Western Michigan University
ScholarWorks at WMU

Dissertations Graduate College

12-2004

Effectiveness of Teaching Modalities for Pre-College Level Mathematics Courses

Dorothy Latuszek
Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/dissertations

Part of the Science and Mathematics Education Commons

Recommended Citation

Latuszek, Dorothy, "Effectiveness of Teaching Modalities for Pre-College Level Mathematics Courses" (2004). *Dissertations*. 1119.
https://scholarworks.wmich.edu/dissertations/1119

This Dissertation-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Dissertations by an authorized administrator of ScholarWorks at WMU. For more information, please contact wmu-scholarworks@wmich.edu.

EFFECTIVENESS OF TEACHING MODALITIES FOR PRE-COLLEGE LEVEL MATHEMATICS COURSES

by

Dorothy Latuszek

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Doctor of Philosophy
School of Public Affairs and Administration
ADVISOR: DR. BARBARA LIGGET

Western Michigan University
Kalamazoo, Michigan
December 2004

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

UMI Number: 3154502

Copyright 2004 by
Latuszek, Dorothy

All rights reserved.

INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

UMI®

UMI Microform 3154502
Copyright 2005 by ProQuest Information and Learning Company.
All rights reserved. This microform edition is protected against unauthorized copying under Title 17, United States Code.

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

©2004 Dorothy Latuszek

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

ACKNOWLEDGMENTS

I want to express my sincerest appreciation and gratitude to my committee chair, Dr. Barbara Liggett, as well as to Dr. Alan Walker and Dr. Keon-Hyung Lee from Western Michigan University. Their approach as a committee to the dissertation process fit perfectly with my learning style. I also want to acknowledge and thank Dr. Marianne DiPierro for her guidance, insight, suggestions, and encouragement from the beginning of this process through to its completion.

My colleagues, the president, and members of the Board of Trustees at Kirtland Community College, encouraged me throughout this process. I have a very special appreciation and thankfulness for my coworkers at M-TEC^{SM} at Kirtland – Gaylord. They are truly a dream team with whom I am most privileged to work.

My family and friends have been thoughtful and unselfish all along the way. Their unconditional love and support allowed me to work as needed to meet my self-imposed timeline to graduate in December 2004.

Finally, but most importantly, I want to acknowledge and thank my partner, June Savoie, for her love and support throughout this entire endeavor. June tirelessly encouraged me to continue as she took on all of the family chores because she knew this goal was important to me. I am a most fortunate person.

Dorothy Latuszek

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TABLE OF CONTENTS

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

LIST OF TABLES

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

LIST OF FIGURES

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 1

INTRODUCTION AND BACKGROUND

Introduction

Thomas Jefferson, one of our nation's Founders, believed that education was a vital component of a democratic society. He wrote to James Madison in 1787 that

> Above all things I hope the education of the common people will be attended to, convinced that on their good sense we may rely with the most security for the preservation of a due degree of liberty (Ford, 1892-1899, 4:480).

The compulsory system of primary through secondary education in the United States as well as noncompulsory postsecondary education provided by colleges and universities have made available the means to the fulfillment of Jefferson's vision of "an enlightened citizenry" (Ford, 1892-1899). Seeking ways to increase student achievement and success in postsecondary educational environments contributes to Jefferson's dream of a well-educated citizenry in a democratic society.

The first two-year colleges in the United States were established early in the 20th century (Zwerling, 1976, p. 47) and more were founded subsequent to the Truman Commission Report with a mission to provide low-cost, nonselective, postsecondary education (President's Commission on Higher Education, 1947). According to the National Center for Education Statistics, over 1000 two-year colleges serve 5.6 million students accounting for approximately 45% of all undergraduate postsecondary enrollments in the United States (Lutzer, Maxwell, & Rodi, 2002; NCES, 2000).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Two-year colleges have been described as a "democratizing force in higher education" (Roueche & Baker, 1987, p. 3) due in part to the concept of nonselectivity which implied a type of open admission or "equality of opportunity" (Birenbaum, 1974). The concept of nonselectivity later became known as "the open-door" policy (Roueche, Baker, & Roueche, 1987, p. 22). Acceptance into two-colleges for persons without regard for their age, race, gender, social status, or educational achievement level has created both opportunities and challenges for the students and the institutions.

Economists estimate that by 2006, close to two-thirds of all jobs will require education and skills levels beyond a high school diploma (Golonka & Matus-Grossman, 2001); however, nearly half of all entering freshmen in two-year and four-year colleges are deficient in the basic skills of reading, writing, and mathematics taught in high school (McCabe, 2003). The student population deficient in these basic skills has been growing each year (Parsad & Lewis, 2003) and colleges are challenged with finding ways to raise the skills levels of students who enter their institutions. In fact two-year colleges have nurtured the reputation of giving a second chance to these academically underprepared students for whom academic success can be a fragile commodity.

Although public two-year colleges were more likely than other types of postsecondary institutions in the fall 2000 semester to provide pre-college level courses, 80% of public four-year and 59% of private four-year colleges and universities also provided pre-college level courses in fall 2000 (Parsad & Lewis, 2003, p. 8). All public and private two-year and four-year educational institutions face the challenge of various levels of academically underprepared entering freshmen (Parsad & Lewis, 2003). The term "pre-college level" is defined as courses in reading, writing, and mathematics for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

college students lacking those skills necessary to perform college-level coursework at the institutions (Parsad & Lewis, 2003, p. 1).

The research in this dissertation focused exclusively on the content area of pre-college level mathematics. The fall 2000 semester found 35% of entering freshmen at the nation's public two-year colleges enrolled in pre-college level mathematics courses; this figure is up from 32% in the fall semester of 1995 (Parsad & Lewis, 2003, p. 18). Although not listed specifically, the percentage of students who actually tested into pre-college level mathematics may have been higher than 35% since not all colleges require students who need pre-college level mathematics courses to enroll in them (Parsad & Lewis, 2003, p. v). Institutions without mandatory placement into pre-college level courses may find some students circumventing such a prescription and enrolling in college-level courses for which the students are academically inadequately prepared. Additionally, some students may postpone their enrollment into any mathematics course until nearer the end of their academic program requirements. Such a delay puts these students at risk of not completing their certificate, degree, or other educational goals.

At Kirtland Community College, a rural public two-year college located in northern Michigan, the average percentage of entering students who test into pre-college level mathematics is over 70%. In the fall 2000 semester, only 43% of the students who received a pre-college level mathematics placement actually enrolled into the recommended math courses that same semester (Dyer, 2004). Since Kirtland Community College is an institution without mandatory placement, the remaining students who did not enroll in the recommended pre-college level courses may have either enrolled into a higher level math course or delayed enrolling into any math course that semester.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Mandatory placement of students into pre-college level courses to prepare for college-level courses is not a uniform policy at two-year colleges in Michigan (Michigan Department of Education [MDE], 1999). Nationally, the trend is to require students to enroll in pre-college level courses if their placement test scores indicate the need. Up from 67% in 1995, 75% of public two-year colleges in 2000 have such mandatory placement (Parsad & Lewis, 2003, p. 23). Similarly up from the 1995 rates, the percentage of public and private four-year colleges that maintained mandatory student placement into pre-college level courses was 81% and 88%, respectively, for the fall 2000 semester (Parsad & Lewis, 2003, p. 23).

Even with the opportunity for learners to remediate their deficient mathematical skills through either mandatory student placement or voluntary acquiescence into the prescribed courses, only 52% of students who enrolled in pre-college level mathematics in Michigan's two-year colleges from 1995-1998 earned a grade of "C" or higher (MDE, 1999, p. 15). According to Kirtland Community College's primary academic counselor and director of testing, 56% of those students enrolled at Kirtland in pre-college mathematics courses earned a grade of "C" or higher in the fall 2000 semester (Dyer, 2004). Increasing the number of students enrolled in mathematics courses as well as increasing the student success rates in the courses is a necessity in a time now driven by scientific and technological advances (Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century, n.d.).

Efforts to improve mathematics education have been received with varying levels of enthusiasm although many in our society recognize the need for change and the importance of these reforms. Professional organizations dedicated to excellence in mathematics

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

education and improved student learning have joined together in recent years to encourage and promote the efforts to reform the current beliefs and practices of teachers of mathematics at all levels of our educational system. Included among these organizations are the American Mathematical Association of Two-Year Colleges (AMATYC), the American Mathematical Society (AMS), the Mathematical Association of America (MAA), the National Association of Developmental Education (NADE), and the National Council of Teachers of Mathematics (NCTM).

Mathematics Instruction Reform Efforts

The National Council of Teachers of Mathematics initiated the efforts to improve mathematics education in 1989 with the release of *Curriculum and Evaluation Standards for School Mathematics* and subsequently released documents on teaching standards (NCTM, 1991) and assessment standards (NCTM, 1995). In 2000, *Principles and Standards in School Mathematics* revised and made more explicit the basic assumptions of the original Standards documents (Goldsmith, 1999).

The *Principles and Standards in School Mathematics* (NCTM, 2000) presents a view of mathematics teaching, learning, and assessment that emphasizes the development of conceptual understanding and reasoning, rather than direct instruction, drill, and practice. Advances in learning theory and cognitive theory embrace more active student engagement with mathematical ideas (Goldsmith, 1999).

Complementing and supporting the efforts of NCTM to reform primary and secondary mathematics education, the American Mathematical Association of Two-Year Colleges (AMATYC) released *Crossroads in Mathematics: Standards for Introductory*

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

College Mathematics before Calculus (1995). The two major goals of *Crossroads in Mathematics* included the improvement of mathematics education in two-year colleges and at the lower division of four-year colleges and universities as well as the encouragement of a greater number of students to study more mathematics (AMATYC, 1995).

Crossroads in Mathematics articulated the following philosophical principles:

1. All college students should grow in their knowledge of mathematics while attending college.

2. The mathematics that students study should be meaningful and relevant.

3. Mathematics must be taught as a laboratory discipline.

4. The use of technology is an essential part of an up-to-date curriculum.

5. Students will acquire mathematics through a carefully balanced educational program that emphasizes the content and instructional strategies recommended in the standards along with the viable components of traditional instruction.

6. Increased participation in mathematics and in careers using mathematics is a critical goal in our heterogeneous society.

The document also recommended the use of instructional strategies that provide for student activity and interaction and for student-constructed knowledge. The five statements focused on pedagogy follow:

1. Mathematics faculty will model the use of appropriate technology in the teaching of mathematics so that students can benefit from the opportunities it presents as a medium of instruction (Standard P-1: Teaching with Technology).

2. Mathematics faculty will foster interactive learning through student writing, reading, speaking, and collaborative activities so that students can learn to work

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

effectively in groups and communicate about mathematics both orally and in writing (Standard P-2: Interactive and Collaborative Learning).

3. Mathematics faculty will actively involve students in meaningful mathematics problems that build upon their experiences, focus on broad mathematical themes, and build connections within branches of mathematics and between mathematics and other disciplines so that students will view mathematics as a connected whole relevant to their lives (Standard P-3: Connecting with Other Experiences).

4. Mathematics faculty will model the use of multiple approaches—numerical, graphical, symbolic, and verbal to help students learn a variety of techniques for solving problems (Standard P-4: Multiple Approaches).

5. Mathematics faculty will provide learning activities, including projects and apprenticeships, that promote independent thinking and require sustained effort and time so that students will have the confidence to access and use needed mathematics and other technical information independently, to form conjectures from an array of specific examples, and to draw conclusions from general principles (Standard P-5: Experiencing Mathematics).

Components of this effort to reform the teaching and learning of mathematics include the following: (a) the appropriate use of technology in the teaching and learning process (NCTM, 1991; AMATYC, 1995, Standard P-1), and (b) the idea that students will build upon their previous mathematical experiences (NCTM, 1991; AMATYC, 1995, Standard P-3).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Teaching Modalities

Teaching and learning environments include a range of teaching modalities from traditional lecture to exclusively computer-based to various combinations of traditional and computer-based modalities that are referred to as "hybrid" modalities. For the purposes of this research, the traditional lecture modality refers to an instructor-led environment of a group of students. The instructor is the content area authority who dispenses the instructional content to the students. The traditional lecture modality usually includes the instructor presenting new material in small steps, thinking aloud by the instructor, guiding initial student practice, providing systematic corrections and feedback, and providing expert models of the completed task (Kinney & Robertson, 2003). In this modality, students study the same mathematics at the same moment in time with the instructor determining the order and pace of the instructional content.

The use of computers for the purpose of increasing the knowledge of students in an academic content area such as mathematics is referred to as computer-directed instruction, computer-aided instruction, computer-based instruction, and other similar phrases. Exclusively computer-based instruction may occur in a laboratory setting with assistance provided to students by student or peer tutors or educational paraprofessionals but without the involvement of an instructor. The computer-based modality demands that students study the instructional content and take tests on the content until they are able to demonstrate mastery. To be successful, students need to have effective study and time management skills (Kinney & Robertson, 2003).

The hybrid teaching modality involves a combination of the traditional and computer-based modalities. The hybrid modality may include mini-lectures by an

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

instructor and student use of software to facilitate the development of skills or to review the main concepts. Students have the benefit of the structure of direct instruction by an instructor as well as the increased flexibility in the development of skills with the use of computer software (Kinney & Robertson, 2003). The hybrid modality may also involve the presentation of content area concepts through interactive multimedia software. Students may be learning the same concepts at different moments in time at a pace that accommodates their individual needs.

The primary strengths of the hybrid modality are that it accommodates various learning styles since students are able to learn through the software as well as the instructor (Kinney & Robertson, 2003). Instructors are able to provide individual instruction by allowing students to study at their level of competency and move through other levels at their own pace. Some students require many explanations with accompanying practice and other students may require much less of either instruction or practice (Oxford, Proctor, & Slate, 1998).

Computer-based instructional software in the 1980s and 1990s did not have the capability to offer the high quality video and simulation with student interactivity that is currently available. Recent improvements in computer technology and software have increased capabilities to more easily incorporate video and simulation instructional activities into the learning environment.

Statement of the Problem

In the fall 2000 semester at Kirtland Community College, over 70% of the entering freshmen placement-tested into pre-college level mathematics courses (Dyer,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2004). A mere 43% of the students who received this placement actually enrolled in the prescribed courses and only 56% of those students who enrolled successfully completed the courses with a course grade of "C" or higher (Dyer, 2004). The low success rate of only 56% course completion with a grade of "C" or higher for students enrolled in pre-college level mathematics courses suggests a need to study alternate course teaching modalities from which students may choose that best fit their learning styles or methods by which they processes information.

Deficient skills in mathematics can have a profoundly negative impact on the academic or career choices of students by denying them access to academic disciplines or career fields that require a certain proficiency level in mathematics. Careers in industrial, electrical, and construction technologies that include computer-aided drafting and design, carpentry, heating and cooling, and welding as well as health care require skills in mathematics beyond the placement testing levels of many entering freshmen. Current shortages in the fields of industrial, electrical, and construction technologies, if not abated, will slow the growth of our economy and similar critical shortages in health careers will impede and compromise the delivery of health care services to the upcoming generation of aging individuals unless this challenge is addressed.

Increasing student achievement and success in pre-college level mathematics is necessary for students to continue their academic preparation for careers in a world that is increasingly technological and that requires proficiency in mathematical skills (Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century, n.d.). Opportunities to increase student learning intended to close the gap between students' academic deficiencies and the mathematical

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

skills necessary for career preparation and personal empowerment should be sought at all levels of the educational system.

Research Questions

The main research question addressed by this study was as follows: "Did the hybrid teaching modality positively impact student achievement and success more than the traditional teaching modality for students taking pre-college level mathematics courses?" Student achievement was measured by "gain" scores, defined as the difference between the course final exam score and the pretest score for each student. Student success in the courses was defined as a final exam score of 70% or higher and selected factors contributing to student success in the courses were explored. Students in this study took the same written pretest the first day of class and the same written posttest (final exam) on the last day of class.

Additional research questions consisted of the following:

1. Was student success in the course impacted by the age of the student?

2. Was student success in the course impacted by the gender of the student?

3. Was student success in the course impacted by the part time or full time academic status of the student?

4. Was student success in the course impacted by the placement test score of the student in mathematics?

5. Was student success in the course impacted by whether or not the student helped school-age children learn mathematics?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

6. Was student success in the course impacted by the financial aid status of the student?

7. Was student success in the course impacted by whether or not one or more of the parents or stepparents of the student previously took a college course for credit?

8. Was student success in the course impacted by whether or not one or more of the grandparents or step grandparents of the student previously took a college course for credit?

9. Was student success in the course impacted by the student's level of comfort with mathematics prior to the winter 2004 semester?

10. Was student success in the course impacted by the student's level of internal motivation to learn mathematics prior to the winter 2004 semester?

11. Was student success in the course impacted by the student's level of confidence to succeed in a mathematics course prior to the winter 2004 semester?

12. Was student success in the course impacted by whether the student studied mathematics in a group or alone?

13. Was student success in the course impacted by the number of hours that the student in the hybrid teaching modality spent using the interactive software modules?

14. Was student success in the course impacted by the student's level of comfort with computers prior to the winter 2004 semester?

15. Was student success in the course impacted by the student's self-reported ability to complete projects once begun prior to the winter 2004 semester?

16. Was student success in the course impacted by the employment status of the student during the winter 2004 semester?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

17. Was student success in the course impacted by the average number of hours worked per week if the student was employed during the winter 2004 semester?

18. Was student success in the course impacted by the student's program of study?

19. Do you believe that the use of computers in your college courses contributes to your learning in those courses more than if you had not used computers?

Significance of the Research

As consumers of the educational courses and programs offered by colleges, students will increasingly seek accommodation for their learning styles, scheduling constraints, and desire for more specific and targeted instructional content. Students may prefer to concentrate their instructional time on the mathematical concepts of which they are deficient and to more quickly demonstrate proficiency for the concepts for which they have adequate understanding. This research may provide insights for better course development to meet the specific mathematical skills needs of students.

Designing courses that better accommodate the scheduling constraints of students while at the same time maintaining the instructional integrity and quality of the courses may be an outcome of this research. Limitations of time and scheduling surrounding the taking of an entire course over the length of a semester may hinder academic achievement and success for students who are juggling the demands of home, work, and educational responsibilities.

Gina Harrison et al (2003) have studied the interaction between the teaching styles of instructors and the learning styles of students and found that instructors'

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

approaches to teaching may or may not support their students' styles of learning (Harrison, Andrews, & Saklofske, 2003). And with the diversity of learning styles, students at all levels have been allowed few, if any, choices related to different teaching modalities. Student achievement and success will be improved when students have access to additional choices of course delivery modalities including, but not limited to, traditional lecture, computer-based, online, and various combinations of these modalities.

The academic student advisement process may improve with the insights provided by the research in this dissertation. Students may be advised to take courses that utilize a particular teaching modality that better complements their learning styles or methods of processing information. Similarly, students may be advised to avoid other teaching modalities to which they are not well suited. The development of courses that better meet the needs and learning styles of a changing student population would benefit the students as well as the institution.

Other colleges may wish to conduct institution-specific studies that will provide information for more accurate profiles of their students' performance and to better gauge learning outcomes. This information could become part of the colleges' academic assessment and institutional effectiveness measures and could, in turn, impact academic planning since state and federal funding sources, as well as local taxpayers, are calling for increased accountability of educational institutions at all levels. Improved student success and achievement will improve institutional effectiveness.

Evaluation of the effectiveness of different teaching modalities will contribute to more appropriate decision making regarding the types and extent of the purchases of new computer technology including software. The present climate of constricting fiscal

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

resources requires that college policy and decision makers look for the best use of financial, physical, and human resources.

Organization of the Study

This chapter has provided an introduction to the research comparing the effectiveness of the traditional and hybrid teaching modalities in pre-college level mathematics courses. The study focused on student achievement and success in the courses. Student achievement was measured by gain scores defined as the difference between pretest and posttest scores and student success was defined as a final exam score in the course of 70% or higher. Other factors were examined to determine their impact on student success in pre-college level mathematics courses. Those factors included age, gender, full time or part time student status, employment status, placement score, whether or not the student helped school-age children learn math at the time of taking the pre-college level mathematics course, financial aid status, first-generation college attendance, comfort and confidence levels with mathematics and computers, internal motivation to learn mathematics, studying alone or with others, the student's ability to complete projects, the number of hours spent on the instructional software, and the student's program of study. Students were also surveyed to determine whether or not they considered the use of computers to have contributed positively to their academic success in college.

Chapter 2 includes a review of the related literature in the following categories: factors that contribute to academic achievement and success of two-year college students in general, the academic under preparedness of students in the field of mathematics, theories related to learning styles and the theory of constructivism, and critical studies

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

that examined student achievement and success with the traditional, computer-based, and hybrid teaching modalities.

