ABSTRACT

Title of dissertation: EFFECTS OF INTERACTIVE COMPUTER-BASED INSTRUCTION IN ELEMENTARY ALGEBRA ON COMMUNITY COLLEGE ACHIEVEMENT IN INTERMEDIATE ALGEBRA

Bernadette Anne Beyer Sandruck, Doctor of Education, 2003

Dissertation directed by: Patricia F. Campbell, Associate Professor
Department of Curriculum and Instruction

This study assessed an existing developmental mathematics program from a mid-sized suburban community college to compare the achievement levels, success rates and retention in intermediate algebra of 50 students who were taught elementary algebra in a traditional classroom setting with 62 students who completed elementary algebra in an interactive computer-based environment. Differences in performance were assessed in five ways: (a) final grade in intermediate algebra, (b) number correct on Part 1 of the Maryland Bridge Goals Assessment (BGA), (c) percent scores on with-in course unit examinations, (d) pass rates for intermediate algebra, and (e) retention rates and completion rates in intermediate algebra. Students were categorized as passing intermediate algebra if they earned a grade of C or better, all other students including withdraws were categorized as did-not-pass. Retention rates were based on the number of students who officially withdrew from the course whereas completion rates were based on

the number of students who completed the first three unit examinations. The mathematics program for both elementary algebra and intermediate algebra was highly structured with department-specified lesson plans and examinations. The results of the study supported the null hypotheses that there were no statistical differences in performance in intermediate algebra between the two instructional groups from elementary algebra.

In preparation for the regression analysis, the two groups were evaluated for similarities in age, gender, ethnicity, high school mathematics background, credits attempted, study hours per credit, work hours, absentee level, time-of-day of instruction, and achievement in elementary algebra. The two instructional groups were demographically similar across all of these variables except time-of-day with evening classes populated predominantly by students who had computer-based instruction in elementary algebra.

Interviews with 24 students from three focus groups indicated that students appreciated the flexibility of computer-based instruction and that returning to the traditional format of teacher-led instruction required no adjustments.

EFFECTS OF INTERACTIVE COMPUTER-BASED INSTRUCTION

IN ELEMENTARY ALGEBRA

ON COMMUNITY COLLEGE ACHIEVEMENT

IN INTERMEDIATE ALGEBRA

by

Bernadette Anne Beyer Sandruck

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Education
2003

Advisory Committee:
Professor. Patricia Campbell, Chair/Advisor
Professor Ken Berg
Professor Anna Graeber
Dr. James Greenberg
Dr. Elizabeth Shearn

ACKNOWLEDGEMENTS

I wish to thank the college staff and faculty from the research site for their enthusiastic assistance with this project. Specifically, I wish to thank Pat in Records and Registration, Linda in Administrative Information Systems, Mary in Admissions, and Dianne from the Test Center. Their willingness to assist with registration details and data retrieval made this project feasible. Thanks also to Paula, the intermediate algebra course coordinator, Kathy from the Assessment Office, and the four volunteer instructors for their advice, assistance and cooperation.

Special thanks are extended to my advisor, Patricia F. Campbell. Pat has been exceedingly generous with her time and has painstakingly led me through the dissertation process. It has only been with her assistance that I was able to complete this process in a timely manner. In summary, Pat has been a wonderful mentor and I feel fortunate to have had her as an advisor.

Finally I wish to thank my husband who graciously handled more and more of our household responsibilities and to my children for insisting that I not quit. Thanks everyone for your patience, understanding and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Statement of the Problem

Many colleges have turned to computer-based instruction for their developmental mathematics programs. Some research indicates that computer-based instruction is an improvement over traditional classroom instruction in learning basic information (Bailey & Chambers, 1993; Fletcher, 1990; Kulik & Kulik, 1991) specifically in mathematics (Oxford, Proctor & Slate, 1998; Wills & McNaught, 1996). Two important issues directly related to developmental studies programs are the effects of computer-based instruction on retention in the program and on success in subsequent courses. The goal of this project was to investigate whether prior experience in a computer-based (independent learner) environment for elementary algebra enhances, diminishes, or has no effect on a student's ability to cope in an intermediate algebra classroom environment that incorporates group work and guided discovery teaching techniques.

Using an existing community college developmental program, this study compared the success rates and retention in intermediate algebra of 50 students who were taught elementary algebra in a traditional classroom setting with 62 intermediate algebra students who completed elementary algebra in a computer-based environment. Comparisons were made between the two groups for potentially conflicting demographic factors such as age, gender, and ethnicity. The design of the college program already included controls for course content, grading requirements, and assessment items for both elementary algebra and intermediate algebra. Variables that effect the students' time commitment, such as credits attempted and hours of employment, were also considered.

Community college students need flexible scheduling and the ability to complete their course work as efficiently as possible. While some students have just a few gaps in their knowledge others have had limited exposure to algebra (Boylan, 2002; Roueche & Roueche, 1993; The Institute for Higher Education Policy, 1998). Recent immigrants, especially women, may have had limited access to mathematics education, and returning adults attended high school in an era when algebra was not emphasized. Some high school graduates had not originally planned to attend college and therefore did not take a rigorous curriculum in high school. In addition to these various instructional needs, the time required to complete a remedial program is a major concern. Time barriers come in several forms. In traditional course scheduling, students are limited to one developmental mathematics course per semester whether they are reviewing the material or learning it for the first time. Computer-based programs enable the open enrollment college to provide an individual plan, but additional study is needed to determine the long-range effectiveness of this type of instruction.

Numerous authors have strongly recommended that developmental programs be evaluated by analyzing completion rates for the entire program and by performance in subsequent courses (Boylan, 2002; Johnson, 1996; Levin & Koski, 1999; McCabe, 2003; Roueche & Roueche, 1993). They report that many colleges do not know if their developmental programs are effective in preparing students for subsequent courses. The purpose of this study was to look at what effect prior participation in a computer-based instructional mathematics program at a comprehensive, public, suburban, community college (SCC) had on student retention and success in the subsequent course.

Significance of the Study

Work Force Issues

Since the early 1980s, national efforts have focused on the importance of reestablishing the United States as a world competitor (Trilling & Hood, 1999). The explosive growth of technology in all types of jobs has increased the demand for a more highly educated workforce (Ikenberry, 1999; Roueche & Roueche, 1993; Zeiss, 1999). The majority of future jobs will require some type of post-secondary education. On the Maryland Workforce Educational Needs Assessment Survey (Maryland Business Roundtable For Education, 2001), business executives were asked to list their preferred college majors for positions requiring a bachelor's degree. Of the 633 Maryland businesses that responded, 51% of the employers preferred that students major in a technical or professional field and 41% preferred a bachelor's degree in Liberal Arts with a concentration in a technical or professional field. Although the work force issue for employers has been improving in recent years, Maryland employers still indicate having difficulty hiring qualified workers for manufacturing, special trades, life-science and engineering.

Business executives were also asked to rate various types of educational institutions on the institutions' ability to provide the executive's company with a qualified and educated workforce. The results from the survey of the Maryland Business Roundtable for Education (2001) indicated a high level of dissatisfaction with high school graduates among many employers. Of the 633 respondents, 35% rated public high schools as poor or below average compared to 14% for public 4-year institutions, 17% for community colleges, 21% for certified technical education programs and 22% for private career schools. The list of causes for dissatisfaction included deficiencies in writing, mathematics and reading skills. The developmental courses offered at many colleges attempt to remedy these deficiencies. There is a tremendous need for a time-efficient, successful developmental program that enables students, especially minorities and women, to pursue careers that involve mathematics and technology.

Magnitude of the Problem

Remediation and retention are two of the greatest challenges facing higher education in the United States (Roueche & Roueche, 1993; Schrag, 1999). Data collected from the National Center for Educational Statistics (1996) indicate that 29% of all first-time, first-year college students were enrolled in some type of remedial class. Developmental course work is found in 90% of community colleges and 70% of universities (Boylan, 1999). Boylan estimated that 2.5 million students participate in developmental education in any given year.

Some legislatures have expressed concerns that taxpayers are paying twice to educate students in basic skills (once in high school, again in college) (Bracey, 1999). Boylan (1999) argued that we should not expect the majority of students to be prepared for college-level work. Nearly two-thirds of high school students will attempt college, but only 50% have taken college preparatory courses. The 11th grade results on the Maryland Independent Mastery Assessment Program (IMAP) indicated that 50.5% of the students ranked below the proficient level (Maryland State Department of Education, 2003).

A large number of the students needing remediation are non-traditional students with a median age of 30 (Shrag, 1999; Culross, 1996). Many adult students graduated from high school when participation rate in college preparatory classes was only 14% (Boylan, 1999). In 1994-95, three-fourths of the students in pre-college level courses in Maryland's community colleges were 20 years of age or older. Similarly, 80% of Florida's remedial students had not attended high school recently (The Institute for Higher Education Policy, 1998).

The terms *remedial* and *developmental* highlight the different types of students taking pre-college level classes. Recent high school graduates who have taken college preparatory classes but have inadequate skills are remedial students. Community colleges generally refer to their pre-college level course work as developmental because many students are learning the material for the first time.

Within the literature, the difference between these two terms is frequently ignored. Some contend that the lowering of college enrollment standards to provide equal opportunity has contributed to the increase in the number of students requiring remedial coursework. Clifford Adelman (Shrag, 1999) from the U. S. Department of Education disputed this claim as the percentage of students taking one pre-college-level class has actually dropped from 48% for the period 1973–1982 to 46% for the period 1983–1992.

Because there is a large demand for a successful, self-paced program, many publishing companies are creating computerized instructional systems. Prentice-Hall has field-tested Interactive Mathematics at several Maryland colleges including Howard Community College and the College of Southern Maryland. McGraw-Hill debuted a system at the Fall 2001 conference of the American Mathematics Association of Two-Year Colleges (AMATYC) that included Internet access, which allows the student to work on the program from home. A consortium of college professors from the California area developed the interactive instructional packages known collectively as Academic Systems for developmental mathematics, reading and writing. As the use of these programs proliferates, the need for additional research on their long-range effectiveness becomes more important.

The increased use of computer-based instruction addresses the need for individualized programs that encourage the development of the student as an independent learner, but individualized computer instruction does not incorporate a number of good learning practices that are important in developing the whole learner. For example, studies indicate that students benefit from being exposed to many different learning activities (Boylan, 2002; Gerlic & Jausovec, 1999;

Kalman, 1994; Welsh, 1999; Mayer & Moreno, 1998). One of the purposes of this study was to increase our understanding of the effectiveness of a computer-based, self-paced instructional program for adult learners studying developmental mathematics by evaluating the students' performance and completion of a subsequent mathematics course.

Retention

Adelman concluded that those who must take more than one remedial course and those who need to take a remedial reading course are less likely to graduate from college (Adelman, 1998; Schrag, 1999). Hundreds of students repeat one or more remedial courses, and hundreds of others give up their dream of obtaining a college degree when they are not successful at completing remedial coursework. Reports of success rates of remedial programs vary widely within the literature. In 1993, Roueche and Roueche reported that the current average success rate of traditional programs was below 35%. More recent data compiled by the National Center for Educational Statistics in 1996 indicate that 74% of community college students pass a developmental mathematics course within one year and that 65% passed their first college-level mathematics course[1] after passing the highest-level developmental mathematics course.

According to U.S. Department of Education figures, the persistence rate for African-American males earning an Associate of Arts degree or transferring to a four-year institution is only 9% (Smith, 1999). The persistence rate among other

[1] The term college-level mathematics is not well defined. Intermediate algebra is considered a college-level class in some areas of the country and a developmental course in others.

community college students is also low, approximately 20%. This is an important cultural issue since two-year colleges enroll 46% of all African-American college students. Although there are certainly continuing discrepancies between the races, a college education, more than any other factor, increases opportunities and serves to break down racial stereotypes. Using information from the U.S. Census Bureau, an article in the *Journal of Blacks in Higher Education* ("One statistical measure", 1996) reported that African-Americans with a college degree improved their income by 11.9% over those with only a high school diploma. White Americans with a college degree earned a median average income that was 46% higher than white high school graduates.

The executive summary from The Institute of Higher Education Policy (1998) report, *College Remediation: What It Is, What It Costs, What's At Stake,* recommended the following strategies to improve the effectiveness of remediation:

> (1) Creating interinstitutional collaboration among colleges and universities in a state or system, allowing best practices and ideas to be shared and replicated;
>
> (2) Making remediation a comprehensive program that encompasses more than just tutoring and skills development; and
>
> (3) Utilizing technology to enhance the teaching-learning process. (p.ix)

Ikenberry (1999) suggests that as a nation there are three choices for dealing with the prospective, under-prepared college student. The first is to bar them from a college education; another approach is to lower our academic standards to accommodate them; or the third choice is to provide remediation. It is in our economic best interest to provide courses that prepare students to do college-level work. The total national expenditure for remedial courses is less than 1% of the expenditures for public higher education in the United States (McCabe, 2003; The Institute for Higher Education Policy, 1998). The majority of students complete their developmental course work within one year. Given the alternative of not completing college, this time and expense for the student is a good investment.

Research Questions

This study addressed the following questions about the effect of computer-based instruction with community college students in elementary algebra on their success in intermediate algebra.

1. Is there a difference in the achievement levels between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes based on the percentage score earned in intermediate algebra?
2. Is there a difference in the achievement levels between students who successfully completed elementary algebra

using computer-based instruction and those who completed elementary algebra in teacher-led classes on a standardized mathematics examination given at the end of the intermediate algebra course?

3. Is there a difference in student achievement levels on the department unit exams between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?
4. Is there a difference in the pass rates (C or better) in intermediate algebra between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?
5. Is there a difference in the level of retention at the 10^{th} week withdrawal date between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?

Overview of Method

Using an existing instructional program at a public, comprehensive, suburban community college, this project specifically looked at the SCC students who had completed elementary algebra in the fall semester and were taking intermediate algebra the following spring. Instructors for these courses used lesson plans and unit examinations provided by the mathematics division of the community college. Copies of the course outlines and grading policies for elementary algebra and intermediate algebra are included in the appendix. Demographic information and other data items were obtained from the college computer database.

In the 2002 fall semester there were 229 elementary algebra students with 107 students registered in teacher-led instruction (TLI) sections and 134 students registered in computer-based instruction (CBI) sections of the community college. Past registration rates indicated that approximately 50% of these students would register for intermediate algebra in the spring semester. Parallel sections of intermediate algebra were scheduled for the spring semester to reduce the students' choices to just a few time slots and to make it possible to cluster the students from elementary algebra into a few sections. Each full-time faculty member agreed to teach two sections of the course so that only four instructors would be involved in the project. These scheduling procedures increased the likelihood that each instructor would have a balanced number of TLI and CBI students.

The department curriculum including lesson plans, graphing calculator quizzes and unit examinations were used in all intermediate algebra sections at SCC. The educational philosophy emphasized in the textbook included the use of patterns, graphs and algebraic methods to solve problems.   Group work and discovery learning activities were provided in the textbook. The instructors involved in the study had several years experience teaching this course and were comfortable with integrating the graphing calculator as a learning tool and in using group work within the lessons. The grading policy for intermediate algebra at SCC is standardized across all sections (see Appendix C). Faculty assigned 50 points out of a total of 700 points at their own discretion. Students who dropped a course within the first three weeks of the semester were removed from the class roster, and they received no notation for course registration on their transcripts. Students could withdraw through the tenth week of the fourteen-week semester; in this case a grade of W was recorded. A comprehensive final examination was given during the fifteenth week of the semester.

