	1	1	1	1	1	1	1
ST02	T	F	3	3	3	3	3	3	2	2	3	3	3	3	3
ST03	T	F	4	3	3	3	3	3	3	3	3	?	3	?	3
ST04	T	F	1	1	1	1	1	1	1	1	1	1	1	1	1
ST05	T	M	2	2	2	2	2	2	2	2	2	2	2	2	3
ST06	T	F	3	3	3	3	3	3	3	3	3	3	3	3	3
ST07	T	M	1	3	4	2	3	3	3	1	4	4	3	4	3
ST08	T	F	3	3	3	3	3	3	3	3	3	3	3	3	3
ST09	T	F	3	2	2	-	2	-	2	2	2	2	2	2	-
ST10	T	F	1	1	1	1	1	1	1	1	1	1	1	1	1
ST11	T	F	1	3	2	2	3	1	1	2	3	2	3	5	3
ST12	T	F	3	2	2	3	2	1	2	1	2	3	2	2	2
ST13	T	M	3	-	4	-	3	3	3	3	3	3	2	3	3
ST14	T	F	3	2	2	2	2	2	2	2	2	2	2	1	2
ST15	T	F	3	2	2	3	2	3	3	3	3	2	3	3	3
ST16*	T	F	1	2	2	1	1	1	1	1	1	-	-	1	1
ST17	T	F	3	2	2	3	3	3	1	1	3	1	1	3	1
ST18	T	M	4	4	4	4	3	4	4	4	4	3	3	3	3
ST19	T	F	2	2	3	3	3	4	1	4	1	4	2	3	5
ST20	T	F	3	3	3	3	3	3	3	3	3	3	3	3	3
ST20	T	F	-	2	2	1	2	2	2	1	2	1	2	1	2

Note: * = students are not included in the statistical analyses. - = did not turn in work. ? = turn in work but not feedback

	Q14	Q15	Q16	Q17	A1	A3	A9	A16	A17	A19	A22	A25	T1-1	T1-2	T1-3
SC01	1	1	1	1	5	5	3	1	2	1	1	1	1	1	1
SC02*	-	-	-	-	-	-	1	2	1	-	-	-	1	1	1
SC03	1	1	1	1	1	4	1	1	1	1	1	1	1	2	2
SC04	-	2	2	2	-	1	-	3	3	3	2	2	-	-	-
SC05	3	3	3	3	3	3	2	3	3	3	3	3	4	4	4
SC06	3	2	2	2	1	1	4	2	2	2	4	2	4	3	2
SC07	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1
SC08*	-	-	-	-	-	-	-	-	1	-	-	-	1	1	1
SC09	-	2	2	2	-	-	1	-	-	-	3	-	1	1	1
SC10	1	1	1	1	2	1	1	-	1	1	1	1	1	1	1
SC11	1	3	-	-	5	5	3	2	2	3	-	1	1	1	1
SC12	-	1	1	1	1	1	-	-	-	-	-	1	1	1	1
SC13	2	4	1	3	1	1	1	3	3	-	3	1	3	3	2
SC14	3	3	3	-	4	3	1	3	1	3	3	3	2	1	2
SC15	1	1	1	-	1	1	1	1	-	1	1	-	1	1	1
SC16	3	3	3	3	3	3	3	4	3	-	2	3	5	1	1
SC17	3	2	2	3	3	2	1	1	3	2	-	3	2	2	2
ST01	1	1	1	1	1	3	5	1	1	-	1	-	1	1	1
ST02	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1
ST03	3	-	-		-	-	-	3	-	?	3	3	3	3	3
ST04	1	1	1	1	1	1	-	3	1	-	5	-	5	5	5
ST05	2	2	2	2	3	2	2	2	2	-	2	2	3	3	3
ST06	2	2	2	3	3	3	3	3	3	3	2	4	3	3	3
ST07	4	4	2	2	3	3	3	1	1	3	4	4	3	3	3
ST08	3	3	3	3	4	4	3	3	3	3	3	3	2	4	3
ST09	2	2	2	2	2	2	2	2	3	-	-	-	-	-	-
ST10	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ST11	1	3	2	3	1	1	3	3	3	3	5	4	1	1	3
ST12	1	2	2	1	1	2	2	2	1	-	1	-	3	3	1
ST13	3	3	3	2	3	4	3	3	2	3	2	-	3	3	3
ST14	-	-	-	-	3	3	2	2	2	1	-	-	2	2	2
ST15	3	3	1	1	2	2	3	3	3	4	3	2	2	3	3
ST16*	1	1	1	1	1	1	-	1	1	1	-	-	-	-	-
ST17	3	3	2	2	-	-	-	-	-	-	2	1	3	3	3
ST18	3	3	3	2	3	3	3	3	3	-	2	-	3	3	3
ST19	-	-	5	3	1	3	4	-	-	-	-	-	1	2	2
ST20	3	-	3	3	3	3	3	3	3	3	1	-	3	3	3
ST20	2	-	2	3	4	-	2	3	3	-	-	-	3	3	2