Alexander Astin's Inputs-Environment-Outputs model is the conceptual framework for this study (Astin, 1993, p. 18). Chapter 3 also details the research design that includes secondary data collected from student record files and primary data collected from a telephone interview with students who enrolled in the pre-college level mathematics courses of interest. The research design for the quantitative portion of the study was an ex post facto quasi-experimental design with nonequivalent groups without random assignment. The telephone interview consisted of eleven structured questions with responses. A total of 208 students enrolled in the courses of interest including 190 in the traditional modality and 18 in the hybrid modality.

Analysis of the research data is detailed in Chapter 4. Chapter 5 contains the discussion of the results, conclusions of the study, its limitations, and recommendations for future research.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 2

REVIEW OF THE LITERATURE

Substantial research exists concerning the factors that positively impact student achievement and success at the college level; however, much of it focuses on students in traditional four-year residential settings (Rowland, 2003). Rowland also cites research that estimates that less than 5% of the studies they reviewed focused on two-year college students. This may be due in part to the fact that many two-year colleges lack institutional resources for research. However, factors such as open admissions policies with the accompanying challenges of the under preparedness of entering students, increased assessment of student learning, and calls for institutional accountability contribute to the need for such research. Finding ways for students to be more academically successful in their college experiences, and in particular their mathematics courses, contributes to a better educated citizenry prepared with the academic skills to better compete and succeed in an increasingly technologically advanced workplace.

The review of the literature will be as follows:

1. Review of the literature that addresses factors that lend to academic achievement and success of two-year college students.

2. Review of the literature that addresses the academic preparedness of students in the field of mathematics.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

3. Review of the selected theories related to learning styles and constructivist learning theory.

4. Review of the literature that addresses the success of two-year college students who take mathematics courses structured through (a) computer-based teaching modalities, and (b) traditional teaching modalities.

5. Review of the literature that addresses the achievement and success of two-year college students who take mathematics courses structured through hybrid teaching modalities.

Factors That Lend to Academic Achievement and Success of Two-Year College Students

Graduating college seniors were asked to give advice to college freshmen that would promote successful college completion (Swing & Cangemi, 1996). The two most prevalent responses were to cultivate good time management and avoid procrastination. These graduating seniors further suggested that entering freshmen attend classes regularly, turn academic work in on time, find a good place to study, and go to the library frequently. As important as fostering factors that positively contribute to student achievement and success is avoiding or eliminating those factors that challenge a student's ability to academically succeed.

The Community College Survey of Student Engagement (CCSSE, 2003) identified factors that can adversely impact student success and defined high-risk students as those who exhibit five or more of the following characteristics:

- Academic under preparation
- Single parenthood

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

- Financial independence
- Caring for children at home
- Working more than 30 hours per week
- Being a first-generation college student
- Part time college attendance
- Identifying cost as a significant attendance issue

In the same study, high-risk students were typified by the following behaviors:

- Less likely than low-risk students to seek a four-year degree (54% high risk compared to 64% low risk)
- Try harder academically than other students—not surprising because high-risk are "overcoming significant challenges to attend college" in the first place
- Less likely to come to class unprepared (26% self reported that they were never unprepared compared to 15% who were sometimes unprepared)
- As likely to study, even though 79% of the high-risk group worked more than 30 hours a week compared to 6% of the low-risk group
- More likely to find exams "extremely" or "quite" challenging (39% compared to 27% who did not find exams challenging)
- More likely to feel the financial pinch of college attendance.

Career preparation, career retraining, or the possibility of increased earnings encourages some individuals to seek postsecondary educational opportunities; however, financing such courses or training remains a major concern for many college students (Flint & Frey, 2003). According to Flint and Frey (2003), "financial problems constitute the most likely barrier adults face in completing a degree" (p. 71). And while access to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

financial aid may facilitate the entry of some students into postsecondary education, its impact on student success or achievement is less well known at this time. Financial aid for students attending college on a less than full time basis is a relatively recent phenomenon according to Flint and Frey (2003). This opportunity provides the means by which some students can take fewer courses in a semester, thereby allowing them to advance their educations on a part time basis.

Research on student self management by Macan, Shahani, Dipboye, and Phillips (1990) confirmed time management as a potential coping strategy for students who may find the academic experience of college to be stressful. Students who perceived they had "control of their time" by making lists, planning, and scheduling reported significantly higher student achievement.

Closely related to time management is the concept of self-regulation (Hofer, Yu, & Pintrich, 1998; and Zimmerman, 1994) defined as the process whereby students activate and sustain cognitions, behaviors, and effects that are systematically oriented toward the attainment of goals. According to Zimmerman (1994), there is evidence that a major cause of underachievement is the inability of students to effectively manage self-control. Underachievers are more impulsive, have lower academic goals, and are less accurate in assessing their abilities. They are more self-critical about their performance and tend to give up more easily than achievers. Self-regulated students are (a) self-starters who display extraordinary persistence on learning tasks; (b) confident, strategic, and resourceful in overcoming problems; and (c) usually are self-reactive to task performance outcomes (p. 5).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Thus far in the literature, students have not identified the use of computer technology as a factor that contributed positively to their academic success or achievement in college. This may be related to the level of comfort that students have or do not have with computer technology. In an effort to collect information related to students' perceptions of the extent to which computer technology has contributed to their learning, the researcher added a related question to the student interview instrument (Question #11).

Academic Under Preparedness of Two-Year College Students in the Field of Mathematics

The fall 2000 semester found 35% of entering freshmen at the nation's public two-year colleges and 16% of entering freshmen at public four-year colleges enrolled in pre-college level mathematics courses (Parsad & Lewis, 2003, p. 18). Although not listed specifically, the percentage of students who actually tested into pre-college level mathematics may have been higher than 35% and 16% since not all colleges required students who were identified to need pre-college level mathematics courses to enroll in them (Parsad & Lewis, 2003, p. v). An average of 70% of entering freshmen at Kirtland Community College placement-test into one of the two pre-college level mathematics courses that are taught every semester. Satisfactory completion of these courses or demonstrated competency of the learning objectives in these courses is recommended for preparation for the first college-level mathematics course offered at Kirtland Community College.

Therefore, since enrollment in pre-college level courses is encouraged, but not mandated, this fact may contribute to the decision by some students to bypass the prescribed courses and opt to immediately enroll in a college-level mathematics course. One reason for such a decision is that the credit hours for the pre-college courses do not

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

transfer to four-year institutions. Other students wait to take any mathematics courses until near the completion of their program requirements. The former behavior puts the student at additional academic risk with inadequate skills for the college-level mathematics course and the latter behavior can place undue pressure on the student to succeed under a time constraint of program completion or graduation.

Even with the opportunity to gain proficiency in pre-college level courses, only 52% of students who enrolled in pre-college level mathematics in Michigan's two-year colleges from 1995-1998 received a course grade of "C" or higher (MDE, 1999, p. 15). According to Kirtland Community College's primary academic counselor and director of testing, 56% of those students enrolled at Kirtland in pre-college mathematics courses passed with a grade of "C" or higher in the fall 2000 semester (Dyer, 2004).

Predominantly three groups of individuals comprise the population of students who test into pre-college level mathematics, according to Don Dyer, the primary academic advisor and counselor at Kirtland Community College (Dyer, 2004). One group is composed of individuals who successfully learned the mathematical skills in their previous educational experiences; however, a period of time has elapsed since that earlier learning experience and the skills are not readily intellectually accessible to the student to demonstrate competency on the placement test instrument. These students require only a review of the concepts to become satisfactorily prepared for the first college-level mathematics course.

Dyer describes a second group of students who were not exposed to the needed mathematical concepts in previous educational settings and are learning the skills for the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

first time. These students require an initial presentation of the concepts to be learned combined with activities to reinforce and promote understanding of the concepts.

The third group of students never successfully mastered the mathematical skills in previous educational settings although they were exposed to the concepts. The reasons for student lack of success related to mathematics are varied but could include inadequate maturity levels of some students to master the mathematical concepts at the opportunity of exposure. Some students in this third group may have reached their intellectual capacity in this content area but have been referred to the two-year college by third-party agencies such as Michigan Rehabilitation Services or Michigan Works! to prepare the students as much as possible for jobs. The myriad reasons for deficient mathematical skills of some students coupled with multiple styles of learning for individuals, support the thesis of this research—to increase success, students must have a wider range of course delivery modalities for all college courses in general and mathematics courses in particular.

The two pre-college level mathematics courses at Kirtland Community College are Basic Mathematics and Basic Algebra. In general, to receive a placement in Basic Mathematics, students were deficient in basic computation with whole numbers, fractions, decimals, proportions, and percents without the use of a calculator. Additional topics in measurement, geometry, and computations with positive and negative numbers complete the set of learning objectives for the course (DEV06300 Basic Mathematics course syllabus accessible at http://services.kirtland.edu/math/ftfac.htm).

Placement in Basic Algebra indicates deficient skills in topics that include basic operations with positive and negative numbers, exponents, algebraic expressions, and the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

solving of simple algebraic equations containing one variable. An additional fundamental set of concepts involves the graphing of a straight line, its associated function, slope of a line, and intercepts. (DEV07300 Basic Algebra course syllabus at http://services.kirtland.edu/math/ftfac.htm).

A Review of Selected Theories Related to Learning Styles and Constructivist Learning Theory

Extensive research exists on numerous theories that focus on the ways individuals learn and process information although the distinctions between "learning styles", that represents innate psychological characteristics or traits (Harrison et al., 2003), and "learning strategies" that students make adaptable in different situations are not always easily discernible. Harrison et al. (2003) contend that students do not possess a single learning style. Instead, they believe that students use a variety of approaches or strategies that combine their goals, motivations, nature of the learning task, the learning context, and the learning environment as well as their intelligence to master learning tasks. Moreover, Harrison et al. (2003) believe that a particular learning style of a student will change over time depending on the demands of the learning task (p. 47).

Learning can be a complicated endeavor; however, learning style theories put forward by Gordon Pask (1976), Jean Piaget (Gruber & Voneche, 1977), and Marton, Hounsell, & Entwistle (1984) provide a sound basis on which one can consider additional components that contribute to the learning process. Pask (1976), an early researcher on adult learning theory, categorized student learners into two types; "holists" and "serialists".

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Holists and Serialists

Holists use a deductive approach to learning and view concepts from a global perspective starting with generalizations and then seeking to find relevance of the concepts to be learned through the details of their personal experiences. These students may use analogies or illustrations in their attempt to understand concepts but they also may overlook important details or make invalid generalizations concerning the concepts to be learned (McKay, 2003, p. 37).

Serialists, on the other hand, use an inductive approach beginning with incremental pieces of mathematical concepts and logically build to a more complex understanding and generalization of the concepts to be learned (Pask, 1976). These students prefer to master step-by-step procedural details; however, they may be too concerned about the details to appropriately generalize the concepts they are attempting to learn (McKay, 2003, p. 37).

These two seemingly mutually exclusive approaches to processing information require that an instructor employs a minimum of two different approaches in his or her efforts to present concepts that students will process and learn. The approaches to teaching and learning may require that students read, listen, discuss, write, visualize abstract spatial concepts, or interact with other students or instructional media. Instructors may present mathematical concepts in a way that suits either the holist or the serialist but probably not both (Harrison et al., 2003). An approach to teaching and learning that incorporates both traditional lecture and computer-based instruction may provide the appropriate generalizations as well as details to meet the learning needs of both the holists and serialists in the same course with one instructor.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Students enrolled in a mathematics course that utilizes a traditional lecture modality will probably learn best when they relate well to the presentation approaches of the instructor. Otherwise, those students will miss opportunities to process mathematical concepts on which subsequent concepts will be built. One disadvantage of the traditional lecture modality is that the students experience the presentation of the mathematical concepts only once and do not have an opportunity to "replay" the presentations multiple times. Interactive software provides the students with opportunities to re-experience the presentations of the concepts more than one time with simulations that allow the mathematical parameters to change related to each particular learning concept. The hybrid modality allows for a presentation by the instructor and multiple interactive learning experiences of the concepts with the software. Repeated exposure of the students to the mathematical concepts may help them better process and learn those mathematical concepts required for advancement to college-level coursework.

Surface, Achieving, and Deep Approaches to Learning

Augmenting the description of learners as holists or serialists are three approaches to learning described as surface, achieving, and deep. Siva Sankaran and Tung Bui (2001) defined the surface approach to learning as characterized by the students memorizing facts or procedures with the intent of passing exams and receiving good grades without necessarily having full mastery of the concepts to be learned. The surface approach to learning is related to the traditional lecture teaching modality in which information is transferred from instructors to learners and in which learners maintain passive roles in the learning process (Dart et al., 2000). Barry Dart et al. (2000) defined deep learning as

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

characterized by an intention to seek meaning of the concepts being studied by using the concepts to elaborate and transform them. Without deep learning, students will simply imitate the instructor and not fully understand the concepts to be learned (Du & Havard, 2003).

The surface approach to learning treats learning as a quantitative increase in knowledge, memorization, and the acquisition of facts or procedures (Bessant, 1997; and Harrison et al., 2003). Students tend to memorize course content in order to reproduce it for exams over a relatively short timeframe. Motivated by external persons, events, or deadlines, surface learners are not as concerned with the value of the concepts being learned. Student workloads, anxiety, and poor learning skills can contribute to surface learning (McKay, 2003). According to the researchers, surface learners are externally motivated and rely on someone else such as an instructor to provide them with structure and deadlines (Marton et al., 1984).

Deep learners are described as individuals who have an interest in seeking a greater conceptual understanding of the content to be learned (McKay, 2003). Marton et al. (1984) describe deep learners as internally motivated learners who develop their own structures and timelines. Learning is considered an abstract process (Harrison et al., 2003). These learners are flexible and utilize both holistic and serialist learning skills to identify and enhance the relevance of the concepts to their lives (McKay, 2003).

Students who learn using the achieving approach accept the responsibility of completing specific tasks that can lead to success in an academic setting. They employ strategies such as organizing one's time and using appropriate study skills to accomplish their learning goals (Harrison et al., 2003; Hofer et al., 1998; McKay, 2003).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Motivation and Learning Strategies

Motivation and learning strategies are major components that interact with one another on a situational basis for students to enhance their learning (Harrison et al., 2003; McKay, 2003; and Perez & Foshay, 2002). McKay defines motivation as "a person's need, interest, or desire to learn" and is comprised of intrinsic and extrinsic factors.

Intrinsic motivational factors affect students when they are interested in developing skills, intellectual achievements, or self-improvement (McKay, 2003, p. 46). Extrinsic motivational factors, on the other hand, include recognition, obtaining a college degree, or earning a certain course grade. The more the learning concepts appeal to learners' intrinsic motivation, the deeper the level of learning (McKay, 2003, p. 46). A study by Illich, Hagan, and McCallister (2004) supported the theory that factors such as student motivation and the students' self-beliefs about their ability to succeed play a role in the academic achievement of under prepared college students (p. 450). Supporting these findings was a study by Stella Perez and Rob Foshay (2002) that concluded that learners who demonstrated a sense of motivation, time management, and program or academic goals were more successful than those who enrolled in nontraditional modalities to avoid class meetings.

Cross and Steadman (1996) studied and confirmed the effects of motivation on college students' success and achievement and concluded that self beliefs about students' ability to succeed at a learning task are more important than the actual skill levels or the difficulty of the task. A student's confidence in her or his own ability to learn is central to academic success. Students who can identify their learning needs, implement effective

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

learning strategies, and are in control of their progress are more successful at the learning experience than students who do not have the same skills (Harrison et al., 2003, p. 45).

Student learning can also be affected by the preference of a student to learn independently or in collaboration with others (McKay, 2003). McKay's research includes findings that indicate that interactions between students can facilitate and enhance the student learning environment (p. 44). Collaboration is a component of student learning that allows students to share their understandings of instructional concepts and build on the prior knowledge of each other. Collaboration between students is encouraged in the reforms of mathematics education (AMATYC, 1995, Standard P-2).

Constructivist Learning Theory

The reforms in mathematics education of the last fifteen years, and currently, are predicated on the theory of constructivism and the active role of the student in the learning process (NCTM, 1989, 1991, 1995, 2000; and AMATYC, 1995). Constructivism is a philosophy or belief about the process of learning that was originally put forward by the Swiss biologist and psychologist, Jean Piaget, in the 1950s (Gruber & Voneche, 1977). The main tenet of constructivism is that "(students) invent rather than discover their ideas" and "(students) construct their own mentality through their own activity" (p. xxxvii). Mary Ann Spencer Pulaski (1971) quotes Piaget as saying "Knowledge is derived from action.... To know an object is to act upon it and to transform it" (p. 197).

Since all students are at various levels of knowledge and experience, Piaget believed that educators must plan developmentally appropriate curricula that enhance students' logical and conceptual growth, and teachers must emphasize the critical role

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

that interactions with the surrounding environment play in student learning (Piaget on Constructivism, retrieved from www.funderstanding.com/constructivism/). Constructivism is a philosophy of learning, not teaching (Inch, 2002, p. 111) that places an importance on the process of learning (Brewer & Daane, 2002).

The instructor plays an important role in helping students construct accurate knowledge. Students sometimes construct knowledge that is only valid in specific circumstances (Ward, 2001). The instructor needs to offer varied situations that allow students to assess their conclusions and when students realize that their construction does not work with the new information, they can make the appropriate corrections and check again for validity.

Students' ability to visually connect concepts to prior learning in the effort to better understand the process was the focus of a study by Lauren Cifuentes and Yichuan Jane Hsieh (2003). The researchers believe that

> quality instruction provides learners with opportunities for practice with feedback, revision, and reflection. Students need to actively engage in learning activities that provide them with opportunities to negotiate meaning rather than simply to receive explanations of phenomena from those 'in the know' (Cifuentes & Hsieh, 2003, p. 1).

To what extent, if any, can computers be used to create a constructivist learning environment? Douglas Huffman, Fred Goldberg, and Michael Michlin (2003) introduced computers into 23 high school physics classes involving 13 instructors and 366 students. A unit on force and motion was selected for this comparison. The students' understanding of the concepts was measured with a nationally recognized assessment instrument, the Force Concept Inventory. Three groups of instructors were examined: (1) instructors who were experienced with the use of computers for instruction, (2) instructors who were

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

new to the use of computers for instruction, and (3) instructors who used a traditional teaching modality. Findings confirmed that students in the classes taught by the instructors experienced in the use of computers for instruction received the highest scores on the assessment instrument and students in the classes that utilized a traditional teaching modality received the lowest scores on the assessment instrument.

The visual spatial nature of mathematical concepts and simulations accommodated by computer technology may better engage some students and facilitate their learning processes by allowing them to build upon their current knowledge and construct new knowledge. The introduction of computer technology into pre-college level mathematics courses may allow students the opportunity to accelerate through concepts they master quickly and to spend more time on those concepts that require a longer time for them to learn.

Success and Achievement of Two-Year College Students Taking Mathematics Courses Structured Through Computer-Based Teaching Modalities and Traditional Lecture Modality

The National Council of Teachers of Mathematics believes that technology is essential in the teaching and learning of mathematics. Technology influences the mathematics that is taught and enhances student learning (NCTM, 2000, p. 11); however, not all instructors of mathematics universally embrace the idea of change. Prior to the mid 1990s, computer-based teaching modalities in mathematics were limited by the amount of computer memory and processor speed as well as the nascent status of instructional software development. More recently, expanded computer hardware capacity and affordability coupled with improved video, graphics, and interactivity of software have

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

created the potential for an instructional environment that improves student learning outcomes.

Bernard Gifford defines computer-based instruction as a learner-centered model since the student controls the pace and content of the instruction (Gifford, 1996). The individual student is at the center of the teaching and learning experience. Students are given access to technology and have considerable flexibility in the use of interactive multimedia instruction and assessment, the instructor, and a printed textbook (p. 2). Software that supports computer-based learning must be capable of providing students with a thorough presentation of the concepts and skills using voice, animation, video, text, and graphics. The instructor still remains an important component of instruction but is not the center of the learning experience. According to Gifford (1996), computer-based instruction allows the students to exercise more effective and efficient control over their own learning, secure real-time assessment and feedback, and receive more individualized learning assistance from the instructor (p. 18-19).

Gregory Williams (1996) studied student achievement and success in pre-college level mathematics using computer-based instruction as a supplement to a traditional lecture teaching modality for 199 students. Findings concluded that students utilizing the supplementary computer-based instruction received higher grades and had higher course completion rates than students utilizing the traditional lecture method.

Dixon, Dessens, Harris, and Neal (1990) compared the effectiveness of the traditional lecture teaching modality with a computer-based modality in a pre-college level mathematics course at Houston Community College. The curriculum for both groups was aligned with the Texas Academic Skills Program (TASP) curriculum and the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

groups were determined to be equivalent in the objectives to be learned. The group that utilized the traditional modality (*N*=46) met for 2 hours per day for 4 days per week for 6 weeks and the group that utilized the computer-based modality worked in a lab with tutorial help on request during specified hours. Findings showed that the test scores were significantly higher for the students in the computer-based modality (Dixon et al., 1990, in Foshay, 1994, p. 11).