At the end of the semester, students took one form of the Maryland State Bridge Goals Assessment as part of the final examination. The Bridge Goals are those content outcomes or understandings in algebra that bridge the gap between Maryland high school graduation requirements and entry-level college expectations. This material is typically covered in a high school algebra 2 course or in intermediate algebra in a college developmental mathematics program. The original draft of Maryland's Bridge Goals was developed at statewide meetings that included secondary school, community college and 4-year college mathematics instructors. Modifications were made in 2001 based on the results of a statewide survey sent to all high school mathematics department chairs and several mathematics faculty members at each of the state's four-year public colleges and community colleges. Similarly, items on the Bridge Goals Assessments were developed and selected by mathematics teachers from the high schools and colleges. Statisticians from Montgomery County Public Schools, Maryland, have assisted in the design and field-testing of the examinations and in interpreting the results. The two versions of the Bridge Goals field tested in 2002 had a test reliability of .717 and .758 ("Data Summary", 2003). The process of field-testing and revising the Bridge Goals Assessment was in its third year at the time of this study.

This study evaluated differences in student achievement on the Bridge Goals examination and in the percentage score earned in intermediate algebra. In addition, differences in achievement on unit examinations were examined to highlight potential problem areas that might need additional investigation. For example, if students from CBI Elementary algebra sections needed time to adjust to the teacher-led sessions or to the problem solving focus that characterized intermediate algebra, there could be a significant difference in performance between the two groups on the first unit examination but not on the second examination. Comparisons were also made of success rates in passing intermediate algebra and in retention rates.

One concern underlying the purpose of this study was that students might potentially have some adjustment issues when moving from computer-based instruction back to teacher-led instruction. To further examine this, interviews were arranged with small groups of students to gather qualitative information on students' attitudes concerning their prior experiences with computer-based instruction and its affect on their success in intermediate algebra.

Limitations of the Study & Assumptions

In a community college setting, there are many variables that cannot be fully controlled. These include motivational level, levels of outside assistance, home responsibilities, and job responsibilities. Students withdraw from courses for a multitude of personal reasons. The students comprising the two instructional groups in this study were compared for homogeneity across several variables such as age, gender, ethnicity, credit-load in the spring semester, percent score in prior mathematics course, high school mathematics background, work hours, and study hours per week. This study assumed that the mathematical background of the students was relatively similar for several reasons. Although students may have had prior exposure to intermediate algebra while in high school, the college placement examination recommended placement below intermediate algebra. Only students who completed elementary algebra with a C or better in the previous fall semester were included in the cohort. This eliminated the variable known as 'stopping out' where a student interrupts his/her study of mathematics for a semester or more. The study has limited teacher effect from the elementary algebra course because all sections followed the same syllabus and grading policies and administered common unit examinations and final examination developed by SCC's Mathematics Division.

The students in this study could not be randomly assigned to sections of intermediate algebra. Students self-register for sections based on their own personal needs. The preliminary design focused on clustering registration options to just a few time periods and then assigning the elementary algebra students at each time slot into a specific section. Intermediate algebra classes contained not only the students who completed elementary algebra but also students who placed directly into intermediate algebra as well as students repeating the course. Double sections of 48 students were scheduled at four time slots so that the students from elementary algebra could be sorted into one of the sections, thus reducing the numbers of teachers involved in the project. Each intermediate algebra instructor involved in the study taught two sections of the course, thus increasing the potential that they would have a balance between TLI and CBI students. Instructors' names were not published.

Research on successful developmental programs indicates that good programs include tutorial services and many other support systems (Boylan, 2002; Kull, 1999; Roueche & Roueche, 1993). In his meta-analysis of the developmental programs from approximately 340 four-year institutions, Kull (1999) found that 92% (313 schools) provided tutorial support; 74% (254 schools) provided a counseling/advising program. SCC, where this study was conducted, has a federally funded Student Support Services program that provides students with documented disabilities services such as specialized tutoring, interpreters, note-takers, testing accommodations, sign language interpreters, magnifiers, scanning/reading pens and specialized computer equipment. Every student has access to the following support services at SCC:

- Scheduled group tutoring is available; every student is eligible to receive one hour of tutoring per week for each course in which they are registered.
- Drop-in tutoring is also available; the mathematics division staffs a room with faculty and student tutors where students can come for help on homework.
- Two mental health counselors are available for individual appointments.
- Workshops on study skills, note taking, time management, and test-taking are offered each year.
- A retention counselor works with the faculty to track the progress of students who have been readmitted to the college after academic dismissal.

By including only students who had already successfully completed one developmental mathematics course, it was assumed that the CBI and TLI students were equally capable of completing intermediate algebra and were taking similar advantage of the outside-the-classroom sources of support such as tutoring, office hours, and the drop-in tutoring lab according to their individual needs. Because extensive support systems were in place, this study focused directly on the effects of prior instructional format on future achievement.

Summary of Introduction

Developing an effective developmental program is an important national issue. In addition to the individual economic disadvantages, an undereducated workforce makes it impossible for the U.S. to compete economically in the international marketplace. Developmental education provides an avenue into higher education for many of our citizens. The investment is well spent if these courses prepare students to be successful in their college-level studies. With appropriate assistance, developmental students can achieve their goals of earning a college degree (Boylan, 1999). The emphasis of a developmental mathematics program is skill development and the ability to use those skills within certain contexts. In future mathematics classes, students will be expected to draw on those skills and apply them in new situations. The results of this study should contribute to our understanding of the long-range effects of computer-based mathematics instruction as it applies to retention and subsequent performance.

Definition of Key Terms

Below is a list of key terms as they are used in this study. They are arranged in alphabetical order.

<u>ACCUPLACER:</u> A computer-adaptive battery of tests developed by the Educational Testing Service to be used by colleges to place students into their initial coursework. The tests cover reading, writing and mathematics. The mathematics portion consists of three parts ranging from arithmetic through pre-calculus.

<u>Basic Algebra and Geometry:</u> A preliminary mathematics course offered at SCC that introduces students to simple equation solving, working with similar

terms, and multiplying binomials and reviews geometry concepts such as types of triangles, perimeter, area, and volume formulas.

Computer-enhanced instruction: The use of the computer within the lesson as an educational tool. Examples of this include using spreadsheets and word processors, or using software such as Geometer's Sketchpad to explore concepts in geometry.

Computer-assisted instruction: The use of computers as supplemental drill and practice delivery devices on topics taught by the instructor. Tutoring and drill and practice programs are examples of computer-assisted instruction.

Computer-based instruction: An instructional learning system that includes video-enhanced lessons, practice problems and assessment. In a typical computer-based instructional learning system, the student is given a prescriptive test and assigned lessons based on their individual results. A unit consists of several lessons that include the presentation of information and interactive practice activities. In some programs if the student is having difficulty, the program branches to additional practice and help screens. Quizzes at the end of each lesson indicate student mastery of that portion of the course material. This type of instruction permits the individualization of the program.

Department curriculum: The textbook, homework assignments, grading policies, lesson plans (traditional sections only) and department-written examinations are provided for all mathematics courses offered below the college-level.

Developmental course: Pre-college level course work for college students whose previous educational experiences did not include an exposure to the pre-requisite knowledge needed for college-level work.

Distance Learning: Distance learning includes several modes of instruction such as on-line courses, two-way televised classes, and tele-courses where students are at a different location from the instructor.

Drop-in lab: A room equipped with computers and small tables where students can work on course work individually or in groups. In addition to faculty and student tutors, the technology needed to complete projects (such as a TI-Graph Link) is available in this room.

Elementary algebra: Developmental mathematics course that includes the topics of: factoring quadratics, simplifying rational expressions, solving equations and application problems that involve factoring and/or rational expressions, simplifying radicals, solving two-by-two systems of linear equations using graphing, elimination and substitution methods, and graphing simple quadratic functions using the vertex and intercepts.

Mini-lesson: Brief lesson taught by the course instructor in a CBI class on either a topic not covered by the computer software or on a topic that several students are having difficulty understanding. Mini-lessons can be conducted with all of the students in the class or small groups of students.

Remedial course: Course work in mathematics, writing and reading intended for recent high school graduates who have taken college preparatory classes but have inadequate skills.

Stopping-out: The practice of skipping semesters between taking courses in a sequence such as algebra or foreign language.

Student Packets: A collection of course materials that includes homework assignments, tentative schedule of assignments and test dates, and the problems to be solved in each lesson with space for student work and other notes.

Teacher-led Instruction: The phrase teacher-led instruction (TLI) refers to the more traditionally taught sections. Teachers are encouraged to use an interactive style of presentation and to include some group work activities.

CHAPTER 2: REVIEW OF THE LITERATURE

This review of literature begins with a summary of a recent evaluation of developmental studies programs and the conclusions on best practices as they relate to developmental mathematics education. Many of the components recommended as instructional best practices are components of a computer-based instructional program. The design of the elementary algebra program involved in this research project incorporates many of the best practice recommendations.

This chapter also reviews meta-analyses of computer-assisted instruction and studies comparing computer-based and teacher-led instruction. Some of the reviewed studies only compared success within the course while others extended their research to include success in the subsequent course. This section concludes with a brief discussion of students' attitudes toward computer-based instruction.

A Study of Successful Instructional Strategies For Developmental Education

The Continuous Quality Improvement Network (CQIN) and the National Center for Developmental Education recently published the results of a national study titled *What Works: Research-based Best Practices in Developmental Education* (Boylan, 2002). The scope of the report includes organizational, administrative and institutional practices, program components and instructional practices. In the first phase of the study, 60 institutions were identified as potential best practice institutions through reviews of research and nominations from sponsoring organizations. Each was considered to have a strong reputation for successful developmental programs. Data for the study was obtained from the surveys completed by 36 institutions. Eventually five sites were identified as having exemplary developmental programs. A study team visited each of these sites then developed an extensive case study report.

The most contradictory area of the report is in the first chapter on organizational, administrative and institutional practices. The author strongly advocates a central developmental division while also providing many cautions concerning the disadvantages of this structure. Within the instructional area the message is fairly consistent. The approach best supported by current research advocates using as many different teaching methods as possible in an attempt to accommodate the needs of as many different students as possible. “Instructors at best-practice institutions typically use at least three different teaching modes to present material in every class period” (Boylan, 2002, p.72). Lectures were used frequently, but they were not the only instructional technique used in the class. The instructional methods advocated included distance learning, self-paced instruction, individualized instruction, peer review of student work, collaborative learning, computer-based instruction, mastery learning, and small-group work. “Having students view video tapes or computer graphics, use manipulatives or design Power Point presentations are often effective learning devices in developmental courses” (Boylan, 2002, p. 75).

Boylan (2002) cited many studies that emphasized the importance of frequent testing in developing mastery learning in developmental education. Frequent testing was first associated as an important component of student mastery by B.F. Skinner in 1954. Bloom (1968) also recommended the value of frequent testing. Keller (1968) applied this principle in his Personalized System of Instruction, which required students to study an instructional unit until they demonstrated mastery via testing. Boylan's definition of testing included any activity that required students to demonstrate their skills, including class presentations or the completion of a set of exercises. One of the strengths of computer-based instruction is the inclusion of frequent quizzing, but this review also found that students involved in developmental programs that depended almost exclusively on computer-based instruction performed poorly. At the five schools identified as 'best-practice' institutions, instructional technology was included in a supportive role rather than as the primary instructional delivery system.

Effectiveness of Basic Skills Courses

Undergraduate educators are very interested in the relationship between students' successfully completing basic skills courses and their subsequent success in general college-level coursework. A study was completed at Niagara Community College (NCC) that focused on two possible relationships between basic skills courses and success in general college-level courses (Feldman, 1995). Since completion of basic skills courses is recommended at NCC but not required, the first possible relationship is the correlation between successfully completing basic skills classes and subsequent performance in regular college-level classes and the other possible relationship is the performance of students in regular college-level classes who have not successfully completed recommended basic skills course work. In this study, students were categorized by the number of basic skills courses they needed. The levels of these courses in reading, writing and mathematics were not described and the implication was that there was only one course in each content area. The analysis examined the relationship between the number of basic skills classes passed and student's success in any five general college-level classes without regard to which classes were attempted. No definition of "regular college-level course" was given, so it is unclear if these courses covered a broad spectrum of college material or just a few general education requirements that do not include prerequisite coursework. Feldman concluded that students who had successfully completed their basic skills classes were more likely to be successful in their regular college-level classes. This study supported the premise that basic skills courses may prepare students for general college-level coursework and, thus, students are not wasting their time and money taking basic skills classes. It would have been beneficial if more detailed information had been included in the research report on which college-level courses students were attempting. This study made no attempt to link the content of the basic skills coursework to the content of the college-level classes. More information is needed on the direct relationship between levels of coursework, in fields such as mathematics, where the content is sequentially related.

In an effort to explore the relationship between students' academic performance in elementary algebra and their subsequent performance in intermediate algebra, Johnson (1996) used an ex post facto design looking at registration data. The study focused specifically on three factors, namely demographics, stopping-out of the sequence, and prior performance level. Student records from Austin Community College in Texas yielded a pool of 1,998 students who had been enrolled in both elementary algebra and intermediate algebra between 1989 and 1992. Of these, 824 student files had complete demographic data. A sample of 364 records was randomly selected to be used in the calibration study. A cross-validation sample was created from the remaining 460 cases. The demographic information included age, gender, ethnicity, number of dependents, and level of employment. Other academic and contextual variables included were the length of time passing between taking the successive courses, the number of attempts made at each of the courses, a student satisfaction rating, and students' academic performance.

Discriminant function analysis was used to determine if elementary algebra course grades predicted academic success in intermediate algebra controlling for the effects of the demographic, academic and contextual variables (i.e. age, gender, ethnicity, number of dependents, level of employment, the length of time allowed to pass between successive enrollments in the mathematics sequence, the number of attempts made at each course, and student satisfaction with the developmental instruction). The most powerful predictor of success in intermediate algebra was the student's grade in elementary algebra. Not surprising "stopping-out" had a negative effect on subsequent success, regardless of prior success. This project also highlighted the complexity of determining which factors influence academic success. The demographic, academic and contextual variables in this model explained only 16.5% of the variance. The other 83.5% are unaccounted for, but as Johnson surmised, can probably be attributed to personal and psychological factors. Johnson recommended that additional research be conducted to include measurement of other factors such as the student's goal, stress-level, self-esteem, and assertiveness.

The second question that Johnson investigated was which combinations of demographic, academic and contextual variables best-predicted academic success in intermediate algebra. A stepwise discriminant function analysis was used that included forward selection and backward elimination. The four significant variables that emerged were previous course grade, stopping-out time, satisfaction with the previous course, and age. Age and success in the previous course were positively related to success in intermediate algebra. Stopping-out and the student's satisfaction with the previous course were negatively related to academic success. Further analysis indicated that the longer a student "stops-out", the worse his or her chances of succeeding in the subsequent course.

In reviewing the files of the 1,998 students who had completed both courses over the three-year period, Johnson found that 271 students had attempted intermediate algebra after receiving a D, F or W grade in elementary algebra. A cross-tabulation study testing the relationship between their achievement in intermediate algebra and their lack of success in elementary algebra revealed that 79% of these students were unsuccessful in the second course. This statistically significant result reinforces the conclusion that successful completion of developmental mathematics courses prepared students for the subsequent course.

Support for Computer-based Instruction

Since the 1960s, computer technology has made rapid advancements and has increased its presence in our school systems. Computers have many advantages. They are infinitely patient, keep perfect records, provide immediate feedback, and allow for endless repetition. The instructors are equally important in computer-based learning environments as they provide academic advice, refer students to appropriate services, and provide social reinforcement. The best developmental programs respect both the strengths and limitations of computerized instruction. New interactive programs are designed around the scaffold educational model. First the learner observes an activity (or skill), then the learner is guided through a similar problem and finally the student is given problems to do independently. Immediate feedback helps students to refine concepts as they build new knowledge. Like frequent testing, immediate feedback is also associated with improved learning (Boylan, 2002).