	T1-4	T1-5	T1-6	T1-7	T1-8	T1-9	T1-10	T2-1	T2-2	T2-3	T2-4	T2-5	T2-6	T2-7	T2-8
SC01	1	1	1	1	1	1	1	1	2	1	1	1	1	1	2
SC02*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC03	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1
SC04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SC05	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3
SC06	2	4	3	3	1	3	4	1	2	4	1	3	2	1	4
SC07	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC08*	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
SC09	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-
SC10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC11	1	1	1	1	1	1	1	1	2	1	3	2	3	1	-
SC12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC13	4	3	2	3	2	3	4	1	1	1	1	1	1	1	1
SC14	3	3	3	2	4	3	4	1	3	1	1	2	4	3	1
SC15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC16	1	1	1	1	3	1	1	3	3	3	3	3	3	3	3
SC17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
ST01	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ST02	1	1	3	3	3	3	1	3	3	3	3	3	3	3	3
ST03	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
ST04	5	5	5	5	5	5	5	3	3	3	3	1	1	1	1
ST05	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
ST06	3	3	3	3	3	3	3	2	2	3	1	3	3	3	3
ST07	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3
ST08	3	3	2	2	3	4	3	2	2	3	2	4	4	3	2
ST09	-	-	-	-	-	-	-	1	1	1	4	1	2	1	1
ST10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ST11	2	2	3	2	1	1	2	3	3	1	2	3	3	2	5
ST12	5	4	3	5	3	1	1	1	1	1	3	3	2	3	-
ST13	3	3	3	2	3	3	3	5	4	4	4	3	3	3	3
ST14	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
ST15	2	3	2	3	2	3	3	1	1	1	1	1	1	1	1
ST16*	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1
ST17	3	2	1	1	3	3	1	1	1	2	1	3	3	3	1
ST18	3	3	3	3	3	3	3	4	1	4	3	3	3	3	3
ST19	2	2	3	2	3	3	1	-	-	-	-	-	-	-	-
ST20	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
ST20	3	2	1	1	3	1	1	2	2	2	1	2	2	2	2

	T3-1	T3-2	T3-3	T3-4	T3-5a	T3-5b	T3-5c	T3-5d	T3-5e	T3-6	FE-1a	FE-1b	FE-2	FE-3
SC01	1	1	1	1	1	1	2	1	1	1	1	1	1	1
SC02*	-	-	-	-	-	-	-	-	-	-				
SC03	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC04	1	2	1	1	1	1	1	1	1	3	2	2	1	1
SC05	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SC06	4	5	2	5	5	4	3	3	3	5	3	2	3	2
SC07	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC08*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SC09	1	1	1	1	1	2	2	1	2	2	1	1	1	1
SC10	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC11	1	1	1	1	1	1	1	1	1	1	1	1	3	1
SC12	1	1	1	1	1	1	1	1	1	1	3	3	3	3
SC13	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC14	3	4	1	2	3	3	3	3	3	2	3	2	2	3
SC15	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SC16	1	1	3	1	1	1	1	1	1	3	3	3	3	3
SC17	2	2	2	2	2	2	2	2	2	2	2	2	2	2
ST01	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ST02	3	3	3	3	3	3	3	3	3	3	3	3	3	3
ST03	3	3	3	3	3	3	3	3	3	3	3	3	3	3
ST04	3	3	3	3	3	3	3	3	3	3	1	1	1	1
ST05	2	5	5	4	4	5	5	5	5	5	2	2	2	2
ST06	5	3	2	3	2	2	2	2	2	3	2	2	2	3
ST07	3	3	3	3	3	3	3	3	3	3	4	4	3	4
ST08	3	3	3	3	3	3	3	3	3	3	2	3	3	2
ST09	2	2	2	2	2	2	2	2	2	2	1	1	2	2
ST10	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ST11	1	1	1	4	3	3	4	1	1	4	1	1	2	1
ST12	5	3	3	3	2	2	2	4	3	1	1	2	2	2
ST13	4	4	4	3	4	4	4	4	4	3	5	5	2	4
ST14	1	1	1	1	1	1	1	1	1	1	2	2	2	2
ST15	4	4	4	4	4	4	4	4	4	4	2	2	2	3
ST16*	2	2	2	2	2	2	2	2	2	2	-	-	-	-
ST17	4	4	1	3	1	1	1	1	1	1	4	1	3	3
ST18	3	3	2	3	2	2	2	2	2	2	3	3	3	3
ST19	1	4	3	3	4	2	4	1	3	1	2	2	2	2
ST20	3	3	3	3	3	3	3	3	3	3	3	3	3	3
ST20	2	2	1	2	1	1	1	1	1	2	3	2	2	2