"A meta-analysis of findings from twenty-four controlled evaluations of computer-based instruction showed that computer-based education usually has positive effects on adult learners" (Kulik, Kulik, & Shwalb, 1986, p. 235). Criteria for inclusion in this meta-analysis were: (a) studies had to be actual field studies in which adults received for-credit instruction, (b) studies had to provide quantitative results on outcome variables measured in the same way in both the computer-based and traditional teaching modalities, (c) studies not included were those with different rates of subject attrition from the groups being compared or "teaching" of the criterion test to one of the comparison groups, and (d) studies had to be retrievable from university or college libraries.

Results from the Kulick et al. meta-analysis (1986) indicated that higher examination averages were found in nineteen of the studies that utilized computer-based instruction compared to higher examination averages in four of the studies that utilized the traditional teaching modality. Both quasi-experimental studies and true experiments produced similar results (p. 248). And "one of the more dramatic findings was the reduction in instructional time associated with computer-based education" (p. 249). On average 71% of the instructional time required by traditional teaching modalities was

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

needed in total for the computer-based instruction as reported by twelve of the thirteen studies reporting instructional time as a variable.

Bernadette Anne Beyer Sandruck (2003) studied the achievement levels, success rates, and retention of 50 students who took elementary algebra that utilized a traditional teaching modality and 62 students who completed the identical course in an interactive computer-based environment. The setting for this study was a mid-sized suburban two-year college in Maryland and the two groups of students were demographically similar in age, gender, ethnicity, high school mathematics background, credits attempted, study hours per credit, work hours, absentee level, and time-of-day of instruction. Results indicated that there were no statistical differences in student achievement between the two teaching modalities. Students did, however, appreciate the flexibility of computer-based modality.

Not all results were positive for computer-based instruction for studies focused on pre-college level mathematics courses. Donald Ely (1993) described four aspects of computer technology in education in the United States: (1) the number of computers available to students and teachers, (2) the location and type of use of the computers, (3) the impact of the use of computers, and (4) hypotheses concerning non-use, limited use, or inappropriate use of computers. Ely estimates that every institution of higher education in the United States has computers available to students, faculty, and administrators. The uses of instructional software are varied but include 30% utilized as conceptual tools for instruction. Ely's conclusion is that computer-based instruction in schools and universities in the United States has had minimal impact. "By any measure of learning

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

achievement, significant changes in styles of teaching and learning, or curriculum reform, the conclusion is little or no effect" (p. 55).

Research by Cynthia Miglietti and C. Carney Strange (1998) challenges the more recent conclusions that college students are independent, practical, and oriented toward experiential modes of learning. Findings from their study indicate that students prefer an instructor-centered teaching modality and less concrete, hands-on forms of learning in pre-college level mathematics courses although "serving students well should include examining students' preferences for different teaching styles as well as their expectations of the classroom environment." (p. 1). Students indicated a preference for an instructor-centered teaching modality, in part, because all of the mathematics courses in this study used a traditional lecture modality. Mathematics instructors in this study chose to use a traditional teaching modality only so students did not have the opportunity to experience different modalities that may have better matched some students' learning styles. Student exposure to varying teaching modalities for the mathematics courses may have resulted in more diverse student preferences for teaching modalities other than traditional lecture.

Their study involved student records and surveys for 156 students who completed courses in pre-college level mathematics and English at a two-year college in Ohio with a student population of 1500 (Miglietti & Strange, 1998). The major variables included student preferences for teaching modality, classroom environment, learning styles, course grades, student accomplishment, experience of the instructor, and student age. Student accomplishment, as perceived by the student, reflected the degree to which the course helped increase the student's knowledge, skills, and competencies in comparison to other

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

courses taken. Experience of the instructor reflected the teaching, content, readings, tests, outside activities, and homework associated with the course.

The variable "gender" may have been confounded by other variables such as age. Many students in two-year colleges who are older than 25 years are females seeking educational opportunities following an extended absence from formal education (Miglietti & Strange, 1998). In Miglietti and Strange's study, 85% of the nontraditional-aged students were female and 75% of the under-25 age group were female.

The teaching modalities were assessed by Conti's Principles of Adult Learning Scale (Miglietti & Strange, 1998) and ranged from a learner-centered teaching modality that incorporated collaboration between the instructor and students in the teaching/learning process to a more teacher-centered teaching modality in which the instructor had the authority related to the teaching/learning process. The instructor self-reported teaching modality for the mathematics courses was exclusively teacher-centered preventing any consideration of learner-centered teaching modalities in that content area.

The ages of the students were of interest in the context of traditional-aged students (18-24 years old) compared with nontraditional-aged students (25 years or older). Student age did not account for a significant amount of the variance in students' expectations of the classroom environment and learning styles; however, the non-traditional-aged students in the mathematics courses received higher grades and reported a greater sense of accomplishment and a more positive total course experience than did younger students. Researchers theorized that these students may have had low initial expectations of course success, and that by successfully completing the pre-college level

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

mathematics courses, they experienced an elevated sense of accomplishment from an instructor-centered teaching modality.

The assessment of learning styles utilized Kolb's Learning Style Inventory (Miglietti & Strange, 1998). This instrument measures a student's preference on each of four learning styles: (1) concrete experience, (2) reflective observation, (3) abstract conceptualization, and (4) active experimentation. Also measured were the students' preferences for abstractness over concreteness and action over reflection.

John Rachal (1993) examined twelve studies that compared the effects of computer-based instruction and modalities that did not incorporate computers. To be included in Rachal's meta-analysis, the studies had to meet the following criteria: (a) the studies had to be actual field studies examining basic skills, such as pre-college level reading or math among adult populations; (b) utilization of experimental or quasi-experimental designs using a computer-based teaching modality with a control or comparison group using a traditional teaching modality; (c) pre and post testing had to be completed with all groups; and (d) publication occurred during or after 1984.

The experimental designs of the twelve studies examined by Rachal (1993) were not identical. The length of the treatment periods, the number of participants in each study, the lack of consistency concerning the randomization of participants, differing software packages, and inconsistent designs were some of the limitations in these studies. Although ten of the twelve studies suggested that use of a computer-based teaching modality resulted in at least as good as and sometimes better than the use of a traditional teaching modality, two of the studies indicated that use of a traditional teaching modality yielded higher levels of achievement than use of a computer-based teaching modality.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Results indicated that there were no statistical differences in student achievement between the two teaching modalities. Students did, however, appreciate the flexibility of computer-based modality. The finding of no statistical difference between the two groups in Rachal's study (1993) offers support to the concept that students should have more choices of teaching modalities available to them.

Two Australian researchers, Sandra Wills and Carmel McNaught (1996), also studied the effectiveness of computer-based instruction compared with traditional teaching modalities. They caution that the comparison of teaching modalities is only valid if the content of the instruction is identical and the computer is the only variable causing the learning effect (p. 114). The researchers are careful to note that future studies may want to consider that not all assessment and evaluation procedures are sensitive to the fact that different teaching modalities from traditional to computer-based may create the need for different student learning objectives that require appropriate changes in the types of assessment. Traditional student assessment techniques may not be appropriate to assess the level of student learning that is possible with interactive computer simulations.

Success and Achievement of Two-Year College Students Taking Mathematics Courses Structured Through Hybrid Teaching Modalities

Research exists that indicates that although computer-based instruction has positive results, it is more successful when it is used in combination with traditional teaching modalities (Cox, 1990; Oxford, Proctor, & Slate, 1998; Villarreal, 2003). The degree of success in blending the two modalities and the accompanying emphasis on one modality or the other is not uniform across the literature.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Hybrid approaches range from using computer-based instruction as a substitute for paper and pencil drill and practice exercises with the lecture modality as the primary instructional experience for students to computer-based instruction as the primary teaching modality. The lecture component of the hybrid modality could provide organization and structure for the students and the computer-based component could accommodate differing learning styles as well as provide problem-solving situations for the students that are more complex than could be taught with the lecture modality.

Students interacting with computer software that allows them to create and construct further mathematical knowledge is compatible with the tenets of constructivist learning theory (Perez & Foshay, 2003) and the reforms of mathematical education (NCTM, 1991; AMATYC, 1995, Standard P-3). Mathematical concepts presented in an interactive format with the students using animation, graphics, voice, video, and simulations puts the instructor in a secondary role and facilitates students building new knowledge (Kinney & Robertson, 2003), and the computer-based interactive instruction could provide the primary instructional experience for them.

Instruction that is delivered primarily through a traditional lecture modality is considered teacher-centered and instruction that is experienced as primarily computer-based is considered student-centered (Gifford, 1996; Kinney & Robertson, 2003). The strength of the hybrid modality is that it accommodates different learning styles (Kinney & Robertson, 2003). The traditional modality allows students to hear, speak, and converse with the instructor and other students in the language of mathematics and the computer-based modality allows students the opportunity to move through the mathematical concepts at their own pace with multiple chances to "replay" the presentation of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the concepts with the software. Privacy for students and interactive feedback are enhanced in the computer-based instructional environment (Perez & Foshay, 2003).

One study involving a hybrid teaching modality was conducted by Laura Villarreal (2003) at a two-year college in Texas. She began supervising self-paced, computer-based, pre-college level algebra courses in a technology lab with 60 computers. Students were not given a choice in the modality of instruction and met in the lab five days per week, for six contact hours per week. The lab was staffed with one faculty member and several student tutors who assisted students with mathematical content and technical software difficulties. Students were given a list of the computer assignments that needed to be completed by the end of the semester. Villarreal found student achievement and success to be lacking in this computer-based modality.

According to the researcher, the majority of the students lacked the self-discipline and motivation needed to complete the coursework. Many students procrastinated until the last day of the semester to complete the assignments and most of those students were unsuccessful in the course. Villarreal decided to redesign the courses to provide a higher degree of structure and organization by combining a traditional lecture component to the computer-based instruction. The instructional software was installed on computers in other labs on the campus to provide students with additional access to the technology. Results on a departmental final examination revealed that the exam average was higher in the courses taught with the hybrid modality. Villarreal concluded that students in pre-college level mathematics courses who have a choice of teaching modalities for overcoming academic deficiencies will perform better if only because they have a vested interest in their choice.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Gregory Cox (1990) designed a study to determine the effects of computer-based instruction using software that supplements a textbook for a college algebra course. The students were randomly assigned to one of two groups that utilized a traditional lecture modality without the software or to an experimental group that used the software as drill and practice to supplement the traditional lecture modality. Results indicated that the achievement of those students who supplemented the traditional lecture modality with software received significantly higher scores than those students who experienced the traditional lecture modality only.

Oxford et al. (1998) reported statistically greater gain scores for adult students in a two-year technical institute in a Southern state who were enrolled in a beginning algebra course utilizing a hybrid teaching modality than students who took the same course that utilized a traditional lecture teaching modality. The two research questions were as follows: (1) is there a statistically significant difference in algebra achievement between computer-based and traditional instruction for students enrolled in a post-secondary technical institute? And (2) what are student attitudes toward having used computers in the algebra course?

Archival data over a two-year time period from 1993 to 1995 was collected although information regarding students' ethnicity and gender were not collected. Student assignment into each teaching modality was based on computer lab availability. Those students in the courses without computer-based instruction comprised the traditional group (N=56) and those students in computer lab comprised the hybrid group (N=59).

A pretest-posttest quasi-experimental design and no random assignment of the 115 students into the two teaching modalities occurred. The pretest instrument was the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Algebra section of the ASSET Placement Test (Version 2B) and the posttest instrument was Version 2C of the same test. The gain score for each student was calculated by subtracting the pretest score from the posttest score. Student interviews were conducted with a survey instrument composed of six open-ended questions concerning the students' feelings related to the algebra course and computer use.

The hybrid teaching modality consisted of a combination of lecture and computer-based instruction. The students worked on mathematics concepts for several days before they were made aware that their class would utilize computer-based instruction with PLATO software. They were then given the choice to proceed with the hybrid modality or use traditional paper and pencil worksheets for their assignments. After hearing a concept discussed, the students were then taught the same concept using tutorials and exercises on the computer. During the end of the ninth week of a ten-week quarter, the students were given the posttest instrument in a typical classroom setting using paper and pencil.

The results of the study by Oxford et al. (1998) showed statistically significant greater gain scores for students who were in the courses that utilized the hybrid teaching modality compared with the students who experienced the traditional lecture teaching modality. Forty-three percent of the students who participated in the interviews indicated that they had no computer experience prior to taking the course and 86% of them did not have a computer at home. Sixty-three percent said that they were not good in math and 36% of the participants were afraid of taking math courses. Seventy-nine percent of the participants felt that the enhancement of their ability in mathematics was a direct result of use of the computer component of the courses.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The goal of incorporating technology into pre-college level mathematics courses is not to develop a single instructional model that best meets the needs of all students but rather to offer students more choices in terms of "where, when, and how" they learn mathematics. Instruction that allows students to learn using technology and their preferred learning style can lead to improved student outcomes (Kinney & Robertson, 2003).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

Conceptual Model

The assessment of the effectiveness of two different teaching modalities implies that the only difference between the two groups undergoing comparison is the actual method of instruction or teaching modality (Cook & Campbell, 1979). The learning objectives for both groups would be the same and the instruments used to measure student achievement would be identical. One conceptual guide for assessment activities in higher education was developed in the late 1960s by Alexander W. Astin (1993) and that model has been used in educational research for over three decades (Nedry, 2003).

Astin named his conceptual guide the Inputs-Environment-Outputs (I-E-O) model. Inputs refer to those factors the student brings initially to the mathematics course such as demographic information, part time or full time student status, employment status, placement score, and other independent variables. The Environment refers to the two teaching modalities to be compared, and the Outputs refer to the dependent variables that are the measurements of student achievement and success. Figure 1 gives a visual depiction of the model.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

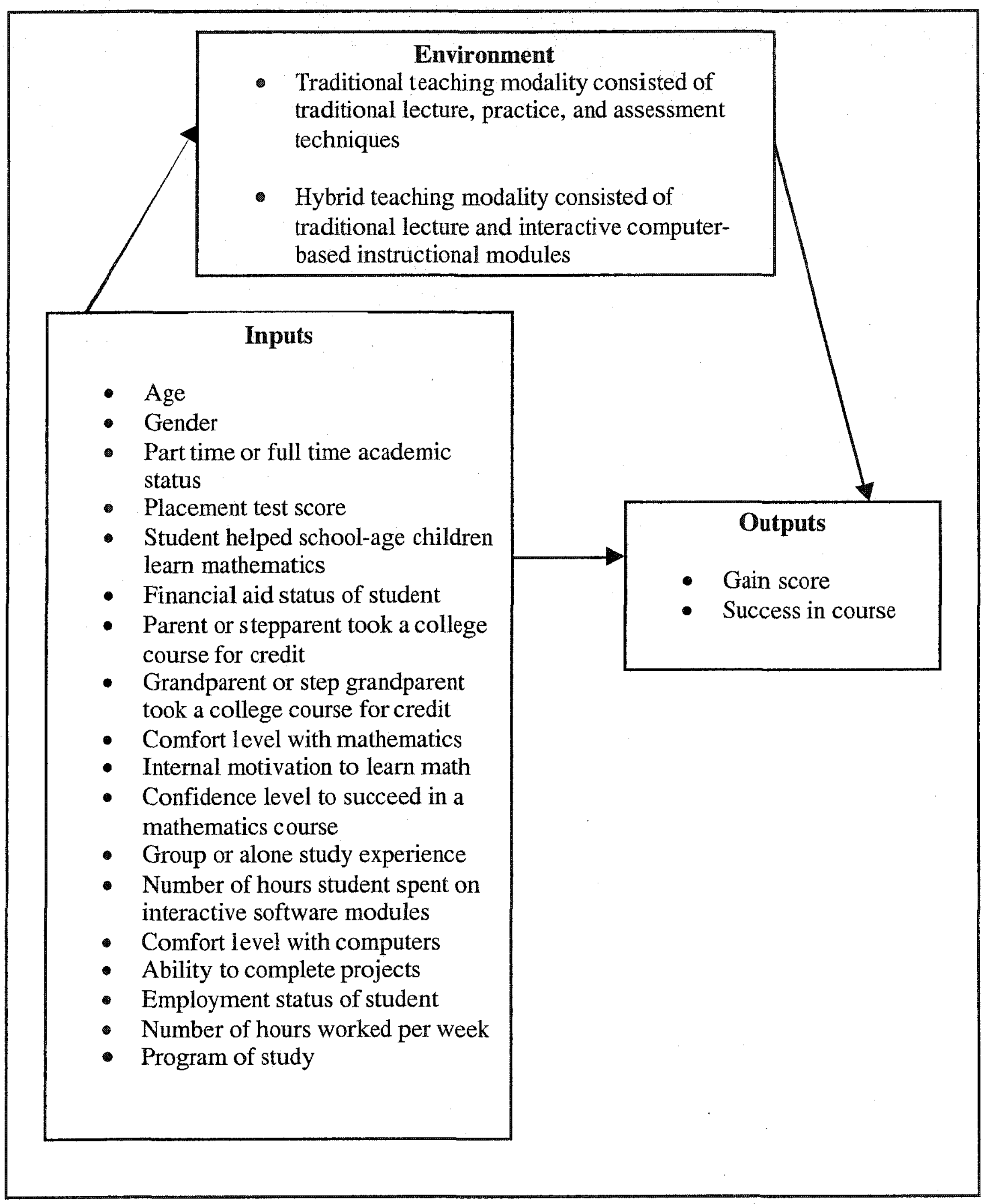

Figure 1. Astin's I-E-O Model and Variables for This Study.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Definitions

The following terms are defined for use in this study:

Computer-based instruction: Education or training in which instructional concepts are presented and/or reinforced using computers and interactive software.

Daytime section: A course offered between the hours of 8:00AM and 6:00PM.

Full time Student Status: 12 or more credit hours taken by a student in one semester.

Gain Score: Posttest score (final exam taken last week of course) minus pretest score taken first week of course.

Hybrid Teaching Modality: An instructional delivery method that combines traditional lecture with an instructor and computer-based modular instruction. Interactive instructional activities are self-paced to allow students to spend more or less time than other students on instructional concepts. Mathematical skills proficiency is demonstrated with computer-based assessment components.

Online Teaching Modality: Education or training that is primarily delivered online via the Internet, rather than in a classroom.

Open Learning: A learning environment utilized for selected courses and programs at Kirtland Community College that allows students to register and begin courses at any time during the academic semester, work at their own time and pace in possibly various locations, and complete their course learning objectives faster than a traditional course delivery system.

Part time Student Status: Less than 12 credit hours taken by a student in one semester.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

PLATO: An instructional software program produced by PLATO Learning, Inc. that includes a modular, self-paced, individualized learning environment with concept tutorials and practice, interactive presentation of concepts, and student learning assessment components.

Pre-college Level Courses: Courses in reading, writing, or mathematics for college-level students lacking those skills necessary to perform college-level work as defined by the institution (Parsad & Lewis, 2003, p. iii).

Pre-college Level Mathematics: Basic Mathematics and Basic Algebra are the two pre-college level mathematics courses at Kirtland Community College. Each two or four-year college defines and names the pre-college level mathematics courses unique to its institution.

Student Achievement: Measured in gain scores.

Student Success: Measured by a course final exam score of 70% or higher.

Traditional Lecture Teaching Modality: An instructional delivery method that utilizes instructor lecture as the primary way that instructional concepts are presented to students in a group. Concepts are reinforced predominantly with paper-and-pencil drill and practice activities. Mathematical skills proficiency is demonstrated with paper-and-pencil assessment instruments.

Data Resources

Kirtland Community College has two campuses; its central campus is located near Roscommon, Michigan and its satellite campus is located 54 miles north of central campus in Gaylord, Michigan. Kirtland's central campus provides students with a variety

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

of instructional modalities for several content areas. These modalities include traditional lecture, online, and open learning modalities for select courses and select programs. The pre-college level mathematics courses on Kirtland's central campus utilize predominantly the traditional lecture modality although recently, an online modality for pre-college level mathematics has been piloted. Kirtland's satellite campus utilizes an open learning environment for the majority of its courses and programs and is piloting the hybrid teaching modality for its pre-college level mathematics courses.

Students included in this research from Kirtland's central campus were enrolled at the beginning of the winter 2004 semester in the Basic Math and Basic Algebra courses in the daytime sections utilizing the traditional lecture teaching modality. Also included were students on Kirtland's satellite campus enrolled in the Basic Math and Basic Algebra courses in the only teaching modality that was offered to them, a combination of the traditional lecture and computer-based instruction—the hybrid modality. The students on central campus did have a choice of instructor, day, and time since several sections of each course were offered; however, the students at the satellite campus had no choice as to instructor, day, and time since there was only one section of each course offered during the winter 2004 semester.

Data for this study were obtained from four sources: student records in the Student Services department of Kirtland Community College, faculty assessment records, the administrative management component of the interactive software program, and student participant responses from a telephone interview survey instrument designed by the researcher. The Student Services department on central campus maintains all student records for both campuses and the administrative management component of the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

instructional software is maintained at the satellite campus only. The administrative management component of the interactive software provided the number of hours and minutes that students in the hybrid teaching modality spent on the interactive software activities for each module.