A recent federal report (President's Committee of Advisors on Science and Technology, 1997) discussed the effectiveness of tutorial-based computer-aided instruction. In this report the Panel on Educational Technology summarized the results of four meta-analyses that were each based on data gathered from dozens of diverse studies. These studies included a variety of disciplines such as algebra skills for ninth-grade students, arithmetic for elementary school students and English language skills for Hispanic high school students. The report concluded that students using computer-based systems outperformed students who did not use these systems and that the greatest benefits were found among students of lower socioeconomic status, lower-achievers and those with special learning problems. The meta-analysis also reported that students learned faster and enjoyed their classes more when technology was available. Although the majority of the evidence seems to argue in favor of the efficacy of CBI, criticism has been raised concerning the size and experimental design of many of the studies cited in the meta-analyses. (See Table 1.)

In developmental programs, another major benefit of computer-based instruction is the engagement of every student in the learning process. The student must interact with the program. Further, a videodisc or CD lesson does not vary in quality. Researchers (Cavalier & Klein, 1998; King & Crown, 1997) report the following benefits from incorporating interactive video instruction into the curriculum: instructional consistency; increased student participation; increased motivation; reduced learning time; flexible scheduling; increased retention; and reduced cost.

Comparing Teacher-led and Computer-based Instruction

It is difficult to carry out reliable, valid research comparing different instructional modes (Wills & McNaught, 1996) using computer-assisted instruction

Table 1

Summary of Meta-Analysis of the Effectiveness of Traditional Computer-based Instruction

Meta-Analysis	Number of Studies	Instructional Levels	Average Effect Size
Hartley (1978)	33	Elementary & Secondary	0.41
Burns & Bozeman (1981)	44	Elementary & Secondary	0.36
Bangert-Drowns, Kulik & Kulik (1985)	51	Secondary	0.25
Kulik, Kulik & Bangert-Drowns (1990)	44	Elementary	0.40

Note: Taken from President's Committee of Advisors on Science and Technology, 1997, p.85

in higher education because there are many variables that are difficult to control. In addition to variability associated with differing teachers, there is further instructional variability as students generally have access to outside tutoring and walk-in learning laboratory assistance. Described in the following paragraphs are limiting factors for a number of comparisons.

In her study comparing the effect of computerized instruction on Grade 9 mathematics achievement, Guerney (1996) controlled for inadvertent or extraneous exposure to computerized instruction by having a control group consisting of students from a school without a computer lab as the control group. She did not find a significant benefit favoring the use of computer software when addressing new mathematics content. There was an advantage when using the software to review mathematics previously taught in the eighth grade.

Kinney (2001) described a computer-based instructional model very similar to the one used at SCC. Interactive multi-media software from Academic Systems Corporation (ASC) was used to instruct students on concepts and skills within both elementary algebra and intermediate algebra. Students received detailed feedback from the computer program. A class instructor and teaching assistant were available to provide individual instruction upon request. Students were expected to complete assignments and to take exams according to a set schedule. The lecture classes followed a demanding schedule similar to that of the computer-based classes with the same expectations for attendance and timely completion of homework assignments. These courses offered at the General College of the University of Minnesota typically included 25 to 35 students with 12 sections of Introductory Algebra and 24 sections of Intermediate Algebra each year. There was no significant difference on the common final examinations or in the pass rate in Introductory Algebra or in Intermediate Algebra between the computer-mediated (computer-based) and the lecture classes. Students who had officially withdrawn or received incompletes were excluded from the pass rate data. Findings on withdrawal rates were inconclusive. Students in lecture courses had a statistically significantly higher withdrawal rate than the computerized classes the second year, but had nearly identical withdrawal rates in the previous year. This study also followed the students into subsequent registration in college algebra and precalculus, but the analysis did not differentiate between the two instructional strategies used in intermediate algebra. The pass rates of the developmental students were statistically equal to those who had placed directly into college algebra and precalculus.

Students from both lecture and computer-based classes indicated that good study habits and time management skills were equally important in both formats, but the students from the computerized class "…felt that they developed better study habits and time management skills while enrolled in the computer-mediated class than they would have in a lecture class because they were in control of their learning rather than the instructor" (p. 16).

Other colleges have reported similar results using ASC's software. Working with several sections of introductory algebra in a community college setting, Stewart (1996) found that the programmed instruction was equally effective when compared to traditional classes. In partnership with ASC, Valencia Community College (Kinser, Morris, Jr. & Hewitt, 1997) began offering multimedia, interactive instruction in several sections of elementary algebra. They reported that 53% of the students enrolled in the sections using computer-based instruction in the Fall of 1996 had a grade of C or better compared to 49% of the students in the sections of traditional instruction. In intermediate algebra, those students who had participated in the computerized classes for elementary algebra had a subsequent success rate of 78% compared to a 45% success rate for the students from the traditional sections.

A small study by Kitz and Thorpe (1995) addressing algebra instruction for students with learning disabilities reported that the 13 students randomly assigned to instruction covering the first few chapters of intermediate algebra using a video-disk program statistically out-performed the13 students in the teacher-led control group. The 26 students, with a mean age of 19.2 years, were part of a summer transition program intended to prepare learning disabled students for coursework at a four-year university.

In both instructional formats, students were required to show mastery of materials before advancing to the next lesson. The report noted several important differences between the CBI and TLI conditions. In CBI, concepts were illustrated using computer graphics, and more practice problems were available to the students than in the textbook. In TLI, the teacher focused on one concept per lesson whereas CBI was stranded and emphasized the connections between new material and previously learned concepts. At the conclusion of the six-week program, students in the CBI group significantly outperformed the students in the TLI group on an algebra placement test. This difference in performance was maintained in the subsequent intermediate algebra class.

Course and Program Retention

As part of an outcomes assessment project, Stewart (1999) examined the retention rates of students in Howard Community College's computer-instructed basic algebra classes. This sample of 140 students included 63% White and 21% African-American students, 67% of the sample were fulltime students and 55% were female. These students reflected a diverse but not atypical age distribution as students ranged from 16 to 49 years of age with a median age of 19. There were no significant differences in completion rates due to gender, but there was a greater percentage of African-Americans among those who completed the course (23%) compared to those who withdrew (11%). Although the failure rates for all groups were similar, African-American males were proportionally more likely to earn C's rather than A's and B's. A study of registration and completion rates in the subsequent course in the next semester revealed that 73% of these students passed the next course, but only 53% of the basic algebra students enrolled in this subsequent course.

Student's Attitudes Toward Computer-based Instruction

The possibility exists that attempting to teach mathematics via a computerized lesson may be negatively influenced by the student's attitude towards computer-based instruction. Szabo and Poohkay (1996) completed a study investigating the effects of animation in a geometry lesson for elementary education majors and on the students' attitudes towards the CBI instruction. The 173 volunteers were stratified by gender and the results on a mathematics skills pretests, and then randomly assigned to three treatment groups. The instructional treatments included text only, text with static graphics and texts with animated graphics. The task presented in the lessons addressed the procedures needed to use a compass to construct triangles from given line segments. All students completed a post test that included both the completion of a construction and multiple choice questions concerning constructions of triangles. The animation group outperformed both of the other two groups. Both higher and lower ability students benefited, but the lower ability students had a larger variation in their results. Attitudes toward CBI were higher for both of methods including illustrations when compared to the text only format. While this study provided evidence that computerized instructional programs that include animation are preferable to text-only programs, it did not provide a comparison to teacher-led instruction. There have been a few studies in the area of students' attitudes toward computer-based instruction using educational psychology courses, but these do not seem closely related to learning mathematics.

An article in the Chronicle of Higher Education (1998), referred to Virginia Tech's computer-based instructional laboratory as the "Wal-Mart of mathematics instruction" (p.A32). The room initially contained 250 computer stations with plans to increase capacity to 500 stations. Students study precalculus and linear algebra using computerized lectures prepared by the instructors and complete on-line examinations. Students are required to spend 3 hours a week in the lab, known as the Math Emporium. Precalculus students are required to attend a focus group once a week, and linear algebra students have the option of attending lectures that are offered at a variety of time slots throughout the week.

According to the article, mathematics faculty have generally been enthusiastic about the CBI format emphasizing that it allows them to spend more time working individually with students and it requires active involvement of the students while in class. Success rates in the classes have increased. The response from some students has been negative including criticism that the program is boring. The mathematics division has received emails complaining that students "would rather learn from a human being."

The information contained in this news article highlights one neglected concern with computerized mathematics instruction, the attitude of the students towards this relatively new instructional format. This study did not directly address the relationship of achievement and the student's attitude concerning the computerized instructional format, but comments from the student interviews indicated that this may be an important, but neglected variable.

Conclusion

Meta-analysis of the effectiveness of computer-based instruction supports the use of computer-based instruction, but the studies in this meta-analysis included diverse topics and diverse age groups. A meta-analysis by Kulik and Kulik (1991) included only two studies in mathematics with college students out of 20 college studies; one focused on tutoring, the other on drill and practice. As CBI programs have been developed for remedial mathematics courses, more recent studies have investigated the effectiveness of CBI compared to more traditional formats of instruction. Only a few studies have followed students through subsequent registration into the next course. These studies are usually limited in scope, include many variables or have an ex-post facto design.

Achieving a true experimental design with a sufficiently large sample is practically impossible in the community college setting. The research site in this study provided an optimal situation that controlled many of the academic variables normally found in college environments. The students in this study were all involved in a highly structured developmental mathematics program and had equal access to extensive support services. Because of these features, this study provided an opportunity at the community college level to investigate the effects of using a CBI program in elementary algebra on students' subsequent retention and success in intermediate algebra.

CHAPTER 3: METHOD

Purpose

The purpose of this study was to evaluate the effectiveness of computer-based instruction with community college students in elementary algebra on students' subsequent success in intermediate algebra. Five research questions provided the framework for this evaluation.

Research Questions

1. Is there a difference in the achievement levels between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes based on the percentage score earned in intermediate algebra?
2. Is there a difference in the achievement levels between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes on a standardized mathematics examination given at the end of the intermediate algebra course?
3. Is there a difference in student achievement levels on the department unit exams between students who successfully completed elementary algebra using computer-based

instruction and those who completed elementary algebra in teacher-led classes?

4. Is there a difference in the pass rates (C or better) in intermediate algebra between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?
5. Is there a difference in the level of retention at the 10th week withdrawal date between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?

Since it was not possible to randomly assign students to the two instructional methods used in elementary algebra, the magnitude of demographic differences between the two groups was examined to determine if the two groups were comparable in terms of gender, age, ethnicity, prior educational experience in mathematics, and outside stress factors such as employment hours and full-time/part-time status. Two tests were used to analyze homogeneity. The Chi-square Test of Homogeneity was used to analyze categorical variables and scale variables that could be categorized. The General Linear Model Univariate procedure evaluated the homogeneity of the covariate coefficients for each scale demographic variable with type of instruction as the factor variable.

Setting

The research site for this study (SCC) is a public comprehensive community college located in the mid-Atlantic region with a credit enrollment of approximately 6,200 students, 60% of the students are women and 40% are minorities. Enrollment at SCC increased by approximately 7% each year for the last three years prior to this study. Approximately 1500 students were typically enrolled in developmental mathematics at SCC each semester. Placement testing was required for all students who score below 550 on the mathematics portion of the SAT or below 21 on the mathematics portion of the ACT. Appropriate Advanced Placement scores are also accepted. The placement test results for students at SCC who took the test between March and August 2002 are listed in Table 2. Approximately 25% of the fall cohort of college algebra students placed without taking the placement test and therefore are not reflected in Table 2. Using an existing instructional program, this study specifically looked at the success of students who completed elementary algebra in the fall 2002 semester and registered in intermediate algebra the following spring.

Computer- based Instruction at SCC

SCC began using computer-based instruction in its basic mathematics class approximately 10 years prior to this study. At an open enrollment institution, a course that focuses on arithmetic is a very difficult class to teach because it includes learning disabled and English as Second Language students who need to move at a slower pace as well as others who are merely brushing up their skills and

Table 2

Mathematics Placement Results By Course For SCC Students Taking The Placement Test Between March And August 2002

Course Placement									
Arithmetic		Basic Algebra and Geometry		Elementary Algebra		Intermediate Algebra		College-level Mathematics	
n	%	*n*	%	*n*	%	*n*	%	*n*	%
392	20%	611	31%	472	24%	186	9%	321	16%

are eager to move quickly. After a few small-scale trials to test effectiveness and students' acceptance of computerized instruction, SCC switched all of its basic mathematics sections to computer-based instruction. Because of the clientele, the course still begins with a session addressing mathematics anxiety. The computer program used for basic mathematics instruction at SCC is highly visual and emphasizes understanding concepts, not just skills. On the second day of class, the students take a prescriptive test, which determines which lessons they must complete during the semester.

The computer-based instructional mode is not a cost savings to the college. Class-size for basic mathematics is limited to 18 students. The college bears the expense of purchasing and maintaining the computers, employing both supporting computer and instructional personnel and purchasing the original site license for the program. This cost is regained by charging all mathematics students a $50 course fee. This fee also covers the expenses of the walk-in tutoring laboratory and the computerized classrooms used by college-level mathematics classes, such as calculus and statistics, which include computer-aided instruction.

The use of technology in instruction is enthusiastically embraced and strongly encouraged at SCC. Most mathematics classes and all writing classes meet in computer labs, and every classroom is equipped with a computerized teacher station with an overhead projection system. With the proliferation of computer-based systems for teaching pre-college-level algebra, the mathematics faculty were strongly encouraged to provide additional self-paced, computer-based developmental classes beyond the arithmetic course. After several years of experimenting with various software packages in the Basic Algebra and Geometry course, all sections of this course were also switched to computer-based instruction. The majority of the students in this class have little or no familiarity with algebra. These students meet in sections of 24; each section is staffed with a teacher and a student aide. This again represents an expense rather than a cost savings to the college.

Originally, the use of computers in the elementary algebra course was limited to quizzing and drill and practice. Partially to satisfy the college leadership's desire to have a self-paced developmental mathematics program and partially to satisfy requests from students, the mathematics program was modified to include some sections of computer-based instruction in elementary algebra.

Using the standard of performance results on the departmental, comprehensive final examination, both modes of instruction are viewed at SCC as being equally effective. The faculty at SCC have not conducted any formal research on the level of student satisfaction with the CBI format in the elementary algebra courses. On course evaluation forms, student comments concerning CBI range from very critical to enthusiastically positive.

There are definite political and educational benefits to the computer-based program. Every semester there are a few students who complete two developmental courses in one semester. Flexible schedules can be designed for students with irregular work schedules. Students who cannot keep up with the pace of the regular class are able to put in additional time and repeat lessons. All students have access to exactly the same lessons, and mastery-learning requirements are more easily integrated into computer-based programs. One of the biggest problem areas with computer-based instruction is with the instructors. The computer-based instructional environment requires the teacher to be the mentor and the tutor. Some teachers at SCC have enthusiastically embraced the opportunity to work individually with students; others are having difficulty giving up their role in the front of the classroom.

The SCC mathematics faculty has no intention of converting its intermediate algebra course to a computer-based instructional format. The current course is designed to encourage discussion of modeling and multiple solution methods, including the use of graphing calculators. These instructional strategies are considered necessary to foster development of critical thinking skills and to prepare students for their college-level mathematics courses.

There has been no evaluation at SCC of the developmental course's impact on the students' success in the next mathematics course. This study was designed to provide information on whether the use of computer-based instruction to learn the basic skills included in elementary algebra had any effect on students' retention and success in the next course, intermediate algebra.

The Preliminary Course: Elementary Algebra

In a typical fall semester, the majority of the students in elementary algebra are placed into the course after completing a computer-adaptive placement test (ACCUPLACER, 1997). Elementary Algebra is offered in two formats, namely teacher-led (TLI) or computer-based instruction (CBI). Students self-select which sections of the course they register for based on their personal schedules. Some classes are scheduled for three days per week (Monday, Wednesday, Friday) and others for only two (Tuesday, Thursday or Monday, Wednesday). After a new instructor is hired, the course coordinator provides training on the course requirements, the grading policy and the instructional software. A copy of the course outline and grading policy is in Appendix B.