	FE-4	FE-5	FE-6	FE-7	FE-8	FE-9	FE-10	FE-11a	FE-11b,c	FE-12	FE-13a	FE-13b
SC01	2	1	1	1	1	1	1	1	2	2	1	1
SC02*	-	-	-	-	-	-	-	-	-	-	-	-
SC03	1	1	1	1	1	1	1	1	1	1	1	1
SC04	1	1	1	1	2	2	2	1	2	2	2	1
SC05	3	3	3	3	3	3	3	3	3	3	3	3
SC06	3	3	2	3	2	2	2	3	3	1	4	3
SC07	1	1	1	1	1	1	1	1	1	2	1	1
SC08*	-	-	-	-	-	-	-	-	-	-	-	-
SC09	1	1	1	1	1	1	1	1	1	1	1	1
SC10	1	1	1	1	1	1	1	1	1	1	1	1
SC11	1	1	1	1	1	1	1	1	1	1	1	1
SC12	3	3	3	3	3	3	3	3	3	3	3	3
SC13	1	1	1	1	1	1	1	1	1	1	1	1
SC14	3	3	3	3	3	3	3	3	3	3	3	3
SC15	1	1	1	1	1	1	1	1	1	1	1	1
SC16	3	3	3	3	3	3	3	3	3	3	3	3
SC17	2	2	2	2	2	2	2	2	2	2	2	2
ST01	1	1	1	1	1	1	1	1	1	1	1	1
ST02	3	3	3	3	3	3	3	3	3	3	3	3
ST03	3	3	3	3	3	3	3	3	3	3	3	3
ST04	1	1	1	1	1	1	1	1	1	1	1	1
ST05	2	2	2	2	2	2	2	2	2	2	2	2
ST06	3	3	3	3	4	4	3	3	3	3	2	2
ST07	4	1	4	4	4	4	4	4	4	4	4	4
ST08	3	4	3	3	3	3	3	3	2	2	2	2
ST09	3	3	2	3	3	3	2	3	3	2	2	2
ST10	1	1	1	1	1	1	1	1	1	1	1	1
ST11	2	5	5	2	2	1	4	2	2	2	1	1
ST12	2	2	4	4	4	2	2	4	3	3	3	4
ST13	4	4	3	3	3	3	3	3	3	2	3	3
ST14	2	2	2	2	2	2	2	2	2	2	2	2
ST15	2	2	2	3	1	1	1	2	4	2	2	1
ST16*	-	-	-	-	-	-	-	-	-	-	-	-
ST17	1	2	3	5	5	5	5	3	3	4	1	1
ST18	3	3	3	3	3	3	3	3	3	3	3	3
ST19	3	4	3	5	5	3	4	2	2	2	1	1
ST20	3	3	3	3	3	3	3	3	3	3	3	3
ST20	1	2	2	3	3	3	3	1	1	1	2	1

	FE-13c	FE-14a	FE-14b	FE14c	P1	P2	P3	SP
SC01	1	1	1	1	1	1	2	2
SC02*					1	1	1	-
SC03	1	1	1	1	1	1	1	1
SC04	1	1	1	1	2	2	2	3
SC05	3	3	3	3	3	3	3	3
SC06	3	4	4	4	3	1	3	2
SC07	1	1	1	1	-	1	1	2
SC08*					1	-	-	-
SC09	1	1	1	1	1	-	-	2
SC10	1	1	1	1	1	1	1	1
SC11	1	1	1	1	3	-	3	2
SC12	3	3	3	3	1	1	-	1
SC13	1	1	1	1	2	3	1	3
SC14	3	3	3	3	3	-	3	3
SC15	1	1	1	1	1	1	1	3
SC16	3	3	3	3	-	3	2	3
SC17	2	2	2	2	2	2	3	3
ST01	1	1	1	1	1	1	-	1
ST02	3	3	3	3	3	3	3	-
ST03	3	3	3	3	3	3	3	-
ST04	1	1	1	1	1	-	1	1
ST05	2	2	2	2	3	2	2	3
ST06	2	2	2	2	3	2	2	3
ST07	4	4	4	4	3	3	3	4
ST08	2	3	3	3	3	3	3	-
ST09	2	3	3	3	-	-	2	2
ST10	1	1	1	1	1	1	1	1
ST11	1	1	1	1	2	2	3	3
ST12	4	2	2	2	4	3	3	3
ST13	3	3	3	3	-	4	-	3
ST14	2	3	3	3	2	1	1	1
ST15	1	1	2	2	4	3	1	1
ST16*					-	2	-	-
ST17	1	1	1	1	-	-	-	1
ST18	3	3	3	3	3	3	-	3
ST19	1	1	1	1	-	-	-	-
ST20	3	3	3	3	4	3	3	3
ST20	1	3	3	3	1	2	2	2