Data for this study were imported into the Statistical Program for the Social Sciences (SPSS v 11.5) for analysis and stored on CD as detailed in Human Subjects Institutional Review Board protocols at Western Michigan University.

Research Design

The purpose of this research was to compare the effectiveness of a traditional teaching modality and a hybrid teaching modality in pre-college level mathematics courses. The research design for the qualitative portion of the study consisted of a telephone interview of eleven structured questions with responses (Creswell, 1998) and the research design for the quantitative portion of the study consisted of an ex post facto quasi-experimental design with nonequivalent groups without random assignment (Cook & Campbell, 1979). The potential number of participants for this research totaled 208 students from both campuses of Kirtland Community College who enrolled in daytime sections of Basic Math or Basic Algebra for the winter 2004 semester and were taught with the traditional or hybrid teaching modalities.

Approval to use student records and information received from the students at the college for this study for the purposes of improving instruction was received from the president of Kirtland Community College. Please see Appendix A for the approval letter. Human Subjects Institutional Review Board (HSIRB) of Western Michigan University

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

approved this research and the methods of data collection. Please see Appendix B for the approval letter.

Informed Consent

Since informed consent of the students to participate in the study needed to be ascertained at the time of the telephone interview, the interview comprised the first part of data collection process. Information concerning the names, addresses, and telephone numbers of those students enrolled in the courses of interest was requested and received by the researcher. A Pre Notice Letter of the interview was sent to all 208 potential student participants a week prior to the start of the telephone interviews. Please see Appendix C for the Pre Notice Letter.

Risks to Participants

As in all research, there may be unforeseen physical or psychological risks to each participant. In the physical realm, participants may have been inconvenienced at the time of the telephone contact. The day or time of the call and its duration may have interfered with other personal or family experiences that were in progress at the time of the call.

Psychologically, some participants may have felt self-conscious about the researcher knowing that they were enrolled in a pre-college level mathematics course as well as other information related to the course. Some students may have been embarrassed that they had tested into a pre-college level course of any kind.

To minimize the possible risk of inconvenience to the potential participant, the interviewer asked at the time of the telephone call whether or not it was a convenient time

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

for the potential participant to receive the call. If it was not convenient, the researcher asked the student whether or not he or she would like to schedule a more convenient time for the call. Depending on the response of the student, the call was either rescheduled or the student was thanked for his or her time and omitted from the study.

To minimize the possible risk of embarrassment of the student that he or she tested into a pre-college level mathematics course, the interviewer offered the student the option of terminating the call if the student felt uncomfortable answering any of the questions or participating any further in the interview.

Confidentiality

To assure confidentiality of the participants, each of the potential participants received a code number and the student identifying information was kept on a separate master list from the actual Interview Guides that were used to collect the responses of the participants. The date, start time of call, end time of call, call length, and comments were recorded on the Interview Guide.

Interview Process

Calls and interviews were conducted by the researcher and two additional persons who had experience with interviewing techniques. The researcher led a training session for the interviewers to assure that identical procedures were followed and the Interview Guide was read to participants exactly as written. In an effort to increase the response rate for the interviews, each potential participant was called several times until contact with the interviewee was made or until it was determined that he or she was unreachable for

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

this interview. Messages were left on answering machines to anticipate a future call by the interviewer or to have the interviewee call the interviewer back if he or she was interested in participating in the study. Informed consent was received at the time of the call but prior to the interview. Subsequent to verification that the name of the person receiving the call matched the identification of the student who enrolled in the course of interest for the study, the interviewer read the script for the interview exactly as written in the Interview Guide. If the student responded in the negative, he or she was thanked and the call was terminated.

The eleven independent Input variables (Astin, 1993, p. 18) for this study were as follows:

- Student employment status during the winter 2004 semester (Question 1)
- Student was a first-generation college student (Questions 2 and 3)
- Student studied alone or with others (Question 4)
- Student helped school-age children learn mathematics concepts (Question 5)
- Student comfort level with mathematics (Question 6)
- Student internal motivation to learn mathematics (Question 7)
- Student confidence level to succeed in mathematics course (Question 8)
- Student comfort level with computers (Question 9)
- Student's ability to complete a project once begun (Question 10)
- Student belief that computers contributed to their learning in college (Question 11)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Some interviewees wanted to know the specific information that would be accessed from their student record file. The interviewer answered the questions with the appropriate information. Please see Appendix D for the Interview Guide.

Reliability

Issues related to the reliability of responses were addressed in the training session by including the following instructions to the interviewers:

1. Read the introductory statement to introduce the survey and establish rapport.

2. Impress the respondent with the importance of the interview and of each answer.

3. Read the questions exactly as they are written in a slow steady voice.

4. Read the questions in the same order.

The interviewers asked if the interviewee would like to have any questions repeated (SPSS, 1997).

Request for the secondary data from student records was made only for the 86 students who gave consent and agreed to participate in the telephone interview.

Variable Dictionary

The dependent and independent variables are defined and described below in Table 1.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 1

Variable Dictionary

Dependent Variables		
Name	Type	Description
GAIN	Ratio/continuous	Gain score. The final exam score minus the pretest score. Gain is the measure of student achievement.
SUCCESS	Categorical/dichotomous	Success in course. Variable where 1=final exam score of 70% or higher, 0 otherwise. Success is the measure of student success in the course.
Independent Variables		
Name	Type	Description
IDCODE	Nominal	Student code number.
COURSE	Categorical	Pre-college level mathematics course of interest. 1=DEV06300 Basic Math, 2=DEV07300 Basic Algebra
SECTION	Categorical	Section. Two digit number for each section e.g. 00, 01, 02, etc
MODALITY	Categorical/dichotomous	Teaching modality. 1=Traditional, 2=Hybrid
CALLLEN	Interval/continuous	Length of telephone call in minutes for interview.
PRETEST	Interval/continuous	Pretest score.
POSTTEST	Interval/continuous	Final exam score.
AGE	Interval/continuous	Student age in years at the beginning of the winter 2004 semester.
GENDER	Categorical/dichotomous	Student gender. 1=Female, 0=Male
PTFTSTAT	Categorical/dichotomous	Part time or full time student status. 1=Part time when student takes less than 12 credit hours, 0=Full time when student takes 12 or more credit hours
PLACEMNT	Interval/continuous	Placement test score.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 1—continued

CHILDREN	Categorical/dichotomous	Student helped school-age children with mathematics. 1=yes, 0=No
FINAID	Categorical/dichotomous	Student financial aid status. 1=student on financial aid, 0=No
PARENT	Categorical/dichotomous	Parent or step parent took a college course for credit. 1=Yes, 0=Otherwise
GRAND	Categorical/dichotomous	Grandparent or step grandparent took a college course for credit. 1=Yes, 0=Otherwise
COMFMATH	Interval/discrete	Student level of comfort with mathematics. 1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high, 6=Don't know, 99=No answer
MOTIVATE	Interval/discrete	Student level of internal motivation to learn mathematics. 1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high, 6=Don't know, 99=No answer
CONFIDEN	Interval/discrete	Student level of confidence to successfully complete a math course. 1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high, 6=Don't know, 99=No answer
STUDY	Categorical/dichotomous	Group or solo study experience of student. 1=Studied alone, 0=Otherwise
HRSSOFT	Interval/continuous	Number of hours students in hybrid modality spent on interactive software.
COMFCOM	Interval/discrete	Student level of comfort with computers. 1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high, 6=Don't know, 99=No answer
PROJECT	Interval/discrete	Student level of ability to complete a project once begun. 1=Very low, 2=Low, 3=Moderate, 4=High, 5=Very high, 6=Don't know, 99=No answer
EMPLOY	Categorical/dichotomous	Employment status of student. 1=Employed, 0=Otherwise
HRSWORK	Interval/continuous	Number of hours worked per week.
PROGRAM	Categorical	Program of study. 1=Career Tech but not Nursing, 2=Nursing, 3=Other
COMPUSE	Categorical/dichotomous	Computer use by student contributed positive-ly to student learning. 1=Yes, 0=Otherwise

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Hypotheses

The focus of this research was "Does the hybrid teaching modality more positively impact student achievement and success than the traditional teaching modality for pre-college level mathematics courses?" Student achievement was measured by gain scores and student success was measured by a course final exam score of 70% or higher.

The following hypotheses were tested:

H_1: Student achievement in the hybrid teaching modality was the same as student achievement in the traditional teaching modality in pre-college level mathematics courses.

H_2: Student success in the hybrid teaching modality was the same as student success in the traditional teaching modality in pre-college level mathematics courses.

Analyses

Descriptive and inferential statistical techniques using SPSS v 11.5 were used for the analyses. Inferential techniques included Chi-Square, *t*-tests, and logistic regression. The difference between the posttest score and the pretest score comprised the gain score for each student and the Student's *t*-test was used to determine whether or not a significant difference existed between the gain scores of the students in the traditional and hybrid teaching modalities for the Basic Mathematics course. A pretest was not given to the students in the Basic Algebra course who experienced the hybrid teaching modality, so no *t*-test could be conducted for the scores in the Basic Algebra course. Chi-square was used to determine whether or not a significant difference existed for the number of successful course completions in each modality and logistic regression was used to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

determine which independent variables were attributed with influencing the successful course completion of students.

Logistic regression was the appropriate statistical technique to use to predict the dependent variable, student success, since student success was a categorical and dichotomous (Mertler & Vannatta, 2001; SPSS, 1997). Logistic regression is preferred in predicting a dichotomous dependent variable where the regression coefficients can be used to estimate odds ratios for each of the independent variables in the model.

One assumption that is not necessary for logistic regression is the existence of homoscedasticity, i.e., equal variances of the error term (Berman, 2002, p. 140). The reason for not requiring homoscedasticity for logistic regression is that there is a functional relationship (s = square root of (p)*(1-p)) between the mean and standard deviation across the zero and one values of the dependent variable. The logistic function is bounded by 0 and 1 and is appropriate for the prediction or calculation of the probability of the event SUCCESS. One other assumption that need not be made in logistic regression is that the independent variables are normally distributed (SPSS, 1997).

The assumptions necessary for logistic regressions are: (a) the dependent variable (student success) is dichotomous; (b) the independent variables are interval, ratio, or dichotomous; and (c) all relevant predictors are included, any irrelevant predictors are not included, and the form of the relationship is linear (SPSS, 1997).

Logistic Regression Model

Logistic regression is based on probabilities, odds, and the logarithm of the odds (Mertler & Vannatta, 2001). In this study

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

$y = \text{probability(success)} = e^u/(1+e^u)$, where $u = b_0 + b_1*x_1 + b_2*x_2 + \ldots + b_{18}*x_{18}$,

where

y = student success in course

x_1 = student age

x_2 = student gender

x_3= part time or full time status of student

x_4 = placement test score

x_5 = student helped school-age children learn math

x_6 = financial aid status

x_7 = parent or stepparent of student took a college course for credit

x_8 = grandparent or step grandparent took a college course for credit

x_9 = comfort level with mathematics

x_{10} = student level of internal motivation to learn mathematics

x_{11} = confidence level to succeed in a mathematics course

x_{12} = student studies alone or in a group

x_{13} = number of hours spent on interactive software by student

x_{14} = student level of comfort with computers

x_{15} = student level of ability to complete projects once begun

x_{16} = employment status of student

x_{17} = number of hours worked per week by student

x_{18} = program of study

e = the base of the system of natural logarithms which equals

2.71828182846

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

b_0 = constant

$b_1, \ldots b_{18}$ = coefficients of the independent variables for the model

The probabilities are simply the number of outcomes of a specific type expressed as a proportion of the total number of possible outcomes. The effect of an independent variable on a dichotomous dependent variable is usually represented by an odds ratio. In logistic regression, the probability of success is based on a nonlinear model resulting from the best linear combination of the independent variables.

Although all of the independent variables were initially considered for inclusion in the logistic model, only those independent variables that were statistically significantly correlated with student success were ultimately included in the predictive model.

Threats to Internal Validity

Internal validity refers to the concept that the researcher is measuring that which is intended to be measured (Cook & Campbell, 1979, p. 50) and external validity refers to the concept that inferences from the study can be generalized to various persons and settings (Cook & Campbell, 1979, p. 70).

The use of logistic regression to predict a dependent variable based on the interactions of independent variables is predicated on the fact that at least some of the dependent and independent variables covary with one another. Once it has been established that the variables in a study covary with one another, the issue of which independent variable(s) causes an effect on the dependent variable(s) can then be considered and issues related to threats to internal validity are then pertinent and germane to the inferences that are made (Cook & Campbell, 1979, p. 50).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Drawing conclusions of covariation between variables can be impacted by the validity of the relationships between the variables. Making the appropriate decisions concerning the extent to which one or more independent variables cause measurable effects on the dependent variables can be affected by threats to internal validity. Threats to internal validity may act separately or in combination and are usually never completely eliminated from a study. Threats to internal validity are most often mitigated by the design of the experiment (Cook & Campbell, 1979).

The most common threats to internal validity are listed and described below.

History is a threat when an observed effect may be due to an event that takes place between the pretest and the posttest and this event is not the treatment of research interest (Cook & Campbell, 1979, p. 51). Since the Basic Mathematics course involved fundamental computational skills, students who helped children learn mathematics during the same time frame that they were enrolled in the course of interest may have learned those skills from this interaction with children instead of from either the traditional or hybrid teaching modality. The effects of students' achievement and success by helping school-age children learn mathematics could not be controlled for in this study.

Maturation is a threat when an observed effect may be due to the students' growing older, wiser, stronger, or more experienced between the pretest and posttest and when this maturation is not the treatment of research interest (Cook & Campbell, 1979). Maturation may have occurred and was not controlled for in this study.

Testing threatens internal validity when an effect may be due to the number of times particular responses are measured. Familiarity with a test can sometimes enhance performance because test items may be remembered at later testing sessions (Cook &

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Campbell, 1979). This threat is mitigated when different forms of the same assessment instrument are used instead of using the same test multiple times. The same assessment instruments were not used more than once. The final exams for the courses of interest were different forms with different problems than the pretests; this issue should not have adversely impacted internal validity.

Instrumentation is a threat when an effect may be due to a change in the measuring instrument between the pretest and posttest (Cook & Campbell, 1979). The effects of instrumentation will be worsened if the scales between items on the assessments vary between the pretests and posttests. The scales between the pretests and posttests were not identical so instrumentation could not be controlled for in this study.

Statistical regression threatens internal validity when a selection to be part of a study is made based on an extremely low or extremely high score. If someone scores extremely high or low on a test, his or her next score would tend to go in the opposite direction causing an incorrect attribution of the cause to the independent variable. Variables that are normally distributed usually regress to their average values (Cook & Campbell, 1979). Since all of the students in this study placement-tested into pre-college level mathematics which are the lowest level of mathematics courses offered, statistical regression is a possible threat to internal validity for this study.

Selection is a threat to internal validity when an effect may be due to the difference between the kinds of people in one experimental group as opposed to another. Different groups may receive different treatments instead of probabilistically equivalent groups receiving treatments as in a randomized experiment (Cook & Campbell, 1979). Selection may have occurred in this study since the students at the satellite campus were

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

predominantly in health careers and other career technical programs of study. The students on main campus included students in transfer programs as well as health careers and other career technical programs.

Mortality threatens internal validity when participants drop out of the study prior to the completion of the research. Some students did drop the course in which they were enrolled prior to the end of the semester so that a final exam was not taken and the corresponding gain score could not be measured. Mortality could not be controlled for in this study.

Design contamination threatens internal validity when participants may be aware that they are included in a study and their behavior or results may be thus affected. Students and instructors were not aware of their participation in this study during the winter 2004 semester. The first opportunity for the students to become aware of their participation in this study was at the time of the telephone interview. Design contamination is not a factor in this study.

The research design for the quantitative portion of the study consisted of an ex post facto quasi-experimental design with nonequivalent groups without random assignment (Cook & Campbell, 1979). Cook and Campbell describe the research design of this study to control for all threats to internal validity except selection, maturation, instrumentation, mortality, and history (p. 104). Since random assignment to teaching modalities did not occur, statistical regression may also be a threat to internal validity for this study.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Descriptive Summary of the Traditional and Hybrid Modalities

The focus of this research was to compare the effectiveness of the hybrid teaching modality and the traditional teaching modality for two pre-college level mathematics courses, Basic Math and Basic Algebra for the winter 2004 semester. The learning objectives for Basic Math involved whole numbers, fractions, decimals, percents, proportions, measurement, geometry, and elementary algebraic operations and the learning objectives for Basic Algebra emphasized the fundamental operations of algebra using integers and rational numbers, exponents, linear equations, word problems, special products, factoring, and the graphing of straight lines. These two courses are the lowest level pre-college math courses offered at the college (Kirtland Community College catalog, 2003-2004).

By taking the pretest during the first week of the semester and receiving a score of 70% or higher, students may "test up" to the next higher-level mathematics course, or "test out" of further mathematics courses if the level of prerequisite skills was demonstrated.

The hybrid teaching modality combined traditional lecture and interactive computer-based instruction for one section of each course. The interactive software was PLATO, an instructional software program owned by PLATO Learning, Inc. PLATO was installed on 34 computers in two computer labs on Kirtland Community College's satellite campus and students had access to it Monday through Friday 8:00AM-10:00PM for the winter 2004 semester.

Courses utilizing the hybrid modality incorporated half of the traditional lecture time combined with student participation with PLATO mathematics modules. Pre and

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

post computer assessments were included for each module containing interactive activities and simulations. The course learning objectives for all sections of each course and both teaching modalities of each course were identical. The pretests and posttests (final exams) for the two courses were also identical for all sections and the same criteria for success were used. Success was defined as a final exam score of 70% or higher for the course. Table 2 further delineates the similarities and differences of the two modalities.

Table 2

Comparison of Activities and Processes for the Two Teaching Modalities

Traditional Modality	Hybrid Modality
All students took a written pretest on the first day of class. Any student who attained a score of 75% or higher "tested up" to the next higher math course	All students took a written pretest on the first day of class. Any student who attained a score of 75% or higher "tested up" to the next higher math course
Otherwise students attended two 2-hour group lectures per week for 15 weeks.	Otherwise students attended one 2-hour group lecture per week for 15 weeks augmented by student use of interactive software modules containing activities related to those learning objectives for that week.
Structured synchronous (at the same time) lecture modality	Mixture of structured synchronous (at the same time) lecture with self-paced, software modules

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 2—continued

Student mastery of learning objectives were achieved through drill and practice required via written assignments submitted to the instructor each class period. Each student was required to complete the same number of drill and practice exercises. Student mastery of learning objectives was confirmed through written exams taken periodically throughout the semester. Mastery was defined as 75% or more of the total number of test items answered correctly.	Student mastery of learning objectives was achieved through student involvement with interactive modules containing computer-based instruction and activities. Each module had a pretest and posttest for the learning objectives of that module. If a student scored 80% or higher on a modular pretest, mastery of the learning objectives in that module was recorded in the software's course management component. There were no written assignments completed by the students. If needed, additional time was taken by the students with the activities in the modules to achieve mastery of the learning objectives. Mastery was defined as 75% or more of the total number of test items answered correctly. Students required differing amounts of time in each module to achieve mastery of the objectives. Time spent by the student in each module was also documented in the course management component of the software. Students who progressed satisfactorily and were further along than the objectives to be learned at the weekly lecture opted out of attendance at the lecture and progress individually at a faster pace than the student cohort. No student took longer than the pace of the student cohort.
Student-assisted tutoring through the College's Tutoring Center at no cost to student was available upon student request. Instructors were available for student questions during class time, office hours, informally with mutual agreement, and by appointment.	Student-assisted tutoring took place only in an informal way since there was no Tutoring Center at this campus location. Instructor availability to students was increased by a teaching load schedule that provided increased flexibility for up to 32 hours per week.
A comprehensive written final exam was taken during the last week of class. A minimum score of 70% was required for successful completion of this course.	A comprehensive written final exam was taken during the last week of class. A minimum score of 70% was required for successful completion of this course.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 4

PRESENTATION AND ANALYSIS OF THE DATA

This chapter will begin with a presentation and analyses of the data for this research using descriptive statistical techniques such as frequency distributions. Pearson's Chi-Square, Student's *t*-test, and Pearson's Correlation Coefficients were used to compare the significance of the findings. Logistic regression was used to consider the best predictive model for student successful course completion from the independent variables in this study.

Potential participants in this study totaled 208 students. One hundred ninety students experienced the traditional teaching modality, while eighteen students experienced the hybrid teaching modality. Table 3 summarizes the number of students who agreed to participate in this study.