In the teacher-led sections, each instructor receives a set of lecture notes for the course. Students receive a department-developed workbook, which corresponds to the lecture notes. Although the mathematics department provides the unit exams, instructors are encouraged to give their own quizzes. During the interview process and the initial training, each new instructor is encouraged to use an interactive teaching style that encourages student participation in the lesson. Classroom teaching observations are scheduled for all new instructors and every three years for returning faculty. Skill in the use of question-and-answer teaching techniques is emphasized on the observation form.

All of the computer-instructed sections use the videodisc lessons, known as ModuMath (2000), produced by the Wisconsin Foundation for Vocational, Technical and Adult Education. The ModuMath program contains audio-visual presentations that require the student to interact with the lessons. It is available in the classroom and in the math lab, but cannot be accessed from home. To maximize the instructional time, the students are provided with a workbook that includes the problems from the video with space for them to complete their work and to take additional notes. At the end of each lesson, students complete a short set of problems in their notebook, which summarize the skills in the lesson. When students are comfortable with the material, they can attempt the computerized quiz. Students must get a minimum of 65% before the computer program will allow them to begin the next lesson. Students are given a minimum pacing schedule to follow as they work through the lessons. They can put in additional time outside of class to allow them to complete the lessons at their own speed and still keep up with the course schedule.

In both formats, the students use the same text, have the same homework assignments and take the same department-provided unit exams. A text comes with a computerized drill and practice disk, which can be used at home or in the college computer labs. A few of the computerized practice sessions are included in the assignments, but the majority are optional. Most students do only the required assignments. All students are expected to take unit exams on the dates indicated in the syllabus and are subject to an attendance policy indicating that students who are absent for more than 20% of the classes will fail. All classes meet for four instructional hours per week. All students also have access to weekly tutoring through the learning assistance center and, informally, in the drop-in math lab. Students who are repeating a developmental course for the third time are required to participate in one hour of individual tutoring a week. See Appendix A for a table that highlights similarities and differences between the two course formats.

Intermediate Algebra

Using guidelines from the National Council of Teachers of Mathematics (2000, 1989), the intermediate algebra course stresses inclusion of graphing calculator problem-solving strategies in addition to algebraic solution methods. The text, *An Intermediate Course in Algebra: An Interactive Approach* by Warr, Curtis & Slingerland (1996), was developed using NSF funding and includes some discovery learning and group activities. In the introductory chapters students solve linear and exponential problems using patterns whereas the previous course in elementary algebra includes only algebraic solution methods to linear and quadratic applications. The intermediate algebra text contains many novel problem situations including extraneous information. Even in the worst-case scenario, where a teacher ignores the opportunities for group explorations, the students are being exposed to multiple methods of solving a problem and relatively complex, multi-dimensional problems. Although this format is different from the instructional approaches used in all the elementary algebra sections, the difference may be much more dramatic for the CBI students.

The mathematics department at SCC controls many facets of the intermediate algebra course. There are prescribed homework assignments, required quizzes on graphing calculator proficiency, department tests, reviews for exams, and a comprehensive final. Out of the 700 points in the course, instructors are allowed 50 discretionary points to assign writing assignments or additional quizzes. A copy of the course outline and grading policy is in Appendix C.

In a typical spring semester, there are 13 sections of intermediate algebra with approximately 24 students in each section. The placement history of students registered in intermediate algebra can be categorized into four broad sources:

- Students who placed directly into the course,
- Students coming from the standard elementary algebra course,
- Students coming from a slower-paced version of elementary algebra, and
- Students who are repeating the course.

Procedures

This study focused on only those students coming from the standard, one-semester version of elementary algebra. In the spring 2003, as of the third week of class, there were 114 students eligible to be included in the study. Two of these students did not complete any examinations in the course so they were only included in the analysis of retention.

Initially it was anticipated that there were potentially two major confounding variables – students' prior mathematics level and the impact of different intermediate algebra instructors. In the statistical analysis the student's prior mathematics level could be indicated by their grade in elementary algebra and the last mathematics course taken in high school. To reduce the effect of teacher differences, scheduling was controlled so that all of the students were assigned to one of four instructors. Each of the day instructors had a relatively balanced group of CBI students and TLI students. However, because of scheduling factors outside the control of this study, the evening instructor had primarily CBI students.

As a member of the mathematics faculty at the research site, the researcher had access to all course-related student records. Demographic information, such as age, sex, and race, were obtained from the computer database. Projects of this type are considered part of the faculty's normal responsibilities to improve instructional processes at the college. Formal permission to conduct this project was obtained from the college's administration. Instructors involved in the project signed consent forms, and permission to use individual student data was obtained from all of the students. See Appendix D for copies of these permission documents.

Instruments and Analysis

The two broad measures of achievement in this study were the students' course percent score in intermediate algebra and the results on the multiple choice portion of the Maryland Bridge Goals Assessment Form 777 (BGA) given at the end of the semester. To determine if there was any variation in achievement levels throughout the semester, percent scores on the four department-written unit examinations were also reviewed. All statistical calculations in this study were performed using SPSS 11.0 (2001). A comparison of the mean number of questions answered correctly by each instructional group on the multiple choice section of the BGA was evaluated using an independent sample *t*-test. A multiple regression model was used to evaluate the achievement data based on percent scores in intermediate algebra and on the unit examinations. Copies of the unit and final examinations are not provided in the appendix for security reasons because the tests are still in use.

To provide a more focused evaluation of achievement, an item analysis evaluated student responses to questions on the BGA directly related to intermediate algebra topics dependent on the knowledge gained in elementary algebra. Specific areas of interest were items representing new material and items representing extensions of previous skills, particularly exponents and quadratic functions. Statistical significance on these individual test items in this study was determined by a two-sample test of proportional difference of the mean scores of the two groups on that test item (Hinkle, Wiersma, & Jurs, 1998).

In addition to looking at various measures of achievement, success rate was evaluated using the pass rate of each group. The use of this dichotomous variable allowed for an analysis that included all participants in the study including those who did not complete the course. Logistic regression was used to analyze these success rates.

The analysis of retention rates took into account students who officially withdrew and those who did not officially withdraw but did not complete the course. Statistical significance was determined by a two-sample test of proportional difference.

Information on the students' perspective on their experiences in computer-based instruction and its potential effect on their success in intermediate algebra was gathered through student interviews and small discussion groups.

CHAPTER 4: RESULTS

This study examined the level of influence of two different formats of prior instruction in elementary algebra on the subsequent course intermediate algebra. The statistical analysis addressed four overarching null hypotheses.

Null Hypothesis 1: There is no significant difference in cumulative achievement in intermediate algebra between students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TLI classes.

Null Hypothesis 2: There is no significant difference in achievement on the department unit examinations in intermediate algebra between students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TLI classes.

Null Hypothesis 3: There is no significant difference in success rates (C or better) in intermediate algebra between the students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TDI classes.

Null Hypothesis 4: There is no significant difference in retention in intermediate algebra at the 10^{th} week withdrawal date between students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TLI classes.

The first two null hypotheses focused on differences in student level of achievement for the entire course and at benchmarks within the course. To address these hypotheses, multiple regressions were completed using the end-of-semester cumulative percent scores earned in intermediate algebra and the percent scores on individual unit examinations as the dependent variables. In addition an independent sample *t*-test was completed to evaluate scores on Part1 of the standardized final examination. The third null hypothesis focused on differences in overall success rate in intermediate algebra between the two instructional groups with success defined as earning a C or better in the course. To compare success rates, a logistic regression was performed with the dichotomous dependent variable, pass/not pass. The focus of the fourth null hypothesis was differences in retention. The independent sample *t*-test procedure was used to compare the two instructional groups.

Statistical Analyses of Achievement

Independent Variables

There are many variables that are thought to influence students' success in college courses. Because it was not possible to randomly assign students to the two formats for elementary algebra, initially this analysis investigated the homogeneity of the two instructional groups for demographic variables and included a preliminary evaluation for multiple regression assumptions. These variables included data on gender, ethnicity, age, credit load in the spring semester, instructor, time-of-day for each class section, absentee rate during the first eight weeks, highest level of mathematics completed in high school, achievement in elementary algebra, hours worked each week and study hours per week per credits attempted. The design of this analysis required determination of whether the demographics of the two groups of elementary algebra students were statistically similar for those variables. Subsequently the analysis focused on contrasting student performance and achievement in intermediate algebra by the type of instruction in elementary algebra, retaining only those demographic variables that were statistically different across the CBI and TLI students or were potentially significant control variables.

The data for this study were obtained from three sets of records. The application form to attend SCC includes a request for information on gender, ethnicity and date of birth. As part of the placement test, students also answer demographic questions including citation of the highest level of mathematics studied in high school. This information is recorded into the college database which also includes registration information such as courses taken each semester and number of credits attempted. Gradebook files containing student attendance and performance records are maintained in the Mathematics Division office. The students provided information on study hours per week and work hours via a mid-semester survey (see Appendix E).

Two forms of analysis were conducted to determine if the composition of the TLI and CBI groups had similar demographic characteristics. The Chi-square Test for Homogeneity was used for categorical data, and the General Linear Model Univariate procedure was used to compare numerical scale data. Additionally scale data were grouped into categories to allow for a second analysis of this data using the chi-square procedure. An alpha significance value of .05 was the standard for rejecting the null hypothesis of no significant difference.

The General Linear Model Univariate (UVA) procedure using a Type III Sum of Squares tests the homogeneity of the covariate across levels of a factor variable by entering the interaction effect last in the regression model (Tabachnick & Fidell, 2001). This procedure assumes a linear relationship with the dependent variable. Percent scores on the first unit test were listed as the dependent variable because all students included in the study took the first examination. When considering all 112 students, the mean and standard deviation on the first unit examination score in intermediate algebra were M = 83.17 (SD = 7.064, n = 62) and M = 80.53 (SD = 7.008, n = 50) for the CBI and TLI groups respectively. The demographic variable as a scale variable was the covariate, and the type of instruction in elementary algebra was the fixed factor variable. The model included an interaction between the factor variable and the covariate. Two statistics are presented for each interaction. In the Tests of Between-Subjects Effects, if the significance value of the interaction between the covariate and factor is greater than .10 than the interaction is not critical. A partial eta squared score (η^2) less than .05 indicates that the interaction accounts for little variation compared to the error term. When both of these two conditions are met we can assume homogeneity of the coefficients of the covariate across the levels of the factor (SPSS 11.0 Online Tutorial, 2001).

The ratio of number of cases to independent variables is important in regression analysis. When assuming a medium effect size of .15, $\alpha = .05$ and $\beta = .20$, Tabachnick and Fidell (2001) recommend at least 104 cases plus the number of independent variables when using multiple regression to test individual predictors. Even in the best-case scenario there were only 112 cases available in this study; thus it is important to narrow the number of independent variables to be included.

A common set of predictor variables was obtained by comparing the results of the preliminary multiple regression procedures in which, for each of the dependent variables, all of the independent variables were entered using the Backward Elimination method. Pearson correlation values based on the preliminary multiple regressions and a list of the variables removed and retained during the initial backward elimination procedure are provided in Appendix F.

Each potential independent variable is discussed in the following section. Variables that were not statistically different for the two groups, were determined not to contribute significantly in the multiple regression analyses, or were potentially unreliable were eliminated from further consideration.

Gender

The CBI group had 37 females (59.7%) and 25 males 940.3%) compared to the TLI group with 33 females (66.0%) and 17 males (34.0%). The chi-square analysis indicated that there were no significant difference in gender between the group with students who had previously had computer-based instruction and the student group that had teacher-led instruction (χ^2 (1, N = 112) = .472, p = .492).

The preliminary multiple regressions indicated that gender was not a significant variable in predicting any of the achievement scores. Since the composition of the two instructional groups was comparable for gender and the variable was not statistically significant, gender was not retained as a predictor variable.

Ethnicity

The ethnic diversity of the cohort was similar to the demographics of the college. Table 3 lists the specific distribution for ethnicity. Because several of the

Table 3

Number of Students In Intermediate Algebra by Ethnicity and Elementary Algebra Format

	Instructional Format In Elementary Algebra.		Total	Percent In Cohort
Ethnicity	CBI n = 62	TLI n = 50	N = 112	
African American	11	6	17	15.2%
American Indian	1	0	1	0.9%
Asian	4	2	6	5.4%
Hispanic	2	2	4	3.6%
White	40	37	77	68.8%
Other	4	3	7	6.3%

ethnicity categories had small frequencies, a grouping of only three categories, African American, White and Other, was used throughout the analysis (see Table 4). The chi-square test of homogeneity indicated that there was no significant difference between the two instructional groups based on ethnicity (χ^2 (2, N = 112) = 1.204 with p = .548).

In the multiple regressions, ethnicity was included using two dummy coded variables, namely White (0,0), African American (1,0) and Other (0,1). Preliminary investigations indicated that this variable was potentially significant for all of the dependent variables except Percent Score on the Fourth Examination. The portion of the variable coded for African American was negatively correlated with each of the achievement variables.

Age

Students' ages ranged from 18 to 45 years with a median age of 19 years and a mean age of 20 years. The majority of the students in the study were 19 or 20 years old. The distribution of ages included age 18 (n = 2), 19 (n = 54), 20 (n = 31), 21 (n = 10), and 22 (n = 4). There were 11 students with ages spread between 23 and 45 years old, each with a frequency of 1. To improve the distribution of the ages, all of the students over the age of 21 were recoded as age 29 (the mean value for this age group).

For the chi-square analysis, ages were assigned to one of three categories. The first category of students aged 18 and 19 represented first year out-of-high school students, while the category of students aged 20 – 21 represented second year out of high school, and the third category included those students older than 21. The chi-square test using only these three age groups indicated that there was a significant difference in the distribution based on age between the two groups (χ^2 (2, N = 112) = 8.719 with p = .013). As Table 4 indicates, the TLI students were generally younger than the CBI students.

Table 4

Number and Percent of Intermediate Algebra Students by Ethnicity and Age After Grouping

	Instructional Format In Elementary Algebra			
	CBI (n = 62)		TLI (n = 50)	
	n	(%)	n	(%)
Ethnicity by category				
African American	11	(17.7)	6	(12.0)
White	40	(64.5)	37	(74.0)
All others	11	(17.7)	7	(14.0)
Age by category				
18 - 19	25	(40.3)	31	(62.0)
20 - 21	24	(38.7)	17	(34.0)
Over 21	13	(21.0)	2	(4.0)

The result of the chi-square analysis with age separated into three categories was not supported by the results of the general linear model univariate analysis, which treats age as a scale variable. With percent score on the first examination as the dependent variable, the instructional format in elementary algebra as the factor variable and age as the covariate, the UVA results for the interaction model had a significance value of .736, which is greater than .10. The partial eta squared score of .007 indicated that the interaction accounts for little variation compared to the error term. Thus, the UVA analysis indicated that age did not vary significantly for the two types of instruction (F (1, 108) = .114, p = .736 with η^2 = .007).

In the multiple regression analysis, Age was entered as the independent scale variable. Preliminary analysis indicated that a variable denoting age was potentially significant in predicting percent scores on the first and third unit examinations. There was a positive correlation between the students' ages and each of the achievement measures in intermediate algebra.

Time of Day and Influence of Instructor

Mathematics classes at SCC are generally scheduled in one of three ways; with the day classes scheduled two, three or four times a week and the evening classes scheduled twice a week. Evening classes were defined as those beginning after 3:30 p.m. During a typical semester, intermediate algebra students would be scattered over 13 sections with 8 or 9 different instructors. For this study students coming from elementary algebra were limited to eight sections with only four different instructors.