Table 3

Summary of Student Participants

	Agreed to Participate	Declined to Participate	No Contact	Total
Traditional Modality	74 (39%)	13 (7%)	103 (54%)	190 (100%)
Hybrid Modality	13 (72%)	0 (0%)	5 (28%)	18 (100%)
Total	87 (42%)	13 (6%)	108 (52%)	208 (100%)

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

As Table 3 indicates, of the 208 potential participants in this study, 87 (42%) agreed to be interviewed and to allow information from their student records files to be accessed for this study. Seventy-three (39%) of the 190 students who experienced the traditional teaching modality participated in the study and 13 (72%) of the 18 students who experienced the hybrid teaching modality participated in the study. The high response rate of 42% may be attributable to multiple calls to the potential participants. One student in the traditional modality "tested up" into a college-level mathematics course and was not included in the analysis that followed.

Comparison of Student Achievement

The following hypothesis related to student achievement was tested with a Student's *t*-test.

H_1: Student achievement in the hybrid teaching modality was the same as student achievement in the traditional teaching modality in pre-college level mathematics courses.

Student achievement was measured by gain scores, defined as the difference between the course final exam score and the pretest score for each student, and student success in the courses was defined as a final exam score of 70% or higher.

Table 4 summarizes the comparison of the gain scores for the students who experienced the traditional and hybrid teaching modalities in the Basic Mathematics and Basic Algebra courses. Table 4 compares student achievement as measured by gain scores. After Levene's Test for Equality of Variances verified the assumption of equal variances (F=.626 and p=.439), a two-tailed independent samples *t*-test for Equality of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Means was performed for the mean gain scores of students in the traditional and hybrid teaching modalities for Basic Mathematics. No statistically significant difference was found for the two mean gain scores (t= -.265 and p=.794) indicating that academic achievement for students in the traditional and hybrid teaching modalities for Basic Mathematics was not found to be unequivalent. For the Basic Mathematics course, H_1 was not rejected. Student achievement was not statistically significantly different for students in the traditional and hybrid modalities.

Table 4

Gain Scores by Course and Teaching Modality

		N	Mean	Standard Deviation	Standard Error of the Mean	*t*
Basic Mathematics						
	Traditional Modality	16	48.19	11.309	2.827	-.265 (*p*=.794)
	Hybrid Modality	4	50.00	16.186	8.093	
Basic Algebra						
	Traditional Modality	28	34.32	18.621	3.519	Not calculable
	Hybrid Modality	0	na	na	na	

Students who experienced the hybrid teaching modality for the Basic Algebra course were not given a pretest the first day of class and therefore no gain scores could be calculated and no t-test could be conducted.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Comparison of Student Success Rates

Student success rates for Basic Mathematics and Basic Algebra by teaching modality are summarized in Table 5. Students who dropped or withdrew from the course did not have a final exam score. These students were considered unsuccessful in the courses and no gain scores could be calculated and analyzed for them.

Table 5

Successful and Unsuccessful Course Completions by Course and Teaching Modality

		Successful	Not Successful	Tested -Up	Total	Pearson's Chi-Square
Basic Mathematics						
	Traditional Modality	16 (64%)	9 (36%)	0	25 (100%)	.828 (*p*=.363)
	Hybrid Modality	5 (83%)	1 (17%)	0	6 (100%)	
Basic Algebra						
	Traditional Modality	22 (46%)	26 (54%)	1	48 (100%)	.313 (*p*=.576)
	Hybrid Modality	4 (57%)	3 (43%)	0	7 (100%)	
Courses Combined						
	Traditional Modality	38 (52%)	35 (48%)		73 (100%)	1.314 (*p*=.252)
	Hybrid Modality	9 (69%)	4 (31%)		13 (100%)	
	Total	47 (55%)	39 (45%)		86 (100%)	

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

One limitation of this research is that some faculty did not understand that the pretest was a mandatory component of the courses, and consequently, some students were not required to take a pretest. In some cases, students added the course after the class period in which the pretest was taken and were likewise not required to take a pretest.

Table 5 shows that for Basic Mathematics, 83% of the students in the hybrid teaching modality succeeded while only 64% of the students who experienced the traditional teaching modality succeeded in the course. If, however, only one fewer of the students in Basic Mathematics in the hybrid modality had succeeded, the success rate would have dropped from 83% to 67%, almost identical to the 64% success rate for students in the traditional modality for the same course. Pearson's Chi-Square (.828) therefore indicates that the difference in student success rates for the two teaching modalities in Basic Mathematics is not statistically significant (p=.363). Overall, by combining the Basic Mathematics and Basic Algebra courses and conducting a Chi-Square analysis to compare student success by teaching modality, no statistically significant difference was found (p=.252).

Table 5 also indicates that the success rates for students in the traditional and hybrid teaching modalities for Basic Algebra are 46% and 57%, respectively. Pearson's Chi-Square (.313) indicates that the difference in student success rates for the two teaching modalities is not statistically significant (p=.576). One caveat to the use of the Chi-Square tests for Basic Mathematics and Basic Algebra in this study is that in each category of success, no success, traditional modality, and hybrid modality, a count of at least 5 is expected in each category.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The following hypothesis related to student success was tested with Chi-Square analysis:

H_2: Student success in the hybrid teaching modality was the same as student success in the traditional teaching modality in pre-college level mathematics courses.

Student success was not statistically significantly different for students in the traditional and hybrid modalities, therefore, H_2 was not rejected. Successful course completion was not statistically significantly different for students in the traditional or hybrid modalities.

Age

Research Question 1: Was student success in the course impacted by the age of the student?

The ages of the participants in this study at the start of the winter 2004 semester are summarized in Table 6. One student "tested up" into a college level mathematics course on the first day of class and for the purposes of this study, was not considered in the remaining analysis. Adjusting the number of students used for the analysis related to AGE to exclude the student who "tested up" and to also exclude the student whose birth date was missing from the raw data, produced a total of 85 students. Elimination from the data set of the one student who "tested up", produced a total of 86 students.

Table 6 shows that 38% and 67% of the students who experienced the traditional teaching modality in Basic Mathematics and Basic Algebra respectively were 18-24 years old (traditional-aged). The proportions of students 25 years old or older (nontraditional-aged) who experienced the traditional teaching modality were 62% and 33%, respectively. Seventeen percent and 29% of the students who experienced the hybrid

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

teaching modality in Basic Mathematics and Basic Algebra respectively were traditional-aged. Although traditional-aged students and nontraditional-aged students were approximately equal in numbers for the study overall, 52% and 48%, respectively, there were a higher proportion of older (nontraditional-aged) students who experienced the hybrid teaching modality (10 of 13 or 77%) than experienced the traditional teaching modality (31 of 72 or 43%).

Table 6

Ages of All Participating Students

		Traditional-aged 18-24 Years	Nontraditional-aged 25 Years or Older	Total
Basic Mathematics				
	Traditional Modality	9 (38%)	15 (62%)	24*(100%)
	Hybrid Modality	1 (17%)	5 (83%)	6 (100%)
Basic Algebra				
	Traditional Modality	32 (67%)	16 (33%)	48 (100%)
	Hybrid Modality	2 (29%)	5 (71%)	7 (100%)
	Total	44 (52%)	41 (48%)	85 (100%)

*Birth date of one student was missing from raw data.

The use of Chi-Square for analysis is appropriate when counts are 5 or higher for the categories of comparison. Since student success in each teaching modality is the variable of interest in this study, not the specific pre-college level mathematics course,

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

subsequent analysis combined the number of students from Basic Mathematics and Basic Algebra into the categories of successful or unsuccessful completion of the courses. Success for the students was defined as a final exam score of 70% or higher for the courses.

Table 7 summarizes the groups of traditionally-aged and nontraditionally-aged students and their frequencies of success in each teaching modality.

Table 7

Age Groups and Their Overall Frequencies of Success by Teaching Modality

	Traditional-aged 18-24 Years	Nontraditional-aged 25 Years or Older	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	16	21	37	5.828 (*p*=.016)
Unsuccessful Students in Traditional Teaching Modality	25	10	35	
Successful Students in Hybrid Teaching Modality	1	8	9	2.359 (*p*=.125)
Unsuccessful Students in Hybrid Teaching Modality	2	2	4	

Table 7 indicates that given each teaching modality, the numbers of successful and unsuccessful students in the traditional-aged and nontraditional-aged groups are statistically significantly different. Chi-square analysis indicates that the older students were statistically significantly more successful in the traditional teaching modality at the .05 level (*p*=.016). The number of nontraditional-aged students who were successful in

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

the hybrid teaching modality was higher than those who were unsuccessful; however, statistical significance for success related to age was not achieved at the .05 level (p=.125).

Results of correlation analysis in Table 26 for student success and age corroborated the results of the Chi-Square analysis. Of the students in the study, a statistically significant correlation existed at the .01 level between student success as measured by a final exam score of 70% or higher and the older or nontraditional-aged students.

Gender

Research Question 2: Was student success in the course impacted by the gender of the student?

Given each teaching modality, Table 8 summarizes the genders of the successful and unsuccessful students.

Table 8

Genders of Students Who Successfully Completed Mathematics Courses by Modality

	Male	Female	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	13	25	38	.625 (p=.429)
Unsuccessful Students in Traditional Teaching Modality	9	26	35	
Successful Students in Hybrid Teaching Modality	2	7	9	3.259 (p=.071)
Unsuccessful Students in Hybrid Teaching Modality	3	1	4	

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 8 indicates the number of successful and unsuccessful students of each gender given each teaching modality. Gender did not contribute to statistically ignify-cantly different rates of success in the traditional modality (p=.429). The number of students in the hybrid teaching modality based on gender did not contribute to a statis-tically significant difference at the .05 level in the rate of success in the pre-college level mathematics courses (p=.071).

Part Time or Full Time Status

Research Question 3: Was student success in the course impacted by the part time or full time academic status of the student?

The Community College Student Survey of Engagement (CCSSE, 2003) identi-fied "part time college attendance" as a risk factor that adversely impacts student success in college. Students taking less than 12 credit hours during a semester are defined as part time students. Those students taking 12 or more credit hours during a semester are defined as full time students (CCSSE, 2003). The academic status for the students in this study is detailed in Table 9 given each teaching modality.

Table 9 indicates the number of successful and unsuccessful students for full time and part time student status given each teaching modality. Students on part time status, taking less than 12 credit hours for the semester did have statistically significantly higher rates of success in the traditional modality at the .05 level (p=.027). The number of students in the hybrid teaching modality appears to be more successful if they took less than 12 credit hours in the semester; however, the Chi-Square analysis did not verify that assertion at the .05 level (p=.118).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 9

Part Time or Full Time Student Status of Students by Modality

	Full Time	Part Time	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	10	28	38	4.860 (*p*=.027)
Unsuccessful Students in Traditional Teaching Modality	18	17	35	
Successful Students in Hybrid Teaching Modality	0	9	9	2.437 (*p*=.118)
Unsuccessful Students in Hybrid Teaching Modality	1	3	4	

Placement Test Scores

Research Question 4: Was student success in the course impacted by the placement test score of the student in mathematics?

Chi-Square analysis for student success could not be conducted with the continuous variable of placement test score because placement test score is not a categorical measurement of the data. Correlation analysis of placement test scores was conducted but did not suggest an association with student success (r=.062, p=.634, N=61) for the students in this study. See Table 26.

Helping School-Age Children Learn Mathematics

Research Question 5: Was student success in the course impacted by whether or not the student helped school-age children learn mathematics?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The mathematical skills necessary to succeed in the Basic Mathematics course involved fundamental concepts that are learned at various and multiple grades in the school years prior to the postsecondary level. Some students who may be parents or otherwise have interactions with school-age children to help them learn the mathematics, may have learned the mathematics objectives for their pre-college level mathematics course from that interaction instead of or in addition to the mathematics skills they learned due to the teaching modality they experienced.

Table 10 summarizes the number of participants in this study given the teaching modality who helped school-age children learn mathematical concepts during the same semester that they were enrolled in the pre-college level mathematics courses included in this study.

Table 10

Students Who Helped School-Age Children Learn Mathematics by Modality

	Helped Children Learn Mathematics	Did Not Help Children Learn Mathematics	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	14	24	38	.001 (*p*=.979)
Unsuccessful Students in Traditional Teaching Modality	13	22	35	
Successful Students in Hybrid Teaching Modality	4	5	9	.034 (*p*=.853)
Unsuccessful Students in Hybrid Teaching Modality	2	2	4	

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Given each teaching modality, Table 10 shows the number of successful and unsuccessful students who helped school-age children learn mathematics during the same semester they enrolled in the pre-college level mathematics course. Helping school-age children learn mathematics did not contribute to statistically significantly different rates of success in the traditional modality (p=.979) or the hybrid modality (p=.853).

Financial Aid Status

Research Question 6: Was student success in the course impacted by the financial aid status of the student?

The CCSSE (2003) and Flint and Frey (2003) identified financial concerns as an impediment to college attendance and completing a degree (Flint & Frey, 2003, p. 71). Table 11 identifies the number of students in this study who were receiving financial aid during the winter 2004 semester.

Given each teaching modality, Table 11 indicates that the number of successful and unsuccessful students who received financial aid during the same semester they enrolled in the pre-college level mathematics course. Financial aid status did not contribute to statistically significantly different rates of success in the traditional modality (p=.713) or the hybrid modality (p=.488).

First Generation in College

Research Question 7: Was student success in the course impacted by whether or not one or more of the parents or stepparents of the student previously took a college course for credit?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 11

Students Who Were Receiving Financial Aid by Modality

	Students Receiving Financial Aid	Students Not Receiving Financial Aid	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	35	3	38	.136 (p=.713)
Unsuccessful Students in Traditional Teaching Modality	33	2	35	
Successful Students in Hybrid Teaching Modality	8	1	9	.481 (p=.488)
Unsuccessful Students in Hybrid Teaching Modality	4	0	4	

Table 12 summarizes the number of students in this study whose parent or step parent took a college course for credit.

Table 12 indicates that a student who experienced the traditional teaching modality and had a parent or step parent who had taken a college course for credit did not positively contribute to a statistically significantly different rate of success in the pre-college level mathematics courses (p=.361). For students who experienced the hybrid teaching modality, having a parent or step parent who had taken a college course for credit was associated with a statistically significantly higher rate of success in the mathematics courses at the .05 level (p=.044).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 12

Students Whose Parent or Step Parent Took a College Course for Credit by Modality

	Parent or Step Parent Took a College Course for Credit	Parent or Step Parent Did Not Take a College Course for Credit	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	25	12	37	.834 (*p*=.361)
Unsuccessful Students in Traditional Teaching Modality	20	15	35	
Successful Students in Hybrid Teaching Modality	6	1	7	4.055 (*p*=.044)
Unsuccessful Students in Hybrid Teaching Modality	1	3	4	

Research Question 8: Was student success in the course impacted by whether or not one or more of the grandparents or step grandparents of the student previously took a college course for credit?

Table 13 summarizes the number of students in this study whose grandparent or step grandparent took a college course for credit.

Table 13 indicates that students in neither the traditional teaching modality (*p*=.379) nor the hybrid teaching modality (*p*=.764) had statistically significantly different rates of success in the pre-college level mathematics courses based on their grandparent or step grandparent having taken a college course for credit. Although first

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

generation college students are at a higher risk of an unsuccessful college experience (CCSSE, 2003), no studies were found in the literature that considered the grandparent generation having attended college and its impact on the academic success of the grand-child/child.

Table 13

Students Whose Grandparent or Step Grandparent Took a College Course for Credit

	Grandparent or Step Grandparent Took a College Course for Credit	Grandparent or Step Grandparent Did Not Take a College Course for Credit	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	10	17	27	.773 (*p*=.379)
Unsuccessful Students in Traditional Teaching Modality	7	20	27	
Successful Students in Hybrid Teaching Modality	3	2	5	.090 (*p*=.764)
Unsuccessful Students in Hybrid Teaching Modality	2	2	4	

Student Level of Comfort With Mathematics

Research Question 9: Was student success in the course impacted by the student's level of comfort with mathematics prior to the winter 2004 semester?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Students' levels of comfort concerning mathematics are summarized for this study in Table 14.

Table 14

Student Level of Comfort With Mathematics by Modality

	Very Low or Low	Moderate, High, or Very High	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	11	27	38	3.846 (p=.050)
Unsuccessful Students in Traditional Teaching Modality	18	17	35	
Successful Students in Hybrid Teaching Modality	5	4	9	1.040 (p=.308)
Unsuccessful Students in Hybrid Teaching Modality	1	3	4	

Table 14 indicates that given the traditional teaching modality, students who had a moderate, high, or very high comfort level with mathematics did have a statistically significantly higher rate of success at the .05 level (p=.050). Students in the hybrid teaching modality in the pre-college level mathematics courses for this study did not have a significantly higher rate of success related to their comfort level with mathematics (p=.308).

Student Level of Internal Motivation

Research Question 10: Was student success in the course impacted by the student's level of internal motivation to learn mathematics prior to the winter 2004 semester?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 15 summarizes the level of internal motivation to learn mathematics for the students in this study.

Table 15

Student Level of Internal Motivation to Succeed Mathematics Courses by Modality

	Very Low or Low	Moderate, High, or Very High	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	6	32	38	.024 (*p*=.876)
Unsuccessful Students in Traditional Teaching Modality	6	29	35	
Successful Students in Hybrid Teaching Modality	3	6	9	.090 (*p*=.764)
Unsuccessful Students in Hybrid Teaching Modality	1	3	4	

Table 15 indicates that given the teaching modality, students who had a moderate, high, or very high level of internal motivation did not have a statistically significant higher rate of success in the pre-college level mathematics courses for this study. The significance level for the traditional teaching modality was p=.876 and for the hybrid teaching modality was p=.764.

Student Level of Confidence

Research Question 11: Was student success in the course impacted by the student's level of confidence to succeed in a mathematics course prior to the winter 2004 semester?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 16 summarizes the level of confidence to succeed in mathematics the mathematics course in this study.

Table 16

Student Level of Confidence to Succeed in Pre-College Level Mathematics Courses

	Very Low or Low	Moderate, High, or Very High	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	9	29	38	.549 (*p*=.459)
Unsuccessful Students in Traditional Teaching Modality	11	24	35	
Successful Students in Hybrid Teaching Modality	4	5	9	.442 (*p*=.506)
Unsuccessful Students in Hybrid Teaching Modality	1	3	4	

Table 16 indicates that given the teaching modality, students who had a moderate, high, or very high confidence level to succeed did not have a statistically significantly higher rate of success in the pre-college level mathematics courses for this study. The significance level for the traditional teaching modality was p=.459 and for the hybrid teaching modality was p=.506.

Student Preference to Study Alone or With Others

Research Question 12: Was student success in the course impacted by whether the student studied mathematics in a group or alone?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 17 indicates the preference for students in this research to study alone or with others.

Table 17

Student Preference to Study Alone or with Others by Modality

	Study Alone	Study with Others	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	30	7	37	.294 (*p*=.588)
Unsuccessful Students in Traditional Teaching Modality	25	8	33	
Successful Students in Hybrid Teaching Modality	4	0	4	1.733 (*p*=.188)
Unsuccessful Students in Hybrid Teaching Modality	6	3	9	

Table 17 indicates that given the teaching modality, students who studied alone or with others did not have a statistically significant different rate of success in the pre-college level mathematics courses for this study. The significance level for the traditional teaching modality was p=.588 and for the hybrid teaching modality was p=.188.

Number of Hours Spent Using Interactive Software

Research Question 13: Was student success in the course impacted by the number of hours that the student in the hybrid teaching modality spent using the interactive software modules?

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 18 and Table 19 summarize the number of hours that students who experienced the hybrid teaching modality spent using the interactive software.

Table 18

Descriptive Statistics of Hours Spent Using Interactive Software in Hybrid Modality

Number of Hours Spent Using Interactive Software	*N*	Minimum	Maximum	Mean	Standard Error of the Mean	Standard Deviation
Successful Students in Hybrid Modality	8	8.67	53.35	33.540	4.873	13.784
Unsuccessful Students in Hybrid Modality	3	28.33	39.77	34.210	3.306	5.727
Missing	2					
Total	13					

Table 18 indicates that for students who experienced the hybrid teaching modality and successfully completed the courses, the mean number of hours spent using the interactive software was 33.54 hours. For students who were unsuccessful who experienced the hybrid teaching modality, 34.21 hours were spent using the interactive software.

Table 19 further describes the frequencies of software use for successful and unsuccessful students. Of the 8 students who successfully completed the courses, 3 used the software the shortest amount of hours or 3 used the software the longest amount of hours. Those students who used the software the shortest amount of hours needed less instructional and practice time and those students who used the software the longest amount of hours needed the most instructional and practice time.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 19

Frequencies of Hours Spent Using Interactive Software by Students in Hybrid Modality

Number of Hours Spent Using Interactive Software	Successful	Unsuccessful
8.67	1	
26.67	1	
28.05	1	
28.33		1
29.27	1	
34.53		1
35.13	1	
39.77		1
42.18	1	
45.40	1	
53.35	1	
Total	8	3

Student Level of Comfort With Computers

Research Question 14: Was student success in the course impacted by the student's level of comfort with computers prior to the winter 2004 semester?