The lack of classroom space in the evening during the fall 2002 semester meant that all of the elementary algebra evening sections were scheduled in the computer-based classroom. A last minute attempt to schedule an extra evening section of TLI at 7:30 to 9:30 p.m. failed due to the low enrollments in this time slot. This created an imbalance in enrollment in the spring semester in the evening sections of intermediate algebra that also extended to the distribution of the instructional groups in terms of instructors. One instructor taught both evening sections of intermediate algebra. Of the other three instructors, one taught only day classes that met three times a week, and the remaining two instructors each taught one day class that met twice a week and another day class that met three or more times a week. All four instructors were white males with at least 25 years of teaching experience and they all had experience teaching both the prior course, elementary algebra, and the current course, intermediate algebra. The frequency chart (see Table 5) and the chi-square analysis comparing the distribution of the two instructional groups across instructors, χ^2 (3, N = 112) = 9.219, p = .027, and time-of-day, χ^2 (2, N = 112) = 7.453, p = .024, confirms that balance was not achieved. A chi-square test for homogeneity between instructor and time-of-day confirmed that these two variables are not independent (χ^2 (6, N = 112) = 157.012 with p < .001).

Because time-of–day has one less category, thus one less degree of freedom, it was used as a factor in the rest of the analysis. The results of the preliminary regression analyses indicated that time-of-day was a potentially

Table 5

Number of Students in Intermediate Algebra Sections by Instructor, Time-of-Day, and Elementary Algebra Format

	Time of Day			
	Day		Evening	Total
	2 Times per week	3-4 Times per week	2 Times per week	
		TLI		
Instructor				
1	0	20	0	20
2	6	7	0	13
3	8	3	0	11
4	0	0	6	6
Total	14	30	6	50
		CBI		
Instructor				
1	0	14	0	14
2	8	10	0	18
3	7	2	0	9
4	0	0	21	21
Total	15	26	21	62

significant factor but that it would be sufficient to recode the variable as a dichotomous variable using a code of day = 1 and evening = 0. This recoding also eliminated some minor collinearity issues. Tolerance values for the two separate dummy variables were approximately .55 compared to a single value near .85 for the dichotomous variable. There was a negative correlation between the variable representing day students and each of the achievement measures.

Absentee Rate During the First Eight Weeks

Attendance (or lack of attendance) could potentially be a significant predictor variable of success in college courses. Eight weeks was chosen as an appropriate benchmark for measuring attendance since it is slightly beyond the midpoint of the semester. This period should be long enough to indicate a pattern of poor attendance without being inflated for students who had good attendance at the beginning of the semester and then decided to withdraw. SCC instructors are required to maintain attendance records for their classes. All classes met for approximately 4 hours per week for 14 weeks. Three sections met 3 times a week in 75-minute sessions, one section met 4 times a week for 52-minute sessions, and four sections met twice a week in 110-minute sessions. Absentee records for each student over the first 8 weeks were converted to total hours absent (see Table 6). Absences were categorized into one of four categories equivalent to no absences, one week of absence, two weeks of absence and three or more weeks of absence. The chi-square test for homogeneity indicated that there was no significant difference in the distribution of absenteeism between the two instructional groups

(χ^2 (3, N = 112) = 4.271 with p =. 234).

The UVA procedure used the scale variable of the total hours absent during the first eight weeks of the semester as the covariate. The results of the interaction effect indicate that there was no significant difference in level of absence across the two types of instruction (F (1, 108) = .070, p = .791; η^2 = .001).

The preliminary multiple regressions indicated that level of absence was a significant predictor variable for the score earned on the first and fourth examinations and for the percent score earned in intermediate algebra.

Table 6

Number and Percent of Intermediate Algebra Students by Level of Absence During the First Eight Weeks and Elementary Algebra Format

Hours Absent During The First Eight Weeks	Instructional Format In Elementary Algebra			
	CBI		TLI	
	n	(%)	*n*	(%)
No Absences	20	(32.3)	11	(22.0)
1 - 4 Hours	20	(32.3)	23	(46.0)
4.1 – 8 Hours	18	(29.0)	10	(20.0)
More than 8 hours	4	(6.5)	6	(12.0)
Total	62	(100.0)	50	(100.0)

Note: One cell had a cell count less than 5 with a minimum expected count of 4.46.

Not surprisingly, the variable, representing hours absent during the first 8 weeks, was negatively correlated with the measures of achievement.

Influence of Prior Instruction

Grade in Elementary Algebra

It is difficult to have a measure of aptitude or prior knowledge for community college students. This study included only those students who successfully completed elementary algebra in the previous semester; therefore their grade in elementary algebra represented their most recent prior experience in algebra. Both the students' letter grade and their percent score in elementary algebra were available from division office records. For the chi-square test of homogeneity between the groups, the course letter grade was used for grouping. Recall that only students earning an A, B or C in elementary algebra were included in this study. The distribution of students' grades in elementary algebra by instruction format is provided in Table 7. There was no significant difference between the two instructional groups at the .05 level (χ^2 (2, N = 112) = 4.585 with p = .101).

The UVA analysis allowed for using the actual percent score earned in elementary algebra (%EA) as the covariate. Using the scores on the first examination as the dependent variable, the between-subjects effects of %EA with type of instruction in elementary algebra indicated that there was no significant difference in the coefficients of the covariate (%EA) across the two types of prior instruction (F (1, 108) = .282, p = .596; η^2 = .003).

Table 7

Number and Percentage of Intermediate Algebra Students by Grade In Elementary Algebra, High School Background and Elementary Algebra Format

	Instructional Format In Elementary Algebra			
Grade Earned in Elementary Algebra	CBI (n = 62)		TLI (n = 50)	
	n	(%)	n	(%)
A	17	(27.4)	6	(12.0)
B	25	(40.3)	21	(42.0)
C	20	(32.3)	23	(46.0)
High School Background				
Algebra 1 or less	12	(19%)	4	(8%)
Algebra 2	30	(48%)	29	(58%)
Beyond Algebra 2	20	(32%)	17	(34%)

In the preliminary multiple regressions, the percent score earned in elementary algebra was selected as a significant predictor for all of the achievement measures. Achievement in elementary algebra was positively correlated with all the achievement measures in intermediate algebra.

High School Mathematics Background

The majority of the students in this study placed into elementary algebra using the College Board's ACCUPLACER computer-adaptive test (1997). However, as reported by the students, their highest-level mathematics course taken in high school ranged from general studies to calculus. A complete distribution of high school background compared to age and student achievement in elementary algebra is provided in Table 8. To reduce the number of cells with *n*-values less than 5, the data were regrouped into algebra 1 or lower, algebra 2 and beyond algebra 2. The chi-square test indicated no significant difference based on high school mathematics background between the CBI and TLI groups (χ^2 (2, N = 112) = 3.009 with p = .222).

In the preliminary multiple regression analysis, high school mathematics background was coded using dummy coded variables for algebra 1 or lower (0, 1), algebra 2 (1, 0) and higher than algebra 2 (0,0). For the majority of the analyses, these variables were considered not significant. The dummy variable for algebra 2 was negatively correlated with the dependent variables, whereas the dummy variable for Algebra 1 or lower was positively correlated for three of the dependent variables. For the unit 2 examination data the results were ambiguous since the algebra 1 dummy variable was indicated as not significant and algebra 2 was potentially significant. There are several limitations to using high school mathematics background as a predictor variable that potentially explain the mixed results from the preliminary multiple regressions. For the 19-year-old students it is

Table 8

Comparison of Age, High School Mathematics Background and Achievement in Elementary Algebra

High School Background	Ages				Elem. Algebra	
	19	20	21	29	%	(*SD*)
TLI .						
General studies	1	0	1	1	87.1	(3.72)
Algebra 1	0	1	0	0	69.0	(0.00)
Algebra 2	19	8	2	0	80.5	(7.08)
Statistics	3	1	0	1	78.6	(4.37)
Trig/Pre-calc	7	3	0	0	81.1	(8.21)
Calculus	1	1	0	0	79.1	(1.56)
Total	31	14	3	2	80.5	(7.01)
CBI						
General studies	0	0	0	4	88.2	(7.54)
Algebra 1	3	2	1	2	81.5	(5.43)
Algebra 2	12	8	6	4	82.3	(7.54)
Statistics	2	1	0	1	83.8	(8.51)
Trig/Pre-calc	8	3	0	2	84.2	(7.22)
Calculus	0	1	0	0	85.5	(0.00)
Total	25	15	7	13	83.1	(7.18)

Note: In the local high schools, most students take statistics after precalculus but it is available for students who have taken the advanced algebra 2 course.

reasonable to assume that there was at most a one-year gap between completion of mathematics in high school and beginning mathematics in college. For students age 20 or older the number of years that did not include studying mathematics would depend on the student's age and how many semesters he or she spent in prior developmental mathematics courses. Three out of seven students with a general studies score in elementary algebra for the students with the general studies background and two of nine students with an algebra 1 background had completed a basic algebra and geometry course at SCC and earned an A. The mean percent was higher than expected and may be related to the ages of these students. Table 8 attempts to illustrate the complexity of this data.

Credits Taken in Spring 2003

Both the chi-square analysis and the UVA procedure indicated no significant difference between the two instructional groups based on the number of credits taken in the spring semester. As recorded in the college database, the range of credits taken by the students in Spring 2003 ranged from 3 credits through 17 credits. For the chi-square analysis, credits were grouped into four categories with two categories for part-time students (less than 12 credits) and two categories for fulltime students (see Table 9). The chi-square test indicated no significant difference in the CBI and TLI samples based on number of credits taken in the spring semester (χ^2 (3, N = 112) = .842 with p =. 839).

For the UVA procedure, credits taken in Spring 2003 were included as a scale variable for the covariate. The results of the interaction indicated that there was no significant difference in the coefficients of the covariate, credits, across the two types of instruction (F (1, 108) = 1.774, p = .186; η^2 = .015). The preliminary multiple regressions indicated that credits taken in the spring semester was not a significant variable in predicting any of the achievement scores.

Hours Worked Each Week

Midway through the semester during class time, students were asked to complete a survey titled *How Busy Are You?* (Appendix E). Data to measure information on hours spent working and hours devoted to studying are based on the responses to this survey. Of the original 112 students, 110 or 98.2% of the students completed the survey.

Students' estimates of the number of hours worked each week were grouped based on the frequency distribution of the responses of 110 students. The categories were low level of working hours (0 – 5 hours per week), moderately low (6 hours to 15 hours per week), moderately high (16 – 34 hours per week) and high (more than 34 hours per week). The chi-square test indicated that there was no significant difference in the two groups based on average hours worked each week (χ^2 (3, N = 110) = 2.349 with p =.503).

The actual hours worked were used as the covariate in the UVA procedure for comparing the homogeneity of hours worked between the two instructional groups. Since information was available for only 110 students, the mean and standard deviation on the first examination score differed slightly from the previous analyses with M = 82.48 (SD = 14.873, n = 60) and M = 77.02 (SD = 11.901, n = 50)

Table 9

Number and Percent of Intermediate Algebra Students by Credits, Hours Worked, Study Hours per Credit and Elementary Algebra Format

	Type Of Instruction In Elementary Algebra			
	CBI (n = 62)		TLI (n = 50)	
	n	(%)	n	(%)
Credits by Category				
6 or less credits	4	(6.5)	4	(8.0)
7 to 11 credits	8	(12.9)	8	(16.0)
12 or 13 credits	40	(64.5)	28	(56.0)
more than 13 credits	10	(16.1)	10	(20.0)
Work Hours per Week				
0 – 5 hrs	13	(21.0)	6	(12.0)
6 – 15 hrs	10	(16.1)	12	(24.0)
16 – 34 hrs	24	(38.7)	22	(44.0)
> 34 hrs	13	(21.0)	10	(20.0)
Study Hours per Week per Credits				
0 – 0.5 hrs	16	(25.8)	14	(28.0)
.51 – 1 hrs	21	(33.9)	19	(38.0)
1.01 – 1.5 hrs	13	(31.0)	6	(12.0)
> 1.5 hrs	10	(16.1)	11	(22.0)

for the CBI and TLI groups respectively. The linear model results using the scale data agreed with the chi-square test based on categories indicating that there was no significant difference between the two instructional groups in the number of hours worked (F (1, 106) =1.789, p = .184, η^2 = .017).

Comments on the surveys concerning other responsibilities indicated that a variable categorizing the number of hours worked each week might not be a good or sufficient indicator of students' other commitments. Some students, who had extensive childcare responsibilities, included these hours as hours worked, while others listed them only as a comment. Athletics and volunteer activities also were listed as important time factors. In the preliminary multiple regressions, hours worked each week was indicated only as a potentially significant variable for percent score in intermediate algebra.

Study Hours Per Week

The number of hours students reported that they spent studying each week was divided by the number of credits yielding study hours per week per enrolled credit. This information was grouped by the half-hour of study time per enrollment credit. The chi-square test indicated that there was no significant difference in the amount of study time per enrollment credit between the TLI and CBI groups (χ^2 (3, n = 110) =1.967 with p = .579).

The scale variable, study hours per week per credit attempted in the spring semester, was used as the covariate in the UVA analysis. These results also indicated no significant difference between the two instructional groups based on study hours per credit (F (1, 106) = .300, p = .585, η^2 = .003).

Although it is reassuring to know that the two groups did not differ in the distribution of study hours per credit, the variable itself has questionable predictive value. Students with large differences in ability levels will spend a disproportionate amount of time achieving the same results. Study hours per week per credit was not a significant variable in any of the preliminary multiple regressions.

Summary of Analyses of Potential Independent Variables

The two instructional groups are demographically similar for all variables with the exception of Time-of-day, Instructor and possibly Age. Chi-square analyses were completed on all categorical data and on scale data recoded as categories; the General Linear Model Univariate of Between Subjects Effects procedure was completed on numerical scale variables. Based on preliminary investigations, Gender, High School Background, Credits, Work and Study Hours per Credit were dropped as independent variables. In addition to the variable of interest, type of instruction in elementary algebra, the remaining independent variables were those identifying age, ethnicity, percent score in elementary algebra, absence during the first eight weeks, and time-of-day recoded as day/evening. With tolerance values all greater than .700, there were no indications of multicollinearity among these variables. A correlation matrix of the independent variables with percent scores in intermediate algebra is included in Appendix F.

Dependent Variables

The intent of the first two null hypotheses was to examine whether students from the two instructional formats in elementary algebra performed differently at various benchmarks throughout intermediate algebra. Multiple measures of achievement were used including the end of semester percent score of those students who attempted intermediate algebra, the percent scores on the four unit examinations and the students' performance on Part 1of the standardized final examination.

Each student's end of semester percentage in intermediate algebra was based on 700 points with 400 points available on department-written unit tests, 50 points assigned to department-written take-home quizzes, 50 points allotted to assignments as determined by the instructor, and 200 points reflecting the standardized final examination. In both elementary algebra and intermediate algebra, students complete department-written unit examinations throughout the course. There are multiple versions of each test, which were developed by a pair of instructors. The content and difficulty level of the unit examinations are reviewed each year with revisions possible. Table 10 provides a comparison on the descriptive statistics for these measurements.

The preliminary multiple regression analysis indicated one outlier for the first examination score. No outliers were indicated for the other unit examinations, but cases were eliminated based on no score. In the original analysis of percent score in intermediate algebra (% IA), three cases were eliminated because the students had withdrawn while passing (two were from the CBI group and the other student was from the TLI group). Further reiterations highlighted six additional outliers, 3 CBI students and 3 TLI students. The analysis of the results on Part 1 of the final examination is treated separately at the end of this section.

Participation Rates

One concern in analyzing the results of the unit examinations was the decline in student participation rate throughout the semester. Only the first examination had 100% participation. For the other examinations, students without scores were treated as missing data and were eliminated from the regression analysis. The elimination of these cases could have been problematic if they were not evenly distributed over the two instructional groups. Participation rates for the unit examinations are included in Table 10.