Table 20 summarizes the impact of the students' comfort level with computers and their success in the pre-college level mathematics courses. Table 20 indicates that given the teaching modality, students who have a moderate, high, or very high comfort level with computers did not have a statistically significant higher rate of success in the pre-college level mathematics courses for this study. The significance level for the traditional teaching modality was p=.279 and for the hybrid teaching modality was p=.488.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 20

Student Level of Comfort With Computers by Modality

	Very Low or Low	Moderate, High, or Very High	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	5	33	38	1.171 (p=.279)
Unsuccessful Students in Traditional Teaching Modality	8	27	35	
Successful Students in Hybrid Teaching Modality	1	8	9	.481 (p=.488)
Unsuccessful Students in Hybrid Teaching Modality	0	4	4	

Student Level of Ability to Complete Projects

Research Question 15: Was student success in the course impacted by the student's self-reported ability to complete projects once begun prior to the winter 2004 semester?

Table 21 summarizes the level to which students in this study reported their ability to complete projects once they had begun them. The ability to complete projects could refer to mathematics projects in their courses or projects not related to their mathematics courses. Table 21 indicates that given the teaching modality, students who rated themselves moderate, high, or very high for their ability to complete a project once it was begun did not have a statistically significantly higher rate of success in the pre-college level mathematics courses for this study. The significance level for the traditional

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

teaching modality was $p=.135$. For students in the hybrid teaching modality, Chi-Square analysis was incalculable because the variable PROJECT was a constant value.

Table 21

Student Level of Ability to Complete Projects Once Begun by Modality

	Very Low or Low	Moderate, High, or Very High	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	0	38	38	2.233 ($p=.135$)
Unsuccessful Students in Traditional Teaching Modality	2	33	35	
Successful Students in Hybrid Teaching Modality	0	9	9	Not Calculable
Unsuccessful Students in Hybrid Teaching Modality	0	4	4	

Student Employment Status and Hours Worked Weekly

Research Question 16: Was student success in the course impacted by the employment status of the student during the winter 2004 semester?

Research Question 17: Was student success in the course impacted by the average number of hours worked per week if the student was employed during the winter 2004 semester?

Table 22 indicates the number and proportion of students in this study who were employed during the winter 2004 semester. Table 23 describes the average number of

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

hours worked per week during the semester the student was enrolled in the courses for this study.

Table 22

Student Employment Status by Modality

	Student Employed	Student Not Employed	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	25	13	38	.000 (p=.995)
Unsuccessful Students in Traditional Teaching Modality	23	12	35	
Successful Students in Hybrid Teaching Modality	6	3	9	.090 (p=.764)
Unsuccessful Students in Hybrid Teaching Modality	3	1	4	

Table 22 indicates that given the teaching modality, students who were employed during the semester in which they were enrolled in the pre-college level mathematics courses did not have a statistically significantly higher rate of success in the pre-college level mathematics courses for this study. The significance level for the traditional teaching modality was p=.995 and for the hybrid teaching modality was p=.764.

Table 23 summarizes the average hours worked per week by the students in this study. Table 23 indicates that approximately one-third of the students in each teaching modality were not employed during the semester in which they were enrolled in the pre-

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

college level mathematics courses in this study. Close to two-thirds of the students were employed at various levels with almost 8% of the students in the traditional teaching modality and 23% of the students in the hybrid teaching modality were working 40 or more hours per week at the same time that they were enrolled in the courses of interest for this study.

Table 23

Average Weekly Hours Worked by Students by Modality

	Not Employed	1-10 Hours	11-20 Hours	21-30 Hours	31-40 Hours	Over 40 Hours	Total
Traditional Modality	25 (34%)	2 (3%)	12 (16%)	15 (21%)	13 (18%)	6 (8%)	73 (100%)
Hybrid Modality	4 (31%)	0 (0%)	2 (15%)	1 (8%)	3 (23%)	3 (23%)	13 (100%)
Total	29 (35%)	2 (2%)	14 (16%)	16 (19%)	16 (19%)	8 (9%)	86 (100%)

Program of Study

Research Question 18: Was student success in the course impacted by the student's program of study?

Program of Study was separated into three categories originally: Career Technical but not Nursing, Nursing, and Other. Since many of the students in Nursing are female and nontraditional-aged, the possibility of students in this program masking the effects of some variables, it was decided to recode the categories for program of study into Nursing and All Others.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 24 summarizes the students' programs of study by success or nonsuccess in the traditional and hybrid teaching modalities.

Table 24

Student Programs of Study by Modality

	Nursing	All Other	Total	Pearson's Chi-Square
Successful Students in Traditional Teaching Modality	16	22	38	1.455 (*p*=.228)
Unsuccessful Students in Traditional Teaching Modality	10	25	35	
Successful Students in Hybrid Teaching Modality	7	2	9	3.259 (*p*=.071)
Unsuccessful Students in Hybrid Teaching Modality	1	3	4	

Table 24 indicates that for students who experienced the traditional teaching modality, the comparison of the rate of successful course completion by students in the Nursing program with students in all other programs did not indicate a statistically significant difference (*p*=.228). Similarly, for students who experienced the hybrid teaching modality, the comparison of the rate of successful course completion by students in the Nursing program with students in all other programs did indicate a statistically significant difference at the .10 level (*p*=.071).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Student Beliefs on Computer Usage

Research Question 19 concerns students' beliefs that the use of computers in their college courses contributed to their learning in those courses more than if they had not used computers.

In this study, a question was added to the Interview Guide to elicit student responses concerning their beliefs on the efficacy of computer usage for their learning in college courses. The question did not emphasize computer usage in mathematics courses but rather computer usage in any courses during the students' college experience. Question 11 in the Interview Guide asked: "Do you believe that the use of computers in your college courses contributed to your learning in those courses more than if you had not used computers?" Table 25 summarizes the responses of the participants.

Table 25

Student Beliefs That Computer Usage Contributes to Student Learning in College

	Yes	No	No Answer	Total
Traditional Modality	44 (61%)	27 (36%)	2 (3%)	73 (100%)
Hybrid Modality	10 (77%)	3 (23%)	0 (0%)	13 (100%)
Total	54 (63%)	30 (34%)	2 (3%)	86 (100%)

Table 25 indicates that 77% of the students who experienced the hybrid teaching modality and 61% of the students who experienced the traditional teaching modality expressed their belief that computer usage contributes to student learning. Students who experienced the traditional teaching modality did not use computers as part of their

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

modality of instruction. Overall, close to two-thirds of the students in this study expressed their belief that computer usage positively contributes to student learning. Computer usage was not previously found in the literature as a factor that positively contributes to student learning in college.

Correlation Analysis

Correlation analysis was conducted on all students who participated in this study with the exception of the student who tested-up on the first day of class (*N*=86). Student success was measured by a final exam score of 70% or higher and was tested for significant correlations between other independent variables included in this study. Table 26 summarizes the correlations of independent variables with SUCCESS.

Table 26

Correlations of Independent Variables With Success

		Success		
Independent Variable		N	Pearson Correlation Coefficient	p-value
1. Gain score		48	.454	.001
2. Course		86	-.197	.068
3. Age		85	.327	.002
4. Part time status		86	.289	.007
5. Student ability to complete a project once begun		86	.194	.073
6. Parent or step parent took a college course for credit		83	.171	.121
7. Teaching modality		86	.124	.257

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 26—continued

8. Gender		86	-.012	.911
9. Placement test score		61	.062	.634
10. Student helped school-age children with mathematics		86	-.002	.988
11. Student financial aid status		86	-.066	.545
12. Grandparent or step grandparent took a college course for credit		63	.122	.343
13. Student level of comfort with mathematics		86	.188	.084
14. Student level of internal motivation to learn mathematics		86	.049	.657
15. Student level of confidence to successfully complete math course		86	.049	.654
16. Group or solo study experience of student		83	-.001	.990
17. Student level of comfort with computers		86	-.032	.773
18. Student employment status		86	-.007	.946
19. Number of hours worked per week		57	-.193	.151
20. Program of study		86	-.099	.365

Two-tailed tests

Table 26 indicates that the variables that statistically significantly impacted student success were student age (p=.002), part time or full time status (p=.007), student ability to complete a project once begun (p=.073), and student level of comfort with mathematics (p=.084).

Correlation analysis between student success in pre-college level mathematics courses and factors that may impact that success is an important and useful tool in the student academic advisement process. Students who placement-test into too low of a level of a mathematics course may tend to become bored with the educational experience and students who placement-test into too high of a level of a mathematics course may have an increased possibility of failure in the course. Both situations may increase the

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

inclination of students in these courses to attrite from the courses and possibly the institution. In a study concerning student performance in college-level and remedial courses, Paul Illich, Cathy Hagan, and Leslie McCallister (2004) concluded that "reliance on a single placement test to determine a student's academic preparedness is not sufficient for some students" (p. 452). Additional information that may augment and aid the student advisement process to more accurately and appropriately place students into mathematics courses will improve student success as well as institutional effectiveness.

Predicting Student Success

The assumptions necessary for logistic regressions are as follows: (a) the dependent variable SUCCESS (student success) is dichotomous; (b) the independent variables are interval, ratio, or dichotomous; (c) all relevant predictors are included, any irrelevant predictors are not included, and the form of the relationship is linear (SPSS, 1997). The values for student success are dichotomous since students either successfully completed the course or they did not. The independent variables are interval, ratio, or dichotomous and correlation analysis indicated the relevant predictors to consider in the logistic regression model.

Since student success is a dichotomous dependent variable, logistic regression is the most appropriate statistical technique to use to predict it among and between the groups (Mertler & Vannatta, 2001; SPSS, 1997). Logistic regression is based on probabilities, odds, and the logarithm of the odds. The effect of an independent variable on a dichotomous dependent variable is usually represented by an odds ratio where the probability of an accurate prediction is equal to the odds/(1+odds) (SPSS, 1997, p. 3-14). In

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

logistic regression, the probability of success is based on a nonlinear model resulting from the best linear combination of the independent variables.

The three general assumptions involved in multivariate statistical testing are normality, linearity, and homoscedasticity. Violation of any of these assumptions will result in invalid inferences from the data; however, logistic regression is more flexible than other forms of statistical regression techniques.

> Logistic regression requires no assumptions about the distributions of the predictor independent variables. They do not have to be normally distributed, linearly related, or have equal variances within each group. Additionally, logistic regression has the capacity to analyze predictor independent variables of all types—continuous, discrete, and dichotomous" (Mertler & Vannatta, 2001, p. 314).

Logistic regression using SPSS utilized the forward stepwise method. The assumption of homoscedasticity cannot and need not be made with logistic regression since there is a functional relationship (s = square root of $(p)(1-p)$) between the mean and standard deviation across the zero and one values of the dependent variable (Berman, 2002, p. 140). The logistic function is bounded by 0 and 1 and is appropriate to the prediction or calculation of the probability of the event "success."

For students who participated in this study, three independent variables were positively associated with student success in the courses: student age, the student's level of ability to complete projects once begun, and level of comfort with mathematics. Table 27 summarizes the Pearson Correlation Coefficients and their respective p-values that indicate significance. Table 27 indicates that student age is highly positively correlated to student success at the .01 level ($p = .002$), student level of ability to complete projects once begun is positively correlated at the .10 level ($p = .073$), and the student level of comfort with mathematics is correlated at the .10 level ($p = .084$).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 27

Independent Variables Correlated to Student Success in Traditional Modality

Independent Variables	N	Pearson Correlation Coefficient	*p*-value
AGE (Student age)	85	.327	.002
PROJECT (Student level of ability to complete projects once begun	86	.194	.073
COMFMATH (Student level of comfort with mathematics)	86	.188	.084

Two-tailed tests

The values pertinent to the logistic regression model that predicts student success are detailed in Table 28, Table 29, Table 20, and Table 31.

Table 28

Goodness-of-Fit Statistics

	Chi-Square	*df*	*p*-Value
Model Step 1	17.347	3	.001

Chi-Square (17.347) in Table 28 is an index of model fit. The degrees of freedom (df) indicate the number of independent variables in the model and the *p*-value of .001 indicates that the set of three independent variables improve the prediction of the log odds for the model well within the .01 level of significance.

Table 29 also gives measures of overall model fit. Since the *p*-value (.001) indicates the Chi-Square value (17.347) is significant, one may conclude that the set of variables improves the prediction of the log odds although a highly significant model may not always indicate a highly predictive model (SPSS, 1997, p. 3-16). Chi-Square

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

represents the difference between the -2 Log Likelihood (-2LL) initial and final values for Step 0 and Step 1. A perfect model would have a -2LL of zero. The smaller the value of -2LL, the better the model fits the data. -2LL also represents the sum of the "probabilities associated with the predicted and actual outcomes of each case" (Mertler & Vannatta, 2001, p. 319).

Table 29

Logistic Model Summary

	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
Model Step 1	99.910	.185	.247

Cox & Snell R-Square and Nagelkerke R-Square are two estimates of the amount of variance explained by the model. Therefore, approximately 18% - 25% of the variance in the model is due to the three independent variables age, level of comfort with mathematics, and level of ability to complete projects once begun.

Table 30 indicates that successful course completion by the student was correctly predicted 71.7% of the time and the rate of student lack of success was correctly predicted 64.1% of the time. The overall predictive accuracy of the model is 68.2% or approximately two-thirds of the time the correct prediction of student success would be made. Larger sample sizes are important for accuracy to be improved in logistic regression models.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 30

Predictive Values of the Model

	Predicted		
	Successful Course Completion		Percentage Correct
	Successful	Not Successful	
Successful	33	13	71.7
Not Successful	14	25	64.1
Overall Percentage			68.2

Table 31 summarizes the coefficients to be used in the logistic model and their associated measures of model fit. Logistic regression is a model based on the logarithm of the odds of an event occurring and the value of B is the effect of a one-unit change in an independent variable on the logarithm of the odds (log odds). For the variable AGE, B would only change by .090 for every increase in age of one year for a student. For COMFMATH, the effect is to increase the log odds by .481 for every one-unit change in the value of comfmath. COMFMATH has 5 values ranging from 1 to 5 for very low, low, moderate, high, and very high. These values represent the student's self-reported evaluative measure for his or her level of comfort with mathematics. PROJECT has the 5 values for responses identical to COMFMATH and has a B value of .602. These values of B are the unstandardized regression coefficients for each variable used in the prediction equation of the model.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Table 31

Variables in the Logistic Regression Model

Variable	B	Standard Error of B	Wald Statistic	*df*	*p*-Value	Exp (B)
AGE (Student age)	.090	.031	8.330	1	.004	1.094
PROJECT (Level of ability to complete a project once begun)	.481	.315	2.334	1	.127	1.617
COMFMATH (Level of comfort with mathematic for student)	.602	.272	4.896	1	.027	1.825
Constant	-5.631	1.744	10.429	1	.001	.004

The significance of each of the independent variables used in the model is tested with a measure known as the Wald statistic and their associated significance value (p-value). The Wald statistic for the model is similar to the correlation statistic to determine the association and partial correlation coefficient between each of the three independent variables in the model and the dependent variable, student successful completion of the pre-college level mathematics course, holding constant all other predictors in the prediction equation. For each Wald statistic, the *df* is one because only one independent variable is considered at a time. The p-values are the significance levels for each Wald statistic.

The Exp(B) value provides an abstract yet intuitive interpretive measure to evaluate the impact of each independent variable in the model on the dependent variable or probability of successful course completion for each student. Abstractly, the value of each Exp(B) is equal to Euler's constant (2.71828182846) raised to the Exp(B) power for each independent variable. In other words, for comfmath, $2.71828182846^{.602} = 1.825$.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The intuitive interpretation of the value of Exp(B) involves thinking of it as a multiplier for the impact of each independent variable on the dependent variable since Exp(B) is the calculated odds ratio for each variable (Mertler & Vannatta, 2001, p. 320). A student who declares his or her level of comfort with mathematics as moderate, high, or very high, has almost doubled (1.825) her or his probability of completing the pre-college mathematics course successfully, all other variables held constant. Similarly, a student who self reports a level of ability to complete a project once it is begun as moderate, high, or very high has almost doubled (1.617) his or her probability of successfully completing the same course. A student who has both factors at the moderate, high, or very high levels has almost quadrupled his or her probability of successfully completing the course. The multiplying effect of the variable age (1.094) is very minimal, since multiplying any number by a number near in value to 1, does little to change the value of the probability of successfully completing the course of interest.

Although Table 24 indicated that with Chi-Square analysis, students who experienced the hybrid teaching modality and were in the Nursing program had a statistically significantly higher rate of successful course completion at the .10 level, inclusion of the variable designating program of study did not increase the likelihood of predicting student success with the logistic regression model.

Further discussion of the results, limitations of the study, policy implications, and suggestions for future study are provided in the next chapter.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

CHAPTER 5

RESULTS AND CONCLUSIONS

This chapter is organized into five sections. The first section includes a summary of the results from the research. The second section provides information that compares the results of this study with the findings in the literature. The limitations of this research follow in the third section. A discussion of policy implications and recommendations will comprise the fourth section and suggestions for future research close Chapter 5.

Summary of Results

No statistically significant differences in student achievement or success existed between students who experienced the traditional or hybrid teaching modalities for pre-college mathematics courses in this study. Successful course completion was significantly positively associated with students 25 years of age or older; part time student status; moderate, high, or very high levels of comfort with mathematics; and moderate, high, or very high levels of ability to complete a project once begun. Contrary to findings in the literature, part-time student status did not adversely impact successful course completion. New information from this study revealed that 63% of students expressed a belief that computer usage contributes to their learning in college. Computer usage was not identified in the literature as a factor that contributed to a successful experience for students in college.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Comparison of Results With Findings in the Literature

Traditional Versus Hybrid Teaching Modality

The main research question addressed by this study was as follows: "Did the hybrid teaching modality positively impact student achievement and success more than the traditional teaching modality for students taking pre-college level mathematics courses?" Student achievement was measured by gain scores, defined as the difference between the course final exam score and the pretest score for each student. Student success in the courses was defined as a final exam score of 70% or higher. Selected factors that may contribute to student success were also explored.

The overall success rate of 55% for students in this study was similar to the success rate of students in pre-college level mathematics in the State of Michigan (MDE, 1999) and at Kirtland Community College (Dyer, 2004). Fifty-two percent of students in two-year colleges in Michigan from 1995-1998 successfully completed pre-college level mathematics courses (MDE, 1999, p. 15). Students in pre-college level mathematics courses at Kirtland Community College in fall 2000 succeeded at a rate of 56% (Dyer, 2004).

No statistically significant difference at the .05 level was found for student achievement between the traditional teaching modality and the hybrid teaching modality for the Basic Mathematics course (p=.794). Student achievement could not be compared for the Basic Algebra course because pretests were not given to the 7 students who experienced the hybrid teaching modality for that course. Consequently, gain scores could not be calculated and analyzed. Successful course completion for students who

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

experienced the traditional and hybrid teaching modalities was not found to be statistically significantly different for the Basic Mathematics course (p=.363), the Basic Algebra course (p=.576), or the two courses combined (p=.252).

Finding that students who experienced the hybrid teaching modality academically performed no worse than students who experienced the traditional teaching modality provides support for the recommendation that postsecondary educational institutions provide choices for alternative teaching and learning environments for their students. No one teaching modality can accommodate the multiple and complex factors that affect adult student learning.

Flint and Frey believe that students want alternative approaches, not the stereotypical experience of college (Flint & Frey, 2003, p. 69). Laura Villareal (2003) believes that students who have a choice of options for overcoming academic deficiencies will perform better if only because they will have a vested interest in their choice. Multiple learning systems and varied instructional methods combined with systems to monitor student behaviors and provide timely interventions are important elements that promote student success in pre-college level courses (McCabe & Day, 1998, p. 21).

College students taking pre-college level courses need more structure and support than any other group of learners (Roueche & Roueche, 1999); however, they also believe that the lecture teaching modality is "singularly inappropriate" (Roueche & Roueche, 1993, p. 176). Teaching and learning should be approached with flexibility and open-mindedness (Cross, 1971). Terrel Bell observed: "We simply must recognize how outdated our current teaching practices are and be more aggressive in bringing to the vast

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

American education enterprise all that can be provided through optimum use of technology in teaching and learning" (Roueche & Roueche, 1993, p. 177).

Age

Miglietti and Strange (1998) were interested in whether or not the age of a student affected his or her academic success in pre-college level mathematics courses. They defined traditional-aged students as 18-24 years and nontraditional-aged students as 25 years or older. Nontraditional-aged students received higher grades and reported a greater sense of accomplishment and a more positive total course experience than those students who were less than 25 years old.

Supporting the findings of Miglietti and Strange (1998) related to student age, Chi-Square analysis in this study was used to conclude that nontraditional-aged students 25 years old or older who experienced the traditional teaching modality had a higher rate of success (p=.016) than traditional-aged students 18-24 years old who also experienced the traditional teaching modality. The nontraditional-aged students who experienced the hybrid teaching modality succeeded at a higher rate (8 of 9 and p=.125) than the traditional-aged students (1 of 9). Conclusions based on two-tailed Pearson's Correlation Coefficient analysis supported the Chi-Square analysis. In general, nontraditional-aged students who experienced either the traditional or the hybrid teaching modality successfully completed the pre-college level mathematics courses at a rate that was statistically significantly higher at the .01 level than the traditional-aged students (r=.322, p=.003, N=85).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Further examination of the data revealed that of the 47 successful students in this study, 49% were students in the nursing program and 74% were nontraditional-aged (25 years old or older). Perhaps this group of students is transitioning to a new or different career, and with the maturity of their years, they realize the importance of mathematical skill development to be successful in the nursing profession. Future research that focuses specifically on students in nursing programs may help to better understand the interactions of the variables age, gender, program of study, and other related variables and their impact on student achievement and success.

Gender

Miglietti and Strange (1998) found that 85% of the nontraditional-aged students in their study were female and 75% of the under-25 year old students were female. Miglietti and Strange felt that possibly the effects of gender in their research may have been masked by the variable age. Recall in this study that of the 47 successful students in this study, 49% were students in the nursing program, 74% were nontraditional-aged (25 years old or older), and 70% were female. The confounding of variables age, program, and gender may have also occurred in this study.

The gender of the students in this study did not affect student success although the results of the Chi-Square analysis in Table 8 suggest that female students who experienced the hybrid teaching modality had a higher rate of success than the male students in the same modality (p=.071).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Part Time Versus Full Time Student Status

Contrary to the findings of the Community College Survey of Student Engagement (CCSSE, 2003) that part time student status is a risk factor that adversely impacts student success in college, Chi-Square analysis of the data in this study suggested that students who experienced either the traditional teaching modality (χ^2=4.860, *p*=.027) or hybrid teaching modality (χ^2=2.437, p=.118) who had part time status were more successful than students who had full time student status. Students who had part time status took less than 12 credit hours per semester while students who had full time status took 12 or more credit hours per semester.

Correlation analysis supported the Chi-Square analysis that students in either teaching modality that had part time student status were associated with higher rates of successful course completion (*r*=.289, *p*=.007, *N*=86).

Placement Test Scores

Correlation analysis of placement test scores did not suggest an association with student success (*r*=.062, *p*=.634, *N*=61) for the students in this study.

Helping School-Age Children Learn Mathematics

The mathematical skills necessary to succeed in the Basic Mathematics course involved fundamental concepts that are learned at various and multiple grades in the school years prior to the postsecondary level. Some students who may be parents or otherwise have interactions with school-age children to help them learn the mathematics, may have learned the mathematics objectives for their pre-college level mathematics

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

course from that interaction instead of or in addition to the mathematics skills they learned due to the teaching modality they experienced.

Chi-Square analysis of the data indicated that students who helped school-age children learn mathematics during the same semester they took the pre-college level mathematics course did not impact student success in the courses for students in the traditional modality (χ^2=.001, p=.979) or the hybrid teaching modality (χ^2=.034, p=.853).

Financial Aid Status

The CCSSE (2003) and Flint and Frey (2003) identified financial concerns as an impediment to college attendance and completing a degree (Flint & Frey, 2003, p. 71). The percentage of students who received financial aid during the semester of interest of this study was 98%. The course success rates were not impacted by the financial aid status of students in either the traditional teaching modality (χ^2=.136, p=.713) or the hybrid teaching modality (χ^2=.481, p=.488).

First Generation in College

The Community College Survey of Student Engagement (2003) identified "being a first-generation college student" as a risk factor to student success in college. Although first generation college students are at a higher risk of an unsuccessful college experience (CCSSE, 2003), no studies were found in the literature that considered the grandparent generation having attended college and its impact on the academic success of the grandchild/child.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Chi-Square analysis of the data in this study indicated that students who had a parent or step parent who had taken a college course for credit and who had experienced the hybrid teaching modality had a higher rate of successful course completion (χ^2=4.055, p=.044). Correlation analysis of the data indicated that successful course completion was not impacted for students whose parents or step parents had previously taken a college course for credit (r=.171, p=.121, N=83).

Student Level of Comfort With Mathematics

For students who experienced the traditional teaching modality; a moderate, high, or very high level of comfort with mathematics was significantly associated with successful course completion at the .05 level (χ^2=3.846, p=.050). This finding supports research by Illich, Hagan, and McCallister (2004) and Cross and Steadman (1996) that student comfort and belief that they can succeed is more important than actual skill levels. A student's level of comfort with mathematics as moderate, high, or very high was found to be a predictor of successful course completion in the logistic regression analysis of this study as detailed in Table 31.

Student Level of Internal Motivation

Internal motivation to learn mathematics is also positively associated with student achievement and success (Cross & Steadman, 1996; Harrison, Andrews, & Saklofske, 2003; Illich, Hagan, & McCallister, 2004; McKay, 2003; and Perez & Foshay, 2002). McKay (2003) defines motivation as "a person's need, interest, or desire to learn" (p. 46).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The students' level of internal motivation to learn mathematics was not statistically significantly associated with higher rates of success for students in the traditional teaching modality (χ^2=.024, p=.876) or for students in the hybrid teaching modality (χ^2=.090, p=.764).

Student Level of Confidence

Research also exists indicating that students' self beliefs about their ability to succeed plays a role in the academic success of under prepared college students (Illich et al., 2004, p. 450). A student's confidence in her or his own ability to learn is central to academic success.

The data in this study did not indicate that the students' level of confidence to succeed in the pre-college level mathematics courses was associated with higher levels of student success (r=.049, p=.654, N=86) for either teaching modality.

Student comfort level with mathematics, student comfort level with computers, student confidence level to succeed in mathematics, and student level of internal motivation to succeed in mathematics were measured on a five point scale of the following responses: very low, low, moderate, high, and very high. Very low and low were originally coded as one response and moderate, high, and very high were coded as another response. No significant differences in the rates of student success were found with analysis of Chi-square for the coding above. The responses for "moderate" were recoded to group very low, low, and moderate as one response and high and very high as another response. Although the significance levels improved somewhat, neither reflected a large

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

enough change to warrant a finding of statistically significant difference in the student rate of success.

Student Preference to Study Alone or With Others

Eugene McKay (2003) reported in his study that collaboration between students is a component of student learning that allows students to share their understandings of instructional concepts and build on the prior knowledge of each other (p. 44). Collaboration between students is encouraged in the reforms of mathematics education (AMATYC, 1995, Standard P-2).

The students' preference to study alone or with others for this research was not statistically significantly associated with higher rates of success for students in the traditional teaching modality (χ^2=.294, p=.588) or for students in the hybrid teaching modality (χ^2=1.733, p=.118).

Number of Hours Student Spent Using Interactive Software

The number of hours that the students spent using the interactive software was a variable that was pertinent only to the students who experienced the hybrid teaching modality. Of the 8 students who successfully completed the courses, 3 used the software the shortest amount of hours or 3 used the software the longest amount of hours. Those students who used the software the shortest amount of hours needed less instructional and practice time and those students who used the software the longest amount of hours needed the most instructional and practice time.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Student Level of Comfort With Computers

Oxford, Proctor, and Slate (1998) studied student achievement in a college algebra course using the hybrid teaching modality and the students' attitudes toward the use of computers. Forty-three percent of the students who participated in their study indicated that they had no computer experience prior to taking the algebra course but 79% of the participants felt that the enhancement of their ability in mathematics was a direct result of use of the computer component of the courses.

The students' level of comfort with computers in this research was not associated with higher rates of student success for students who experienced the traditional teaching modality (χ^2=1.171, p=.279) or the hybrid teaching modality (χ^2=.481, p=.488).

Student Level of Ability to Complete Projects

Zimmerman (1994) found that academic underachievement was tied to students giving up more easily than achievers. Persistence and resourcefulness in overcoming problems related to learning tasks contributed to student success.

For students who experienced either teaching modality, the level of their ability to complete a project once begun was statistically significantly associated with success (r=.194, p=.073, N=86). This variable was also determined through logistic regression to be a predictor of successful course completion. Students who had a moderate, high, or very high level of ability to complete a project once begun almost doubled their chance of receiving a final exam score of 70% or higher in the pre-college level mathematics course for which they were enrolled.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Student Employment Status and Hours Worked Weekly

The Community College Survey of Student Engagement (CCSSE, 2003) found that students who worked 30 or more hours per week were at a higher risk of adversely impacting their success. Student success in this study for students who were employed was not lower for students in the traditional teaching modality (χ^2=.000, p=.995) or for students in the hybrid teaching modality (χ^2=.090, p=.764). Approximately two-thirds of the students in this study were employed and student success was not adversely impacted by student employment status.

Program of Study

Students who were in the Nursing program and who experienced the hybrid teaching modality were more likely to successfully complete the pre-college level mathematics courses (χ^2=3.259, p=.071) than those students who experienced the traditional modality (χ^2=1.455, p=.228). Future research specifically related to students in nursing programs may help to understand the interactions between the variables that impact student achievement and success.

Predicting Student Success

Logistic Regression was used to create a predictive model for successful course completion for pre-college mathematics courses. The dependent variable was successful course completion and the independent variables that contributed to a correctly predictive model of 68% included the age of the student, the student's level of ability to complete projects once begun, and the student's level of comfort with mathematics.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The predictive model indicated that the older a student is, the more likely it is that the student will be successful in the course. Students who reported their level of ability to complete a project once begun as moderate, high, or very high increased their likelihood of successful course completion by a factor of 1.6. Students who reported their level of comfort with mathematics as moderate, high, or very high almost doubled their likelihood of successful course completion.

Student Beliefs on Computer Usage

Oxford et al. (1998) found that 79% of the participants in their study felt that the enhancement of their ability in mathematics was a direct result of use of the computer component of the courses; however, no research was found that specifically addressed the beliefs of students concerning computer usage in general impacting their learning in college courses.

Of the students in this study who experienced the hybrid teaching modality, 77% of them believed that computer usage contributed to student learning in college, and 61% of the students who experienced the traditional teaching modality expressed their belief that computer usage contributed to student learning in college. Students who experienced the traditional teaching modality did not use computers as part of their modality of instruction. Overall, close to two-thirds of the students in this study expressed their belief that computer usage positively contributes to student learning.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Limitations

A contradiction became evident as the analyses process unfolded for this research. One of the strengths of this study was that the instructors and students were blind to the fact that they were potential participants in this study. Blindness was the factor that reduced the possible threat to internal validity caused by design contamination. Design contamination threatens internal validity when participants are aware that they are included in a study and their behavior or results may thus be affected. Simultaneously, one of the weaknesses of this study was that the instructors and students in this study were blind to the fact that they were potential participants. This statement was manifested by some instructors not giving the pretest the first day of class, thereby impeding the analysis of student achievement as measured by gain scores for students in the hybrid teaching modality. The lack of a pretest adversely impacted the ability to measure student achievement in this research study.

The telephone interviews were conducted in July 2004, 6 months after the beginning of the winter 2004 semester, and the accuracy of participants' recollections of their beliefs and attitudes could have been influenced by their actual experiences in the courses of interest as well as the passage of time. The more time passed between the beginning of the semester and the interviews, the more the possibility of inaccurate responses from the participants. Conducting the interviews at the beginning of the winter 2004 semester may have provided more accurate responses; however, the students and instructors would have then known that they were potential participants in this research and their subsequent academic behavior may have been altered.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

The number of students who experienced the hybrid teaching modality was small; these students comprised only 18 of the 208 students in this study. Thirteen of these 18 participated in the student interviews with 6 students having taken the Basic Mathematics course and 7 having taken the Basic Algebra course. The lack of a pretest for all of these 13 students limited the number of gains scores to 4 for students in the Basic Mathematics course and 0 for students in the Basic Algebra course. For Chi-Square analysis, the minimum observed count in each cell should be 5 cases. This minimum number of 5 could not be achieved for all of the factors under analysis.

Nine of the 13 students who experienced the hybrid modality were successful (83%); however, each student represented approximately 8% of the group. A larger number of students who experienced the hybrid teaching modality would have permitted a finer level of measurement and differentiation between the students who experienced the traditional teaching modality and the hybrid teaching modality.

Another limitation of this research involved the number of variables, or interactions between the variables, that further help to describe and explain student success in pre-college level mathematics courses. The variables included in this study were not meant to imply that they are an exhaustive list of the factors that impact student success.

Policy Implications

The prescription of policy choices for postsecondary educational institutions as a result of this study include, but are not limited to, student academic advisement, mandatory student placement into pre-college level courses if placement testing scores indicate the need, additional student testing to determine the optimum teaching modality for each

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

student, better course development with accompanying choices for students of teaching modalities to accommodate varied adult learning styles, levels of expenditure for faculty professional development to increase faculty awareness, sensitivity, and effectiveness in accommodating varying student learning styles, alternate definitions of full time faculty workload, and institutional levels of expenditure for computer technology and technology support.

Postsecondary institutions and their students would benefit from improved student academic advisement. Students may be advised to take courses that utilize a particular teaching modality that better complements their learning styles or methods of processing information. Similarly, students may be advised to avoid other teaching modalities to which they are not well suited. Other colleges may wish to conduct institution-specific studies that will provide information for more accurate profiles of their students' performance and to better gauge learning outcomes.

Mandatory placement of students into pre-college level courses to prepare for college-level courses is not a uniform policy at two-year or four-year colleges in Michigan even though proficiency of academic skills in these courses is considered necessary for successful completion of college-level course work. Some policy makers hold the philosophy that a student's prerogative to take higher level courses and his or her "right to fail" is preferable to mandatory placement into pre-college level courses. Pre-college level courses do not count directly toward the student's certificate, two-year degree, or transfer to four-year colleges and universities. Additionally, pressure from some state and federal funding sources encourages two- and four-year colleges to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

expedite the program completion time for students and time spent in pre-college level courses is counter to that objective.

As consumers of the educational courses and programs offered by colleges, students will increasingly seek accommodation for their learning styles, scheduling constraints, and desire for more specific and targeted instructional content. Students may prefer to concentrate their instructional time on the mathematical concepts of which they are deficient and to more quickly demonstrate proficiency for the concepts for which they have adequate understanding.

Designing courses that better accommodate the scheduling constraints of students while at the same time maintaining the instructional integrity and quality of the courses will require input from students and faculty with institutional financial support. Limitations of time and scheduling surrounding the taking of an entire course over the length of a semester may hinder academic achievement and success for students who are juggling the demands of home, work, and educational responsibilities.

Educational policy makers will be faced with considering student testing and testing instruments that can accurately assess a student's learning style. Matching a student's learning style with the most appropriate teaching modality may improve the likelihood of student academic success. At this same time, however, some institutions are seeking ways to facilitate and ease college registration and enrollment procedures for students. The time and funding necessary for such testing run counter to such testing efforts.

Increased levels of funding for faculty professional development activities that increase the faculty members' awareness, sensitivity, and effectiveness in accommodating

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

varying student learning styles will need to be considered. Competing interests for faculty professional development time and dollars will need to be evaluated.

Definitions of full time faculty workload need to be reconsidered based on this research. Typically, workloads for full time college faculty are based on the number of hours spent lecturing students per week. The instructor who utilized the hybrid teaching modality spent half the time lecturing as the instructors who utilized the traditional teaching modality. Faculty workloads defined by the weekly number of hours spent lecturing students are now obsolete and outmoded.

Institutional levels of expenditure for computers and other forms of technology as well as technology support are currently taking increased fiscal, physical, and human resources. Accommodations for students with physical and learning disability issues need to continue to increase. Will students be required to have computers/laptops? Who pays? Will hardware and software be standardized at institutions to limit costs for technology support for institutions?

Educational policy considerations for states and the federal government could include levels of funding or the complete withdrawal of funding for pre-college level instruction at two-year and four-year colleges. Pre-college level courses in reading, mathematics, and writing contain subject matter content and skills that the student should have already mastered in the K-12 levels of his or her educational experience. Taxpayers have already funded the K-12 level of education and are funding it again at the postsecondary collegiate level through federal financial aid dollars to students. Financial aid pays for up to 30 credit hours of pre-college level course work.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Some policy makers have called for pre-college level courses to be offered only at two-year institutions and not at four-year colleges and universities. Michigan state appropriations to all postsecondary educational institutions have been decreasing in the last two years and the decision by postsecondary institutions to fund pre-college level courses could take funding dollars away from other more advanced content areas or research.

The thesis of this research was that the variety of learning styles and students' increased need for flexibility related to their learning environment and experiences require additional options of teaching modalities from which students may choose. Students at all levels have been allowed few, if any, choices related to different teaching modalities. As consumers of the educational courses and programs offered by colleges, students will increasingly seek accommodation of their learning styles and scheduling constraints. Some students may prefer to learn in a structured environment that emphasizes a traditional lecture modality. Others may prefer a more flexible learning environment that allows them to learn and study at their own pace at days and times that are convenient for them, even within the framework of a typical college semester.

The reforms in mathematics education promote the use of technology to facilitate the construction of mathematical concepts (AMATYC, 1995). Constructivist views see individual learners as building up personal, internal conceptual maps as a result of interactive processes between each learner and his/her environment. There are a variety of modes of delivery for computer-based learning and, generally, a specific set of learning objectives are best met by a particular delivery mode (Wills & McNaught, 1996, p. 121). As computer technology improves and becomes more affordable, the opportunity to

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

implement computer-based instruction at public two-year colleges increases (Parsad & Lewis, 2003).

Terry O'Banion sums up the opportunity for change for postsecondary educational institutions with the following quote:

> American education must continue to overhaul its outdated, traditional framework restricted by time, place, bureaucracy, and limited teacher roles. The ideal model of education, the learning college, should inspire substantive change in individual learners, endow them with responsibility for their education, offer as many learning options as possible, assist in collaborative learning activities, define the roles of learning facilitators by the needs of the learners, and record improved and expanded learning. (O'Banion, 1997)

We will all be the beneficiaries of such change in a society founded on Thomas Jefferson's belief that an educated citizenry is a vital component to a sustained and healthy democracy.

Future Research

Adequate skills in mathematics are fundamental to persons living and working in increasingly technological environments. Finding ways to increase student success in the content area of mathematics will contribute to a world requiring workers to have skills and thinking processes to meet and compete at higher levels of mathematical and technological complexity.

This research demonstrates the need for further research related to student achievement and success in pre-college and college level mathematics courses and factors that impact student success. Further examination of the effects of student age, employment, previous generations having attended college, and part time or full time status are necessary. Critical studies involving these issues will encourage postsecondary

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

educational institutions to consider the adoption and implementation of policies and educational innovations that will enhance student learning in an effort to be more responsive to their student and taxpayer constituencies in an increasingly diverse and pluralistic society.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix A

Kirtland Community College Approval to Collect Data

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Kirtland
Community College

Date: July 12, 2004

To: Human Subjects Institutional Review Board at
Western Michigan University

Re: HSIRB Project Number 04-07-02

To Whom It May Concern:

Dorothy (Doty) Latuszek is an administrator at Kirtland Community College and she has approval from the College to collect and analyze information from student records files and interviews or surveys from students for the purpose of conducting research for her dissertation for her doctorate in public administration through Western Michigan University. This approval extends to the publication of the study in whole or in part or presentations in appropriate forums involving the study or its findings.

It is understood that these data may include student identifying information, test scores, academic status, financial aid status, and other information related to her dissertation research. In order to contact the students with a Pre Notice letter and to be able to telephone them for an interview, the student name, address, and telephone number will be accessed for the courses of interest for the study. All other data for the study will not be linked to the students' identities. It is also understood that access to this data will not violate the Family Educational Rights and Privacy Act (FERPA) criteria for its use.

> FERPA Section 99.31, (a)(6)(i)(C) permits disclosure of student information to organizations conducting studies to improve instruction if
> (ii)(A) The study is conducted in a manner that does not permit personal identification of parents and students by individuals other than representatives of the organization; and
> (ii)(B) The information is destroyed when no longer needed for the purposes for which the study was conducted.

Sincerely,

Charles Rorie, Ph.D.
Charles Rorie, Ph.D.
President
Kirtland Community College

10775 N. St. Helen Road • Roscommon, Michigan 48653 • 517-275-5121

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix B

Human Subjects Review Board Approval

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Centennial
1903-2003 Celebration

Date: July 13, 2004

To: Barbara Liggett, Principal Investigator
Doty Latuszek, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Interim Chair Amy Naugle

Re: HSIRB Project Number: 04-07-02

This letter will serve as confirmation that your research project entitled "A Comparison of the Effectiveness of Two Teaching Modalities for Pre-college Level Mathematics Courses at a Two-year College" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: July 13, 2005

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix C

Pre Notice Letter

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Kirtland
Community College

Dear Kirtland Community College Student:

In a few days you will be receiving a telephone call from a representative of Kirtland Community College inviting you to participate in a research study being conducted as part of a doctoral dissertation for Western Michigan University. If you choose to participate in the study, we estimate that it will take about 10 minutes of your time.