The largest difference in participation rates was on the final examination in which 80% of the TLI students completed the final examination compared to 92% of the CBI group. Chi-square tests were used to assess the null hypotheses that both instructional groups had the same participation rate on each of the examinations. With each of the *p*-values denoting significance greater than .05 (see Table 11), the statistics fail to reject the null hypotheses that the two instructional groups had the same participation rate on each of the examinations. Hence, this analysis found that there was no significant difference in participation rates on the unit examinations or on the final examination between the two instructional groups. Therefore, it was permissible to proceed with the multiple regression analyses using just the scores of those students who completed each of the examinations.

Table 10

Comparison of Intermediate Algebra Examination Results

	% in Interm. Alg.	Examinations			
		1st	2nd	3rd	4th
Statistics			TLI		
n	46	50	49	46	43
% Participation	92.0	100	98.0	92.0	86.0
Mean	70.20	77.02	75.94	66.41	71.51
SD	17.114	11.931	14.094	22.280	14.812
Median	75.43	78.00	77.00	73.00	74.00
Minimum	29	36	47	14	29
Maximum	90	95	100	95	93
			CBI		
n	57	61	59	59	56
% Participation	91.9	100	95.2	95.2	90.3
Mean	78.47	83.23	83.76	73.98	77.02
SD	11.019	13.437	13.93	19.653	16.211
Median	80.67	88.00	86.00	78.00	80.00
Minimum	44	50	38	6	25
Maximum	95	100	100	100	100

Table 11

Chi-square Tests of Equal Participation Rates on Each of the Examinations

	Pearson Chi-Square			Fisher's Exact Test	
	Value	*df*	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Exam 2	.648[a]	1	.421	.627	.394
Exam 3	.472[b]	1	.492	.698	.381
Exam 4	.504[c]	1	.478		
Final Exam	3.399[d]	1	.065		
N of Valid Cases	112				

[a] 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.79.
[b] 2 cells (50.0%) have expected counts less than 5. The minimum expected count is 3.13.
[c] 0 cells (0%) have expected count less than 5. The minimum expected count is 5.80.
[d] 0 cells (0%) have expected count less than 5. The minimum expected count is 6.70.

Results of the Multiple Regression Analyses

Addressing Percent Scores

Null Hypothesis 1: There is no significant difference in cumulative achievement in intermediate algebra between students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TLI classes.

Null Hypothesis 2: There is no significant difference in achievement on the department unit examinations in intermediate algebra between students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TLI classes.

In order to evaluate these two null hypotheses addressing intermediate algebra achievement, a sequential regression was employed to determine if the addition of type of instruction in elementary algebra to the selected block of independent variables resulted in a significant increment of R^2. Using the ENTER method of SPSS REGRESSION, the independent variables, identifying age, absence level, ethnicity, %EA, and day/evening, were included as step 1 followed by type of instruction in step 2. The residual scatterplots, histograms and P-P plots indicated that the regression requirements of normality, linearity and homoscedasticity were met. These graphs are included in Appendix G.

None of the regressions resulted in a significant change in R (see Table 12). There was no significant difference in achievement based on the percent score in intermediate algebra or the percent scores on the unit examinations between the two instructional groups. It should be noted that all of the models were considered significantly adequate, but the range of the R^2 values between .319 and .493 indicated that these models accounted for less than 50% of the dependent variables.

Analysis of Final Examination Scores

In order to provide a standardized measure of achievement, students completed the Maryland Bridges Goals Assessment (BGA) version 777 as part of

Table 12

Results of Sequential Regression

Model	R	R^2	*Adj.* R^2	*SE* of the Estimate	Change Statistics: R^2 Change	F Change	df1	df2	Sig. F Change
Dependent Variable: Percent Score in Intermediate Algebra (*n* = 103)									
1[a]	.690	.476	.443	10.887	.476	14.538	6	96	.000
2[b]	.702	.493	.455	10.767	.017	3.146	1	95	.079
Dependent Variable: Percent Score on First Unit Examination (*n* =111)									
1[a]	.556	.309	.269	11.194	.309	7.763	6	104	.000
2[b]	.565	.319	.273	11.170	.010	1.439	1	103	.233
Dependent Variable: Percent Score on Second Unit Examination (*n* = 108)									
1[a]	.651	.424	.389	11.313	.424	12.373	6	101	.000
2[b]	.663	.439	.400	11.216	.015	2.750	1	100	.100
Dependent Variable: Percent Score on Third Unit Examination (*n* = 105)									
1[a]	.625	.391	.354	16.947	.391	10.488	6	98	.000
2[b]	.628	.395	.351	16.983	.004	.585	1	97	.446
Dependent Variable: Percent Score on Fourth Unit Examination (*n* = 99)									
1[a]	.627	.394	.354	12.683	.394	9.954	6	92	.000
2[b]	.627	.394	.347	12.751	.000	.013	1	91	.911

[a] Predictors: (Constant), % EA, Other, Day/evening, African Amer., Absence-8th week, Age

[b] Predictors: (Constant), % Ea, Other, Day or evening, African Amer., Absence-8th week, Age, Instructional Format in EA

the final examination for intermediate algebra. Part 1 of the BGA is a timed multiple-choice examination. Students are allowed 30 minutes for the 23 multiple-choice questions. A content review of the examination by SCC's intermediate algebra course coordinator indicated a fairly strong match between the course content and the multiple-choice content. She determined that 17 of the 23 multiple response questions were reasonable expectations. The three topics covered on the Bridge Goals Assessment but not taught at SCC in intermediate algebra are translations, inverse functions and composition of functions. Students also completed Part 2 of the BGA, which consists of 4 extended response questions. Questions 2 and 4 were strongly related to the course content. Students had the content knowledge to complete questions 1 and 3, but the problem type was new to the students. It was clear during testing that the 20 minutes allowed for Part 2 did not provide sufficient time to complete the extended response questions. Therefore, only the results of Part 1 were considered for this study.

Overall Results on Part 1 of the BGA

The number of correct responses on Part 1 of the BGA ranged from 5 to 21 out of 23 questions. (Recall: Only 17 questions covered material taught in SCC's program.) For the TLI students, $n = 38$, $M = 12.66$, $SD = 3.315$, $SEM = .538$ and for the CBI students, $n = 57$, $M = 12.65$, $SD = 2.656$, $SEM = .352$. An independent sample *t*-test indicated no significant difference in achievement between the two instructional groups for those who completed the final examination ($t\ (93) = .014$ with $p = .989$).

Item Analysis of Critical Test Questions on the BGA

An item analysis was conducted on a few questions from the multiple-choice section of the BGA (Part 1) to determine if there was a significant difference in performance on particular problem types between the CBI and TLI students. The items were coded with 1 point for a correct response and 0 points for an incorrect response. The test items selected were categorized as either measuring material taught in a previous course, material that is an extension of prior skills, or new material. Items 6 and 22 were basic skills problems on rational expressions. This is material from elementary algebra that is not reviewed in intermediate algebra. Both groups of students did poorly on these items. Items 2 and 11 represent new material that is an extension of material on exponents previously taught in elementary algebra. Both groups of students did well on these items. Items 3, 4, 9, and 12 represent new material.

As Table 13 indicates, only items 3 and 4 have any potential for being significantly different. An independent sample t-test was performed on the means (percentage correct) for these two questions. For test item #3, the t-test results when non-equal variances are assumed were not significant. The independent sample t-test for item #4 indicates no significant difference in the performance of the two instructional groups on this test item. Overall, the results indicate that there was no significant difference in performance between the CBI and the TLI students on these items from Part 1 of the BGA.

Table 13

Proportion Of Students Answering Each Test Item Correctly on Part 1 of the Bridge Goals Assessment

Item on final exam	*CBI* (*n* = 56)		*TLI* (*n* = 38)		*t* – test for Equality of Means		
	M	*SD*	*M*	*SD*	*t*	*df*	*Sig.*[a]
#2	.84	.371	.84	.370			
#3	.77	.426	.87	.343	-1.264	89.269	.210
#4	.77	.426	.68	.471	.895	92	.373
#6	.27	.447	.29	.460			
#9	.76	.429	.74	.446			
#11	.96	.189	.95	.226			
#12	.71	.458	.66	.481			
#22	.31	.466	.26	.446			

Note: *t*-tests were not completed on the other test items since it is clear from the data that there is not a significant difference in the mean.
[a] (2 – tailed)

Statistical Analysis of Success Rates in Intermediate Algebra

Null Hypothesis 3: There is no significant difference in success rates in intermediate algebra between the students who successfully completed elementary algebra using CBI and those who successfully completed elementary algebra in TDI classes.

Success rate was defined as a dichotomous variable denoting those students who either passed or did not pass. To pass, a student needed to earn a C or better. Both F's and W's were included in the category did-not-pass. For the TLI group, 33 out of 50 students (*M* = 66.0 %, *SD* = .479, *SEM* = .068) passed intermediate algebra compared to 50 out of 62 (*M* = 81.6%, *SD* = .398, *SEM* = .051) for the CBI students. Logistic regression is appropriate when the dependent variable is dichotomous. It does not require the data to be linear, the errors to be normally distributed or the variance of the errors to be the same for all values of X (Pedhauzer, 1997).

Results of Logistic Regression on Success in Intermediate Algebra

A sequential logistic regression was performed with success in intermediate algebra as the outcome. The variables of Age, Absences, %EA, Ethnicity and Day/Evening were entered in the first step using the ENTER procedure followed by Instructional Format in elementary algebra. Only absence and %EA were indicated as significant predictor variables. The Block $\chi^2(1, N = 112) = .578$ with $p = .447$ at Block 2 indicated no significant improvement with the addition of the instructional format as a predictor. In this model 78.6% of the cases were predicted correctly compared to 80.4 % before the type of instruction was entered. Although it is not possible to calculate R^2 for logistic regression, two approximate measures are calculated. The Cox & Snell $R^2 = .265$ and Nagelkerke $R^2 = .389$ indicated that the amount of prediction accounted for by the model was similar to results of the multiple regressions on achievement. The Wald test of the coefficients (see Table 14) also indicated that type of instruction in elementary algebra was not a significant variable in predicting student success in intermediate algebra.

Statistical Analysis of Retention

Null Hypothesis 4: There is no significant difference in retention in intermediate algebra at the 10th week withdrawal date between students who successfully completed elementary algebra using CBI and

Table 14

Coefficients, Standard Errors and Wald Test on Success in Intermediate Algebra

Predictors	*B*	*S.E.*	Wald	*df*	Sig.	Exp(*B*)
Absence	-.226	.077	8.583	1	.003	.798
Age	-.001	.106	.000	1	.995	.999
% Score in EA	.167	.048	11.846	1	.001	1.181
Day/Evening	.813	.769	1.119	1	.290	2.255
Ethnicity			3.996	2	.136	
African Amer.	-1.153	.706	2.665	1	.103	.316
Other	.626	.760	.680	1	.410	1.871
Type	-.411	.542	.575	1	.448	.663
Constant	-11.203	3.824	8.581	1	.003	.000

those who successfully completed elementary algebra in TLI classes.

Withdrawal Rates

At SCC, students who officially withdraw after the third week of class but before the end of the tenth week of class receive a W grade for the course. Students who drop the class before the end of the third week of class are no longer listed on the class roster. There is no teacher-initiated withdrawal. The official withdrawal information provides a uniform, easily defined benchmark for comparing institutions with similar withdrawal policies.

Six out of 64 CBI students (9.4%) officially withdrew compared to 3 out of 50 TLI students (6.0%). Because of the low number of withdraws for the TLI group, the two sample test for differences in proportions was not appropriate. (This test requires that all combinations of probability times number of occurrences be greater than 5, i.e. $n * p > 5$). The results of the chi-square analysis of the null hypothesis that there is no difference in the retention level between TLI and CBI students indicated that the null hypothesis cannot be rejected (χ^2 (1, N = 114) = .440, p = .507). Thus this analysis indicated that there was no significant difference in the official withdrawal rate between the two instructional groups.

Completion Rates

The intent of measuring withdrawal rates was to examine the proportion of students who did not complete the course. There are several limitations with using only official withdrawal information. Because there is no teacher-initiated withdrawal, some of the students receiving F's had not attended the course for several weeks. There is also no designation for students who withdrew while passing. Table 15 provides a reclassification of the students based on instructors' grade books. Students who did not have a fourth examination score and a final examination score were categorized as not completing the course. There were two students who took no assessments. While they have not been included in the previous analyses, it was appropriate to include them here.

Table 15

Comparison of Completion Rate

	CBI		TLI	
	n	%	*n*	%
Completed	57	(89.0%)	44	88.0%
Passed	50	(78.1%)	33	(66.0%)
Failed	7	(10.9%)	11	(22.0%)
Didn't Complete	7	(11.0%)	6	(12.0%)
Was passing	2	(3.1%)	1	(2.0%)
Was failing	3	(4.7%)	5	(10.0%)
Took no assessments	2	(3.1%)	0	(0.0%)
Totals	64	(100.0%)	50	(100.0%)

The two sample test for differences in proportions requires that all combinations of probability times number of occurrences be greater than 5. This data met this criterion since the lowest computed value is 7. For CBI students, M = .89, SD = .315, and SEM = .039 compared to TLI students, with M = .86, SD = .351, and SEM = .049. The null hypothesis in this analysis was that there was no difference between the two proportions of completion for intermediate algebra. Equal variances were assumed because the Levene's test for equality of variances gave a significance value of .329. The results of the independent sample *t*-test indicated that there was no significant difference in completion rate between the two instructional groups (t (112) = -.491, p = .625). A chi-square analysis produced the same results (χ^2 (1, N = 114) = .244, p = .621). Thus these analyses indicate that there was no statistical difference between the proportion of students completing intermediate algebra in the CBI and TLI groups of students.

Report From Interviews With Students

This study investigated whether there were any differences in performance in intermediate algebra between students who completed elementary algebra using computer-based instruction and those who participated in teacher-led instruction. Thus far this report has presented those analyses that focused on quantitative differences. Qualitative methods were employed to investigate whether students who had completed a computer-based class made any adjustments when returning to teacher-led instruction. Data was gathered through student interviews and focus group meetings where students were asked about their experiences in transitioning from elementary algebra to intermediate algebra and their overall impressions about the differences involved in computer-based learning.

May Focus Group

Near the end of the spring semester, a flier was distributed to approximately 80 intermediate algebra students inviting them to share pizza and conversation. Four students signed up, but only two attended. Both were returning adult women who had completed elementary algebra in a CBI class. After some initial casual conversation and some pizza, the rest of the chat session was tape-recorded with the students' permission. Students were provided with a list of questions to be addressed during the discussion. Excerpts from the transcription are presented below to highlight the main points. Student comments are indicated by *M1* and *M2*. The interviewer's comments are indicated by *I*.

Initially the students were asked to describe some of the benefits of the ModuMath format. Both students focused on the advantages of self-pacing in CBI.

> *M1*: One of the good things I believe is that you can go pretty much at your own pace. If you are pretty comfortable with math and you have seen it recently before, you can move on and go at your own pace, but if you haven't ……. It had been over twenty years since I had really taken any math. It enabled me to slow down and repeat, you know you can play it back and hear it as many times as you need to hear it. On your own, you know you can go to the math lab after the class and go back and listen to the lesson again.

M2: I ended up finishing the class about two-and-half weeks early. It was nice. I worked at my own pace.

The students also commented on features of the elementary algebra program that were available in both instructional formats: the homework assignments and the drill and practice software, which is packaged with the textbook.

*M*2: I liked the fact that you could also do some of the turn-in homework at home. We had the software to do it at home or we could do it at school as well. That was a nice feature.

Several of the students' comments emphasized the importance of the instructor in the computer-based environment. In general, they felt that they could follow the techniques being presented in the computerized lesson but they didn't always understand the material.

I: 'Do you do anything differently [in intermediate algebra] because you took a [previous mathematics] course on a computer then you would have done otherwise?'

M2: I would say no differently but I didn't understand what I was doing. I followed the techniques and all, for every type of problem it showed you how to do it, I repeated it but I didn't always understand what the information meant. In intermediate algebra, there was a lot of 'oh, so that's what that is', so things made more sense in [intermediate algebra].

The style of instruction and the content of intermediate algebra had made them aware of the importance of making connections in mathematics.

Concern was expressed over the student-to-teacher ratio in the computerized lab and the negative effect this had on the instructor's ability to answer questions in a timely fashion. The two students commented that they preferred being able to ask questions during the lecture in the TLI format. Since there were no TLI students involved in this discussion, there was no opportunity for TLI students to provide a rebuttal to these remarks or to list some of the concerns frequently associated with lecture instruction. There were no comments about time wasted while waiting for the teacher to proceed in a TLI lesson or the problems that weaker students might experience if they found the pace of the TLI instruction to be too fast.

Elementary algebra, as taught at SCC, includes a lot of algebraic skills and standardized verbal problem types compared to intermediate algebra, which extends the curriculum to include unique problem situations and graphical approaches to problem solving. The two students were asked to comment on the different formats used in the two courses and if they would have preferred that elementary algebra had less focus on skills and more focus on making mathematical connections.

M2: I think it [elementary algebra] might have been a little more overwhelming [with a focus on mathematical connections]…. He [the teacher in intermediate algebra] keeps saying, 'Now think about it, apply it here, apply it there.' And [if] I [had] just learned even

> how to calculate it, it might have been a little too much. Because even learning how to calculate by itself is stressful. ….I think I like... learning to calculate the problems first and then going back. Once I had the nice firm foundation … I'm not even thinking about how to work them [algebraic routines] any more or memorizing the formulas, then I can just plug the information in and see it a different way.

When we began discussing how CBI format could be improved, the two students got into a discussion comparing how often their elementary algebra instructor had provided short supplemental lessons in their CBI class. One had the opportunity to participate in several teacher-led mini-lessons on difficult topics during the semester and the other student's class had only the one required lesson on polynomial long division. Both also mentioned the initial shock and anxiety they had when they first found that they were going to be learning algebra from a computer. This may be an age-related phenomenon, but it still needs to be addressed. The two students also spent considerable time relating to each other their graphing calculator phobias. One of the students seemed to have mastered this tool, and the other was still struggling.

In summary, both of the students who participated in the focus group discussion were adult women with family responsibilities. One student had taken advantage of the self-paced nature of computer-based instruction and had completed her elementary algebra course early in the fall semester. Both indicated that although they were not unhappy with the computer-based experience, the computers were intimidating at the beginning of the course. Both commented on having to wait to get help in the ModuMath lab and felt that supplementary mini-lessons taught by the teacher on difficult topics should be part of the curriculum. They were glad that intermediate algebra was presented via teacher-led instruction and they did not feel that they had to make any adjustments to the change in instructional format. Both also felt that there was an advantage in having mastered some manipulative skills in elementary algebra before applying them to more complex situations in intermediate algebra. One student was still struggling with the graphing calculator and suggested that some mini-sessions or a tutorial should be available.

July Focus Group

In July, a 15-minute discussion session was held with seven students who were taking intermediate algebra during the summer session. Five had previously taken a computer-based class. The students were asked to jot their ideas on a survey form before and during the discussion. Below is a summary of their comments. A verbatim copy of their written responses can be found in Appendix H.

This group of students felt that the benefits of computer-based instruction included being able to work at their own pace, taking quizzes more than once, being able to go back and review a lesson, and the step-by-step instructions provided by CBI for those problems which a student had first answered incorrectly. As weaknesses of the CBI course, they mentioned waiting to have a question answered by their instructor and the need to have additional teacher-led instruction for more difficult topics. On student responded that she/he “was not as happy with the computer-based program.”

These students could see the connection in content between elementary algebra and intermediate algebra. They particularly commented on the extension of linear functions and quadratic functions. The topics that they indicated having difficulty with were fractional exponents, domain/range, and using the graphing calculator. Two students indicated that they had some difficulty transitioning into intermediate algebra. They missed being able to do extra practice on the computer. One mentioned compensating for this by increased study time. Another indicated that she had taken more notes than in her previous classes. Three students specifically indicated that they had not made any adjustments.

Telephone Interviews

Multiple attempts were made to interview ten students from the spring semester classes by telephone. Four students were actually contacted and agreed to a telephone interview. One CBI student indicated that he compensated for the lack of computerized material in intermediate algebra by getting help from teachers and tutors in the Math Walk-in Lab. Another felt that no adjustments were needed. The third CBI student interviewed indicated that he missed being able to redo the lessons. Only one of the four students had participated in a TLI class for elementary algebra. Her only comment was the mathematics classes, which meet four times a week for 50 minutes, are too short.

September Focus Group

SCC sponsors several academic programs where select groups of students meet together regularly for mentoring, tutoring and some shared classes. A 20-minute discussion period was arranged with one of these groups in which 14 out of 15 students had participated in at least one CBI developmental class the previous year and 3 of them had taken elementary algebra in the fall semester 2002 followed by intermediate algebra in the spring of 2003. The primary focus of this discussion was to gather input from this cohort of students regarding their experiences with computer-based learning including the transition issues between the two modes of instruction. To facilitate the discussion and to gather responses from the whole group, students were asked to jot down their thoughts on paper first. Included in Appendix F presents a summary of the students' written responses.

This group of students agreed that a major benefit of computer-based learning is that you can work at your own pace, but they also put a lot of emphasis on being able to replay the lessons. One student was very opposed to the test deadlines used to keep students on track to finish each course by the end of the semester. "I was rushing to meet the deadline, rather than taking my time to learn." Several students disagreed with this comment. They felt they would have procrastinated more without deadlines. Only one student indicated that she did not like the CBI program. The students indicated making the following adjustments in order to succeed in CBI: attending additional lab sessions, taking additional notes, learning to ask the instructor for individual help and attending tutoring sessions at the Learning Assistance Center. One student felt that it was easier to concentrate in the computer environment.

Discussion Summary

There were several common themes that may be drawn from the discussions with CBI students. Most students liked the option to access additional instructional time based on their own learning needs. This allowed them to work with the material at their own pace and still meet the course deadlines for completing each unit. None of the students expressed concerns indicating that the course material was not presented clearly by the computerized lessons, although one student felt that the computerized quizzes focused the students' attention on memorizing particular problem types. There are two important issues concerning the computer-based program at SCC that need to be addressed: the students' initial adjustment to the CBI environment and adequate staffing for individual assistance. Within intermediate algebra, the mathematics department needs to investigate how to provide students with supplementary instruction early in the semester addressing use of the graphing calculator. There also appears to be some interest in a supplementary computerized tutorial program for the intermediate algebra course.

Summary of Results

Below is a list of results indicated by the statistical and qualitative analyses described in this chapter.

1. Although a random design was not possible, the demographics for those students who completed elementary algebra via a computer-based

instructional format and those who participated in a more traditional teacher-led environment were similar except for time-of-day of instruction in intermediate algebra.

2. Two performance measures assessed students' cumulative knowledge of intermediate algebra: the total percent score determining the final grade in intermediate algebra and the number correct on Part 1 of the BGA. The achievement levels of the students as evidenced by these measures were statistically similar for both instructional groups.
3. When achievement was disaggregated by the topics covered within intermediate algebra, the two instructional groups also had statistically similar performance levels. Results on individual test items on Part 1 of the BGA indicated that both groups had mastered material covered directly in intermediate algebra and that both instructional groups had poor mastery of the skills involved in combining rational expressions, procedures that had been taught in elementary algebra. The percent scores on the unit examinations given throughout the semester were also statistically equivalent for the two instructional groups.
4. Although a higher percentage of CBI students compared to TLI students passed intermediate algebra (78% versus 66%), this difference was not statistically significant for this sample.
5. Retention of students was similar for the two instructional groups. Proportionally a comparable number of students took each unit

examination, and there was no statistical difference in the withdrawal rates for each instructional group.

6. From the limited evidence in the interviews, only a few students indicated having difficulty transitioning from CBI format in elementary algebra to the teacher-led format used in intermediate algebra. However, a number of students indicated the benefits of self-pacing in computer-based instruction. Students indicated that instructional support in the form of computerized practice in intermediate algebra might be beneficial, as well as the need for supplemental instruction in the use of the graphing calculator.

CHAPTER 5: CONCLUSIONS

Overview

This study compared levels of achievement, success rates and retention in intermediate algebra course for 50 students who were taught elementary algebra in a traditional classroom setting with 62 intermediate algebra students who completed elementary algebra in a computer-based classroom. At the participating community college, many of the academic environmental factors were prescribed; hence instructional variance within the instructional setting was controlled. Placement testing and criteria for course placement were mandatory. The mathematics division of the college provided the curriculum and examinations, and set grading policies for all sections of elementary algebra and intermediate algebra.

In a study where random assignment of students is not possible, an investigation characterizing the variance of demographic variables provides a measure of the similarity of the two instructional groups. One of the strengths of this study was the attention paid to the background information of the students. Statistical comparison of the demographics for the two instructional groups found that the two groups were similar in gender, ethnicity, percent score in the previous mathematics course, high school mathematics background, hours absent during the first eight weeks of the semester, credit load, number of hours they reported studying each week, and number of hours they reported working each week.

The course registration choices of the intermediate algebra students involved in the study were limited to the eight sections taught by four fulltime mathematics faculty members. An important variable that this study was not able to control was the distribution of the two instructional groups between day and evening classes. The majority of the evening students in intermediate algebra had participated in CBI in elementary algebra primarily because this was the only format of instruction provided for evening classes in elementary algebra.

The two instructional groups were compared for performance-levels on the multiple-choice section of a standardized intermediate algebra examination and on their total percentage scores earned in intermediate algebra. To determine whether students had made adjustments during the semester, this study examined the achievement level of the two instructional groups on each of the unit examinations.

Missing data for students who dropped out during the semester is an inherent limitation when attempting to compare evaluations of students' performance in a college setting. This study addressed this issue in three ways. First, the analysis of unit examination scores maximized data access for as long as possible by including all students who completed the examination. Then the level of participation of the two instructional groups for each unit examination was compared using a chi-square test. There was no significant difference in participation between the two instructional groups on any of the unit examinations. Second, intermediate algebra percent scores were calculated for all students including those who did not complete the course with the exception of those who withdrew while passing. Third, inclusion of a research question that defined success rate as passed or did-not-pass allowed for the inclusion of all students involved in the study with no missing data.

The cumulative percent scores in intermediate algebra and the percent scores on the unit examinations provided well-defined scale variables as dependent variables appropriate for the multiple regression analysis. Cases that were identified during the preliminary investigations as outliers were removed for the final analysis. The residual scatterplots, histograms and P-P[2] plots indicated that the regression requirements of normality, linearity and homoscedasticity were met (see Appendix G). In order to evaluate success rates, a sequential logistic regression was completed with pass/did-not-pass as the dependent variable.

This study included two analyses of retention. The first analysis, referred to as the retention rate analysis, used the more traditional definition of defining all those students who did not officially withdraw from the course as completing the course. The second, referred to as the completion rate analysis, looked at participation patterns. Students who did not take the fourth unit examination and the final examination were categorized as not completing the course.

Students' opinions were solicited through discussion groups. In these groups, students addressed many of the important themes identified in Chapter 1. They valued their computer-based experience because it provided flexible scheduling and it allowed each of them to "go at your own pace." For most students this meant being able to schedule extra hours in the computer lab so they

[2] Graph of the Observed Cumulative Probability values to the Expected Cumulative Probability values.

could work through the lessons at their own speed. One student interviewed had taken advantage of the opportunity to finish her computer-based course early. Student concerns that arose during the interviews primarily addressed the length of time spent waiting in the computer lab for instructional assistance and the transition to using graphing calculators in intermediate algebra.

Research Questions

The primary question addressed in this study concerned the effect of computer-based instruction with community college students in elementary algebra on those students' success in intermediate algebra. The outcomes investigated included achievement on an end-of-course assessment instrument, overall achievement in the course, pass rate in intermediate algebra and retention rates in intermediate algebra. The specific questions addressing each of these effects and a summary of the results are listed below.

Evaluation of Achievement Based on Course Grade

1. Is there a difference in the achievement levels between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes based on the percentage score earned in intermediate algebra?

Previous research on student achievement in intermediate algebra had indicated that prior achievement in elementary algebra, the length of time between completing elementary algebra and intermediate algebra, and the age of the student were significant predictor variables. In addition to the easily acquired information such as gender, age, ethnicity, and credits, the data gathered for this study included student reported information on employment levels, study hours, high school mathematics background, plus the less readily available data on percent score earned in elementary algebra, the time of day that the intermediate algebra course met, and level of absence at the eighth week of the semester. This study included only students who had completed elementary algebra the previous semester, thus eliminating consideration of the effect of stopping-out.

Preliminary multiple regressions using backward entry were performed on the dependent variables to determine a set of significant predictor variables. The variables on ethnicity, time-of-day, percent score in elementary algebra and absence level at the eight week of class were retained as predictor variables. Course achievement was represented in the multiple regression by the cumulative percent scores earned by students in intermediate algebra. Using a standardized grading policy, instructors were required to use the examinations and quizzes provided by SCC's mathematics division. Discretionary points for homework assignments or other projects were limited to 50 points out of the 700-point total.

Using sequential regression with data on the format of elementary algebra instruction entered on the second step, this study found that there was no statistical difference in achievement based on the cumulative percent score earned in intermediate algebra between the students who completed elementary algebra in a computer-based setting and those who completed elementary algebra in a teacher-led format.

A follow-up use of stepwise regression indicated that a student's cumulative percent score in elementary algebra and his/her level of absence in intermediate algebra measured at the eighth week of instruction were the most influential predictor variables for achievement in intermediate algebra.

Evaluation of Course Achievement Using a Standardized Instrument

2. Is there a difference in the achievement levels between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes on a standardized mathematics examination given at the end of the intermediate algebra course?

The 23 multiple-choice questions on Part 1 of the Maryland Bridge Goals Assessment (BGA) served as the standardized end-of-course assessment. The BGA is a timed examination that was included as part of the final examination for intermediate algebra. The number of items correct for each group was practically identical with M = 12.66 (SD = 3.315) for the TLI students and M = 12.65 (SD = 2.656) for the CBI students. An independent sample t-test confirmed that there was no significant difference in performance by the two instructional groups on Part 1 of the BGA among those who completed the final examination. The difference in participation rate on the final examination also was not statistically significant.

Evaluation of Achievement on Individual Performance Measures

3. Is there a difference in student achievement levels on the department unit exams between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?

Although students' overall achievement was statistically similar on both the BGA and on their cumulative percent scores in intermediate algebra, potentially the two instructional groups may have had different areas of strength or weakness associated with mathematical topics. This possibility was investigated in two ways. Stepwise multiple regressions were performed using the results on each of the unit examinations as dependent variables and, as an ad hoc analysis, individual items from the final examination were examined for performance differences.

The largest gap in achievement on the unit examinations was on the Unit 2 examination with a difference between the means of 7.82 % with standard deviation for each of the two groups near 14 (see Table 10 in Chapter 4). However, based on the multiple regression analyses, there was no statistically significant difference in achievement on the unit examinations given throughout the semester for the two instructional groups.

The largest gap in performance on selected content items on Part 1 of the BGA was 10% with a standard deviation for the two instructional groups near 4.5 (see Table 13 in Chapter 4). Results from independent sample *t*-test indicated no statistically significant differences in performance between the CBI and TLI students on individual test items from Part 1 of the BGA.