You are being contacted for this study because you enrolled in either Basic Mathematics or Basic Algebra in the winter 2004 semester. The purpose of the study is to find ways to help more students learn and succeed in these mathematics courses. There may be risks to you such as the telephone call may come at an inconvenient time for you or you may feel self-conscious about answering some of the questions. If the call comes at an inconvenient time, you may either reschedule the call for a different time or you may decide not to participate at all. Your participation in the study is completely voluntary and by answering the questions you will be giving permission to use your responses to the interview and information contained in your student record file at the college in our research. If you choose to participate in this study, any information you give will be confidential. You will be assigned a code number and your name, address, and telephone number will not be linked to your responses. You will be able to stop the interview at any time during the phone call.

There will be no direct benefit to you for participating in the study but you will be contributing valuable information that may help other students who take these courses in the future. We hope that you will be willing to take the time to answer the questions for this important interview but if you decide not to participate, no harm or benefit will come to you.

If you have any questions or concerns, you may contact Doty Latuszek at 989.705.3683, Barbara Liggett at 269.387.8943, the Human Subjects Institutional Review Board at 269.387.8293, or the vice president for research at Western Michigan University at 269.387.8298. Thank you for your consideration of this request.

Sincerely,

Doty Latuszek
Project Researcher

Barbara Liggett, Ed.D.
Associate Professor
School of Public Affairs and Administration
Western Michigan University

10775 N. St. Helen Road • Roscommon, Michigan 48653 • 517-275-5121

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Appendix D

Interview Guide

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Student Telephone Interview Guide and Consent Document

Note: Information in *italics* is instructional information for the interviewer.

Note: Information in CAPITAL LETTERS is to be read by the interviewer exactly as written to the potential participant.

Student Code Number

____

Date of Call	Time Call Began	Time Call Ended	Length of Call	Comment

AM I SPEAKING WITH *(Must be the student on the master list that matches the code number above)* ?

Yes______, *(Proceed to read the information below exactly as written.)*

No______, *(Establish a call back day and/or time and list in the table above.)*

I AM CONDUCTING A RESEARCH PROJECT THROUGH WESTERN MICHIGAN UNIVERSITY. IS THIS A CONVENIENT TIME FOR YOU TO TAKE THIS CALL?

Yes_______, *(Proceed to read the information below exactly as written.)*

No_______, WOULD YOU LIKE TO SET AN APPOINTMENT FOR ANOTHER TIME THAT MAY BE MORE CONVENIENT FOR YOU? (*If yes, list call back day and time in the table above. If no,* THANK YOU VERY MUCH FOR YOUR TIME.)

AS A STUDENT WHO ENROLLED IN BASIC MATH OR BASIC ALGEBRA AT KIRTLAND COMMUNITY COLLEGE FOR THE WINTER 2004 SEMESTER, YOU ARE INVITED TO PARTICIPATE IN A RESEARCH PROJECT THAT MAY HELP TO IMPROVE THE STUDENT SUCCESS RATE OF OTHER STUDENTS WHO

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

TAKE THESE TWO COURSES IN THE FUTURE. THIS RESEARCH IS BEING CONDUCTED BY DOTY LATUSZEK AND BARBARA LIGGETT FROM WESTERN MICHIGAN UNIVERSITY, SCHOOL OF PUBLIC AFFAIRS AND ADMINISTRATION, AND IS PART OF THE DISSERTATION REQUIREMENTS FOR DOTY LATUSZEK.

IF YOU CHOOSE TO PARTICIPATE IN THIS TELEPHONE INTERVIEW, WE ESTIMATE THAT IT WILL TAKE YOU ABOUT 10 MINUTES TO ANSWER THE QUESTIONS. YOUR PARTICIPATION IN THIS INTERVIEW IS COMPLETELY VOLUNTARY AND BY AGREEING TO ANSWER THE QUESTIONS YOU ARE GIVING US PERMISSION TO USE YOUR RESPONSES TO THE INTERVIEW AND INFORMATION CONTAINED IN YOUR STUDENT RECORD FILE AT THE COLLEGE IN OUR RESEARCH. IF FOR ANY REASON, YOU ARE UNCOMFORTABLE PARTICIPATING IN THE STUDY OR ANSWERING ANY OF THE QUESTIONS, PLEASE LET ME KNOW AND WE WILL STOP THE INTERVIEW IMMEDIATELY. IF YOU CHOOSE TO PARTICIPATE IN THIS STUDY, ANY INFORMATION YOU GIVE WILL BE CONFIDENTIAL. YOUR NAME, ADDRESS, AND TELEPHONE NUMBER ARE ON A SEPARATE LIST FROM THE DATA AND A CODE NUMBER HAS BEEN ASSIGNED TO YOU. YOUR NAME WILL NOT BE LINKED TO YOUR RESPONSES. IF YOU DECIDE THAT YOU DO NOT WANT ME TO CONTINUE WITH THIS INTERVIEW, NO HARM OR BENEFIT WILL HAPPEN TO YOU.

ARE YOU WILLING TO PARTICIPATE IN THIS INTERVIEW?

Yes _____, *(Proceed with the instructions and question 1.)*

No _____, *(If the person decides not to participate in the interview, say* THANK YOU VERY MUCH FOR YOUR TIME.)

Instructions

PLEASE ANSWER EACH QUESTION TO THE BEST OF YOUR ABILITY AND UNDERSTANDING.

1. IF YOU WERE EMPLOYED DURING THE WINTER 2004 SEMESTER, APPROXIMATELY HOW MANY HOURS PER WEEK DID YOU WORK?

_______ Hours worked per week
_______ Not employed winter 2004
_______ No Answer
_______ End Interview

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

2. DID ONE OR MORE OF YOUR PARENTS OR STEPPARENTS EVER TAKE A COLLEGE COURSE FOR CREDIT?

_______ Yes
_______ No
_______ Don't Know
_______ No Answer
_______ End Interview

3. DID ONE OR MORE OF YOUR GRANDPARENTS OR STEP GRANDPARENTS EVER TAKE A COLLEGE COURSE FOR CREDIT?

_______ Yes
_______ No
_______ Don't Know
_______ No Answer
_______ End Interview

4. DID YOU STUDY FOR YOUR MATHEMATICS COURSE ALONE OR WITH OTHERS DURING THE WINTER 2004 SEMESTER?

_______ Alone
_______ With Others
_______ No Answer
_______ End Interview

5. DID YOU HELP ANY SCHOOL-AGE CHILDREN LEARN MATHEMATICS DURING THE WINTER 2004 SEMESTER?

_______ Yes
_______ No
_______ No Answer
_______ End Interview

6. PRIOR TO YOU ENROLLING IN BASIC MATH OR BASIC ALGEBRA DURING THE WINTER 2004 SEMESTER, WHAT WOULD BEST DESCRIBE YOU IN TERMS OF YOUR COMFORT LEVEL WITH MATHEMATICS ON A FIVE POINT SCALE OF VERY LOW, LOW, MODERATE, HIGH, OR VERY HIGH?

_______ Very Low
_______ Low
_______ Moderate
_______ High
_______ Very High

_______ Don't Know
_______ No Answer
_______ End Interview

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

7. PRIOR TO YOU ENROLLING IN BASIC MATH OR BASIC ALGEBRA DURING THE WINTER 2004 SEMESTER, WHAT WOULD BEST DESCRIBE YOU IN TERMS OF YOUR INTERNAL MOTIVATION TO LEARN MATHEMATICS ON A FIVE POINT SCALE OF VERY LOW, LOW, MODERATE, HIGH, OR VERY HIGH?

_______ Very Low
_______ Low
_______ Moderate
_______ High
_______ Very High

_______ Don't Know
_______ No Answer
_______ End Interview

8. PRIOR TO YOU ENROLLING IN BASIC MATH OR BASIC ALGEBRA DURING THE WINTER 2004 SEMESTER, WHAT WOULD BEST DESCRIBE YOU IN TERMS OF YOUR CONFIDENCE LEVEL TO SUCCEED IN A MATHEMATICS COURSE ON A FIVE POINT SCALE OF VERY LOW, LOW, MODERATE, HIGH, OR VERY HIGH?

_______ Very Low
_______ Low
_______ Moderate
_______ High
_______ Very High

_______ Don't Know
_______ No Answer
_______ End Interview

9. PRIOR TO YOU ENROLLING IN BASIC MATH OR BASIC ALGEBRA DURING THE WINTER 2004 SEMESTER, WHAT WOULD BEST DESCRIBE YOU IN TERMS OF YOUR COMFORT LEVEL WITH COMPUTERS ON A FIVE POINT SCALE OF VERY LOW, LOW, MODERATE, HIGH, OR VERY HIGH?

_______ Very Low
_______ Low
_______ Moderate
_______ High
_______ Very High

_______ Don't Know
_______ No Answer
_______ End Interview

10. PRIOR TO YOU ENROLLING IN BASIC MATH OR BASIC ALGEBRA DURING THE WINTER 2004 SEMESTER, WHAT WOULD BEST DESCRIBE YOU

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

IN TERMS OF YOUR ABILITY TO COMPLETE PROJECTS ONCE YOU HAVE BEGUN THEM ON A FIVE POINT SCALE OF VERY LOW, LOW, MODERATE, HIGH, OR VERY HIGH?

_______ Very Low
_______ Low
_______ Moderate
_______ High
_______ Very High

_______ Don't Know
_______ No Answer
_______ End Interview

11. DO YOU BELIEVE THAT THE USE OF COMPUTERS IN YOUR COLLEGE COURSES CONTRIBUTED TO YOUR LEARNING IN THOSE COURSES MORE THAN IF YOU HAD NOT USED COMPUTERS?

_______ Yes
_______ No
_______ No Answer
_______ End Interview

THAT CONCLUDES OUR INTERVIEW. THANK YOU VERY MUCH FOR YOUR TIME AND PARTICIPATION IN THIS RESEARCH PROJECT.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

REFERENCES

American Mathematical Association of Two-Year Colleges (AMATYC). (1995). *Crossroads in mathematics: Standards for introductory college mathematics before calculus.* Memphis, TN: Author.

Astin, A.W. (1993). *Assessment for excellence: The philosophy and practice of assessment and evaluation in higher education.* American Council on Education: Oryx Press.

Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century. (n.d.). Retrieved on June 29, 2004 from http://www.ed.gov/inits/Math/glenn

Berman, E. M. (2002). *Essential statistics for public managers and policy analysts.* Washington, DC: Congressional Quarterly.

Bessant, K. C. (1997, October). The development and validation of scores on the Mathematics Information Processing Scale (MIPS). *Educational and Psychological Measurement, 57*, 841-857.

Birenbaum, W. M. (1974). From class to mass in higher education. In William M. Birenbaum (Ed.), *New directions for community colleges number 7* (pp. 1-16). San Francisco: Jossey-Bass.

Brewer, J., & Daane, C. J. (2002, Winter). Translating constructivist theory into practice in primary-grade mathematics. *Education, 123*(2), 416-421.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Cifuentes, L., & Hsieh, Y. J. (2003). Visualization for construction of meaning during study time: A quantitative analysis. *International Journal of Instructional Media, 30*(3), 263-273.

Community College Survey of Student Engagement. (2003, February). Success is different to each student, community college survey says. *Recruitment and Retention in Higher Education, 17*(2), 3-6.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design & analysis issues for field settings.* Boston: Houghton Mifflin.

Cox, G. C. (1990). The effect of curriculum specific computer-aided instruction on student achievement in college algebra, a comparative study. *Dissertation Abstracts International, 51*(03), 774. (UMI No. 9022601)

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: Sage.

Cross, K. P., & Steadman, M. H. (1996). *Classroom research: Implementing the scholarship of teaching.* San Francisco: Jossey-Bass.

Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000, March/April). Students' conceptions of learning, the classroom environment, and approaches to learning. *The Journal of Educational Research, 93*(4), 262-270.

DEV06300 Basic Mathematics course syllabus at http://services.kirtland.edu/math/ftfac.htm

DEV07300 Basic Algebra course syllabus at http://services.kirtland.edu/math/ftfac.htm

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Dixon, K., Dessens, C., Harris, A., & Neal, W. (1990). Enhancing instruction in remedial mathematics through computer assisted programs. In Foshay, R.. *Technical Paper #1* (1994, January). Houston: Department of Mathematics, Texas Community College System. Retrieved February 12, 2004 from http://www.plato.com/ research.

Du, J., & Havard, B. (2003, Fall). A framework for deep learning in business distance education. *Delta Pi Epsilon Journal, 45*(3), 204-214.

Dyer, D. (personal communication June 3, 2004). Academic and personal counselor, Kirtland Community College, Roscommon, MI.

Ely, D. P. (1993, September). Computers in schools and universities in the United States of America. *Educational Technology, 33*(9), 53-57.

Flint, T. A., & Frey, R. (2003, Summer). Alternative programming for adults. *New Directions for Student Services, 102*, 69-79.

Ford, P. L. (Ed.). (1892-1899). *The writings of Thomas Jefferson*. New York. Retrieved June 29, 2004 from http://etext.virginia.edu/jefferson/

Gifford, B. R. (1996). *Mediated learning: A new model of technology-mediated instruction and learning*. Mountain View, CA: Academic Systems Corporation.

Goldsmith, L. T. (1999, November). What is a standards-based mathematics curriculum? *Educational Leadership, 57*(3), 40-44.

Golonka, S., & Matus-Grossman, L. (2001, May). Opening doors: Expanding educational opportunities for low-income workers. *Manpower Demonstration Research Corporation.* Retrieved December 10, 2003 from National Governors Association Center for Best Practices at www.nga.org/center

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Gruber, H. E., & Voneche, J. J. (Eds.). (1977). *The essential Piaget.* New York: Basic Books.

Harrison, G., Andrews, J., & Saklofske, D. (2003, Spring). Current perspectives on cognitive and learning styles. *Education Canada, 43*(2), 44-47.

Hofer, B. K., Yu, S. L., & Pintrich, P. R. (1998). Teaching college students to be self-regulated learners. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 57-84). New York: Guilford.

Huffman, D., Goldberg, F., & Michlin, M. (2003). Using computers to create constructivist learning environments: Impact on pedagogy and achievement. *The Journal of Computers in Mathematics and Science Teaching, 22*(2), 151-168.

Illich, P. A., Hagan, C., & McCallister, L. (2004, June). Performance in college-level courses among students concurrently enrolled in remedial courses: Policy implications. *Community College Journal of Research and Practice, 28*(5), 435-453.

Inch, S. (2002, Summer). The accidental constructivist: A mathematician's discovery. *College Teaching, 50*(3), 111-113.

Kanji, G. K. (1993). *100 statistical tests.* Thousand Oaks, CA: Sage.

Kinney, D. P., & Robertson, D. F. (2003, Fall). Technology makes possible new models for delivering developmental mathematics instruction. *Mathematics and Computer Education, 37*(3), 315-328.

Kirtland Community College catalog. (2003-2004). http://new.kirtland.edu/studentservices/recordsregistration/Catalog.htm

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Kulik, C., Kulik, J., & Shwalb, B. (1986). The effectiveness of computer-based adult education: A meta analysis. *Journal of Educational Computing Research, 2*(2), 235-250.

Lutzer, D. J., Maxwell, J. W., & Rodi, S. B. (2002). Fall 2000 CBMS Survey. *Statistical abstract of undergraduate programs in mathematical sciences in the United States.* American Mathematical Society. Retrieved June 1, 2004 from www.ams.org/cbms/cbmssurvey

Macan, T. H., Shahani, D., Dipboye, R. L., & Phillips, A. P. (1990). College students' time management: Correlations with academic performance and stress. *Journal of Educational Psychology, 82*(4), 760-768.

Marton, F., Hounsell, D., & Entwistle, N. (Eds.). (1984). *The experience of learning*. Edinburgh: Scottish Academic Press.

McCabe, R. H. (2003). *Yes we can! A community college guide for developing America's underprepared.* American Association of Community Colleges. Washington, DC: League for Innovation in the Community Colleges.

McCabe, R. H., & Day, P. R., Jr. (1998). The case for developmental education in the twenty-first century. In R. H. McCabe & P. R. Day, Jr. (Eds.), *Developmental education: A twenty-first century social and economic imperative* (Chapter 4, pp. 27-34). Mission Viejo, CA: League for Innovation in the Community College.

McKay, E. H. (2003). *Student satisfaction with Michigan community college distance education courses*. Unpublished dissertation, Western Michigan University, Kalamazoo.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Mertler, C. A., & Vannatta, R. A. (2001). *Advanced and multivariate statistical methods: Practical application and interpretation.* Los Angeles, CA: Pyrczak Publishing.

Michigan Department of Education. (1999). *An analysis of developmental education at Michigan's associate degree-granting institutions*. Lansing, MI. Retrieved from http://www.michigancc.net/old/studies/analysis.pdf

Miglietti, C. L., & Strange, C. C. (1998, Summer). Learning styles, classroom environment preferences, teaching styles, and remedial course outcomes for under prepared adults at a two-year college. *Community College Review, 26*(1), 1-19.

National Center for Education Statistics [NCES]. (2000). Condition of Education 2000: Section 5: *The context of postsecondary education.* Washington, DC: U.S. Department of Education.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards in school mathematics*. Reston, VA: Author.

Nedry, P. J. (2003). *The impact of Tech Prep on community colleges readiness in Michigan*. Unpublished doctoral dissertation, Eastern Michigan University, Ypsilanti.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

O'Banion, T. (1997). *A learning college for the 21st century.* A joint publication of the American Association of Community Colleges and the American Council on Education. Phoenix: Oryx Press.

Oxford, L., Proctor, K., & Slate, J. (1998, Fall). Computer-based instruction and achievement of adult learners. *The Michigan Community College Journal.* pp. 77-84.

Parsad, B., & Lewis, L. (2003, November). *Remedial education at degree-granting postsecondary institutions in fall 2000: Statistical analysis report.* Washington, DC: National Center for Education Statistics, U.S. Department of Education.

Pask, G. (1976). Styles and strategies of learning. *British Journal of Educational Psychology, 46,* 128-148.

Perez, S., & Foshay, R. (2002, March). Adding up the distance: Can developmental studies work in a distance learning environment? *T.H.E. Journal, 29*(8), 16-24.

Piaget, J. *On Constructivism.* Retrieved June 30, 2004 from http://www.funderstanding.com/constructivism.cfm

Piaget, J. Retrieved June 30, 2004 from http://www.funderstanding.com/piaget.cfm

President's Commission on Higher Education. (1947). *Higher education for American democracy.* Washington, DC: U.S. Government Printing Office.

Pulaski, M. A. S. (1971). *Understanding Piaget.* New York: Harper & Row.

Rachal, J. R. (1993, Spring). Computer assisted instruction in adult basic and secondary education: A review of the experimental literature, 1984-1992. *Adult Education Quarterly, 43*(3), 165-172.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Roueche, J. E., & Baker III, G. A. (1987). *Access and excellence: The open-door college.* Washington, DC: Community College Press.

Roueche, J. E., Baker III, G. A., & Roueche, S. D. (1987, April/May). Open door or revolving door: Open access and the community college. *American Association of Community and Junior Colleges,* pp. 22-26.

Roueche, J. E., & Roueche, S. D. (1993). *Between a rock and a hard place: The at-risk student in the open-door college.* Washington, DC: American Association of Community Colleges.

Rowland, S. L. (2003). Factors that contribute to the persistence and academic achievement of community college students. *UMI ProQuest Digital Dissertations.* (UMI No. 3081447)

Sandruck, B. A. (2003). Effects of interactive computer-based instruction in elementary algebra on community college achievement in intermediate algebra. *UMI ProQuest Digital Dissertations.* (UMI No. 3107259)

Sankaran, S. R., & Bui, T. (2001). Impact of learning strategies and motivation on performance: A study in web-based instruction. *Journal of Instructional Psychology, 28*(3), 191-198.

SPSS Training Department. (1997). *Advanced statistical analysis using SPSS.* Chicago: SPSS, Inc.

Swing, R., & Cangemi, J. (1996, March). Some advice from graduating college seniors to entering college freshmen. *College Student Journal, 30,* 85-89.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Tabs, E. D. (2003). *Distance education at degree-granting postsecondary institutions.* National Center for Education Statistics. U.S. Department of Education. Institute of Education Sciences. NCES 2003-017.

Villarreal, L. M. (2003, Winter). A step in the positive direction: Integrating a computer laboratory component into developmental algebra courses. *Mathematics and Computer Education, 37*(1), 72-78.

Ward, C. D. (2001, Fall). Under construction: On becoming a constructivist in view of the Standards. *Mathematics Teacher, 94*(2), 94-96.

Williams, G. D. (1996). An examination of computer-aided instruction, the self-concept and achievement levels of developmental mathematics community college students. *Dissertation Abstracts International, 57(03),* 992. (UMI No. 9624013)

Wills, S., & McNaught, C. (1996, Spring). Evaluation of computer-based learning in higher education. *Journal of Computing in Higher Education, 7*(2), 106-128.

Zimmerman, B. J. (1994). Dimensions of academic self-regulation: A conceptual framework for education. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 3-19). Hillsdale, NJ: Erlbaum.

Zwerling, L. S. (1976). *Second best: The crisis of the community college.* New York: McGraw-Hill.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.