Evaluation of Course Success Rates

4. Is there a difference in the pass rates (C or better) in intermediate algebra between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?

Several studies mentioned in the literature review included in their evaluation of success rates only students who finished the course. Because students who do not complete developmental courses are a major concern to community colleges, this study coded all students as either passed or did-not-pass, thus providing a more inclusive evaluation of performance. A sequential logistic regression using backward – stepwise entry for the set of predictor variables indicated no statistical difference in success rates between the two instructional groups. A student's prior percent score in elementary algebra and his/her level of attendance were also selected in this analysis as the most influential predictor variables.

Evaluation of Retention Rates

5. Is there a difference in the level of retention at the 10th week withdrawal date between students who successfully completed elementary algebra using computer-based instruction and those who completed elementary algebra in teacher-led classes?

Only a small number of students officially withdrew from intermediate algebra by the 10th week of the spring semester. The chi-square test of the four cells formed from the crosstabluation of retained and not retained students with the two types of instruction in elementary algebra yielded no significant difference in withdrawal rates between the two instructional groups.

This study not only evaluated differences in institutionally defined retention rates based on students officially withdrawing but also considered completion rates based on participation on unit examinations. Within the completion rate analysis students were categorized as having completed the course if they participated in the fourth unit examination and the final examination. The chi-square test examining completion rates across the two categories for completion and the format of instruction in elementary algebra yielded no significant difference in completion rates between the two instructional groups.

Limitations of the Study

The Setting

The uniqueness of the instructional setting at SCC limits the potential generalizability of the results of this study. Not all colleges have mandatory placement policies or this department-controlled curriculum.

The lack of availability of evening sections of elementary algebra sections using the teacher-led format created an undesirable imbalance in the distribution of elementary algebra students based on instructional format. That is, the distribution of CBI and TLI students over the day and evening sections was not balanced.

Subsequently, the evening sections of intermediate algebra were predominately populated by students from CBI sections of elementary algebra.

The results associated with CBI in this study were uniformly based on the use of ModuMath Algebra (2001). It should also not be assumed that the results obtained using ModuMath Algebra extends universally to all computer-based instructional software.

The Subjects

Students in this study were not randomly assigned to the two instructional formats used in elementary algebra or to the multiple sections of intermediate algebra. Most students select course sections based on personal scheduling considerations. Given the decision to include six independent variables and to eliminate up to nine student cases as outliers, a slightly larger sample of approximately 120 students would have strengthened the results.

Assessment Instruments

The mathematics faculty at SCC designed the unit examinations completed by students in both elementary algebra and intermediate algebra. The multiple versions of each examination contained parallel test items. The use of the various versions of the examinations was distributed over the course sections with some instructors choosing to use two forms within one class. Formal item analyses have not been conducted on these tests.

A standardized assessment of intermediate algebra content is not available from national testing sources. This study used one form of Version 3 of the

Maryland Bridge Goals Assessment (BGA), which was designed by a consortium of high school and college mathematics faculty. Using a locally designed examination provided a reasonable level of content validity, and preliminary evaluations of test reliability for Version 2 of the BGA were acceptable. Time limitations for Part 2 of the BGA continue to be a concern, thus limiting the data in this study to Part 1 of the examination.

The Focus Groups

Fewer students who had completed elementary algebra in the TLI classes participated in the focus groups. Expressed concerns about course content, the pace of instruction, and instructional support were limited to the CBI format.

Conclusions and Discussion

Contribution To Research

Research on best practices in developmental education has indicated that instruction should incorporate different teaching methods and the evaluation of instructional programs should include success at the next instructional level (Boylan, 2002, Roueche & Roueche, 1993). In many college programs, intermediate algebra represents the bridge from developmental mathematics into college-level mathematics. This study is just one of only a few studies that have investigated success in intermediate algebra based on the students' prior educational experience in elementary algebra.

Johnson's ex post facto study (1996) investigated the influence of many demographic factors (i.e. age, gender, ethnicity, number of dependents, level of employment, stopping-out time, the number of attempts made at each course and students' satisfaction with developmental instruction) and several academic variables on students' subsequent success in intermediate algebra. While Johnson's study did not include computer-based instruction, it was important in that it provided information on the relative importance of demographic factors on future success when studying intermediate algebra. The findings of the current study supported his results indicating that the student's grade in elementary algebra was the most powerful predictor of success in intermediate algebra. There was a substantial difference in the level of influence indicated by the two studies. In Johnson's study the discriminat function analysis indicated that the predictor variables accounted for only 16.5% of the variance. The results of this study using multiple regression yielded an adjusted R^2 of 45.5%. One influential predictor included in this study, but not included in Johnson's study, was the student's level of absence at the eighth week of the semester.

Early studies on computer-based instruction in mathematics programs focused on students' success within the current course. Using Academic Systems Corporations' algebra software and a highly structured program similar to the format used at SCC, Kinney (2001) concluded that there was no statistical difference in achievement between students who completed elementary algebra in a computer-based environment compared to students who completed elementary algebra in teacher-led instruction. Kinney's study reported mixed results in the area of retention with TLI students having a statistically higher level of withdrawal in the second year of the study but not the first year. The current study extends the research on retention rates and serves as an extension of the research on computer-based instruction to include success in the subsequent mathematics course.

Only recently have studies investigated the success of CBI students in subsequent mathematics courses. Generally these studies reported that students who had studied elementary algebra using computer-based instruction were more successful than students from traditionally instructed courses, but these studies were limited to small, specialized populations or were post hoc studies that did not include other predictor variables. This study was unique for a community college setting because of the range of demographic data that was available on each student and the level of control over the scheduling of the students as well as the curriculum and course assessment measures. The mean and median scores of the CBI students were higher than the TLI students on all of the achievement measures (see Table 10 in Chapter 4). The regression analyses allowed for the statistical control of significant independent variables representing student performance in the previous course and level of absence. This led to a finding of no significant difference in achievement or success rates for the two instructional groups.

Implications for Instruction

In addition to mastering the mathematics content, developmental mathematics programs attempt to assist developmental students in their efforts to become independent learners. This study supports computer-based instruction as a viable option in comprehensive developmental mathematics programs. However, attention needs to be paid to the full instructional plan. The program utilized in this study required students to attend class and to complete assignments, quizzes and unit examinations based on a pre-determined course schedule.

Students' comments indicated that the role of the instructor is important in the computer-based environment. Instructors need to be aware of the need for supplemental instruction for the class as a whole and for individuals. Having sufficient help is important so that students' questions can be answered in a timely manner. The viability of providing additional assistance through peer tutors or student aides should be investigated.

Recommendations for Further Research

Many institutions are interested in using computer-based instruction as a less expensive method of providing remedial instruction. In the computer-based model at SCC the teacher-student ratio was identical to that of the teacher-led sections with a ratio of 24 students to 1 instructor. Peer tutors provided assistance to students who were spending extra time in the lab. There was no cost savings generated by CBI as compared to TLI at SCC since the CBI classes incurred the additional expenses of acquiring and maintaining a computerized classroom. Additional research is needed on the effectiveness of CBI classroom settings with various amounts and types of instructional assistance.

In this study the majority of the students in the focus groups expressed positive comments about their experiences with the CBI format. There were a few exceptions amongst the responses recorded in Appendices H and I. Additional research is needed to help discern if some types of students are better suited for the computer-based environment and on what educational strategies would be effective in alleviating stress associated with computer anxiety. Of particular interest to community colleges would be additional information addressing the use of computer-based mathematics instruction with students who have a history of withdrawing from or being less successful in traditional instruction or with students with particular learning disabilities.

There are many areas pertaining to computer-based instruction in developmental mathematics that have not been investigated. Most community colleges have developmental studies programs in mathematics that begin at the arithmetic level. Additional studies should examine the success of computer-based programs in basic mathematics.   Another area of interest is the level of student retention of content for students who stop-out of mathematics instruction and within other mathematics courses taken later in the mathematics program sequence.

Final Summary

Computer-based instruction has the potential to provide a flexible learning environment for developmental mathematics that is needed by many community college students. This study provides evidence that computer-based instruction is a viable choice for elementary algebra programs. Students who completed elementary algebra in a CBI environment did not need to make any substantial adjustments when taking a subsequent mathematics course in the TLI format and they were equally successful.

APPENDIX A

COMPARISON OF TEACHER-DIRECTED

AND COMPUTER-BASED PROGRAMS

	Teacher-led Instruction	Computer- based Instruction
Text	Same	
Assignments	Same	
Computerized Drill & Practice	Same	
Final Exam	Same	
Grading Policy	Same	
Unit Exams	Same	
Outside Help	One hour of tutoring per week is available to all students through the learning assistance center. A drop-in lab is also available for homework assistance.	
Timing of Exams	First exam in ModuMath sections is generally one class session behind the TLI sections to allow for time to introduce the program. To compensate for this additional time requirement students in the CBI classes take their first examination at the college test center.	
Content of Lessons	Lesson packet with similar examples to ModuMath.	ModuMath Video-disk Interactive Lessons
Quizzes	Teacher written. Generally 5 - 10, no minimum score or retests	18 computer-generated quizzes. Must get a 65% on each to move to next lesson
Ratio of student to faculty	~24 students per class	~48 students with 2 teachers and a student aide
Hours spent in the classroom	4 hours per week	Scheduled for 4 hours but many students need to put in an additional 2-4 hours per week

APPENDIX B

COURSE OUTLINE
Elementary Algebra
4 Semester Hours
SUBURBAN COMMUNITY COLLEGE

Course Description

In this course, the student will develop skills in manipulating algebraic expressions with integer exponents and in simplifying polynomials, rational expressions and radicals. The student will write an equation for a line from given information. Systems of equations will be solved graphically and algebraically. Methods of factoring second-degree polynomials and applications involving factoring will also be included. The ability to solve equations will be expanded to include rational expressions and quadratics. The quadratic formula will be introduced. Application problems will include the use of the Theorem of Pythagoras. This course is taught using computer-assisted instruction.
Prerequisite: Appropriate score on math placement test.

Overall Course Objectives

Upon successful completion of this course, the student will be able to:

1. Write a linear equation from information given in an application problem.
2. Solve a system of linear equations in two variables.
3. Solve application problems in two variables including percent mixture.
4. Apply the laws of exponents to algebraic expressions.
5. Divide a polynomial by a monomial and a binomial.
6. Factor second-degree polynomials.
7. Combine and simplify expressions involving radicals.
8. Solve quadratic equations by factoring and the square root method.
9. Apply the quadratic formula to application problems.
10. Add, subtract, multiply and divide polynomial rational expressions.
11. Solve equations containing polynomial rational expressions.
12. Apply the Pythagorean Theorem.
13. Use the Means/Extremes Product Property to solve proportion problems.
14. Solve applied problems involving direct and inverse variation.

Major Topics

Linear Equations
- Slope-intercept form
- Application problems

Systems of two equations with two unknowns
- Graphing method; Substitution method; Elimination method
- Application problems including percent mixture and geometric

Exponents and Polynomials
- Integer exponents
- Addition, subtraction, multiplication and division of polynomials

Factoring
- Greatest common factor
- Grouping
- x^2+bx+c by trial and error; ax^2+bx+c by ac method
- Difference of squares

Radical Expressions
- Multiplying and simplifying radicals
- Quotients involving radicals
- Addition and subtraction of radicals

Quadratic Equations
- Solving quadratic equations that factor
- Solving quadratic equations using the square root method
- Quadratic formula
- Application problems

Rational Expression and Equations
- Combining rational expressions and simplifying
- Solving rational equations
- Ratio and proportion; similar triangles
- Applying the Pythagorean Theorem
- Variation

Course Requirements

Attendance/Participation

You are expected to attend every class session. If an occasion arises where you need to be absent, contact your instructor as soon as possible. Absences include anytime you are not present for a scheduled class as well as any penalties for lateness and leaving early. During the Fall and Spring semesters, any student who has missed the equivalent of twenty percent of the class time will fail the course. In extraordinary circumstances, students may petition to the mathematics division chair to be exempted from this policy. Students who are affected by this policy should consult with their advisors and financial aid counselors as to whether they should withdraw.

Assignments

Assignments and certificates give students the necessary practice to help them master the objectives for the course. Assignments must be turned in at the next class period. Any required certificate must be dated after the start of the semester. Students are expected to spend time outside of class working on computer assignments. If you do not have the equipment at your home/office, you must plan to spend extra time on campus in our open computer lab.   Certificates will account for 5% of the total grade, and the other assignments will also account for 5% of the total grade.

Quizzes

In teacher–directed sections, quizzes may be announced or unannounced as determined by your instructor. In computer-based sections, students are expected to complete the computerized quizzes for lessons 14 – 32. At the end of the semester, zeros will be averaged in for any quizzes not completed. In all sections quizzes will account for 15% of your total grade.

Exams

There will be 5 unit exams and a comprehensive final exam. Students are not allowed to use notes or textbooks during exams. Students must take each exam by the deadline scheduled for their class. A zero will be given for any missed exams. A comprehensive final exam will be given during Final Exam Week.

Grading Scale

Exams	50%	*Grade*
Final Exam	25%	A = 90-100%
Quizzes	15%	B = 80-89%
Certificates	5%	C =70-79%
Homework/Reviews	5%	F = below 70%

I-Grade

An I grade may be given for a documented emergency; however, the student must have successfully completed 75% of the course objectives and obtain approval from the course coordinator.

L – Grade

The L grade is assigned in developmental courses to students who have not mastered the course objectives due to individual learning characteristics. In order to qualify for an L grade, students must have near perfect attendance and work with steady diligence and effort beyond class sessions. The L grade is not computed in the student's grade point average. Those who receive an L grade must re-register and repeat the developmental course.

Other Course Information

Credits awarded for the completion of this course do not fulfill degree requirements in any degree or certificate program and are not transferable to four-year colleges.

Required Text: Introductory Algebra, 5th edition, by Wright and New
Required Software: Introductory Algebra CD
Required Supplies: 3 Ring Notebook; head phones for ModuMath sections only
Recommended Calculator: TI30X-IIS

Available Help: Each instructor has office hours when you can make an appointment for individual help. Student Support Services provides both drop-in and assigned tutoring at the Learning Assistance Center in the Library. Videos covering algebra topics are available in the Walk-in Lab and the LAC. Videos can be checked out at the library. The Introductory Algebra software is available in the Walk-In Lab, computer labs, and the LAC.

Academic Honesty as described in the student handbook is required of all students.

APPENDIX C

COURSE OUTLINE & GRADING POLICY
Intermediate Algebra
3 Semester Hours
SUBURBAN COMMUNITY COLLEGE

Course Description

The emphasis of this course is on using algebraic and graphical techniques to model and solve real world application problems. The use of a graphing calculator is required. Topics will include linear, quadratic and exponential functions, rational exponent equations (both linear and quadratic), radical equations, linear and nonlinear systems, use of the discriminant and an introduction to probability and statistics. Prerequisite: Elementary Algebra or appropriate score on math placement test. (4 hours weekly)

Overall Course Objectives

Upon successful completion of this course, the student will be able to:

1. Use problem solving strategies to explore patterns numerically, graphically, and algebraically.
2. Write the equation of a linear function from a graph or a verbal problem.
3. Model applications with linear inequalities.
4. Solve absolute value equations and inequalities.
5. Solve elementary probability problems using counting techniques.
6. Given a set of data, determine the mean, median, mode and standard deviation.
7. Solve radical equations and equations with rational exponents algebraically and graphically.
8. Use the discriminant to determine the number and type of roots for a quadratic function.

Major Topics

Functions and Modeling
- Tables, Graphs and Equations
- Introduction to Functions

Linear Functions
- Slope
- Graphs of Linear Functions
- Equations of Linear Functions

Systems of Linear Equations

Probability

Probability and Counting Techniques

Linear Functions Extended

Linear Inequalities

Compound Inequalities

Absolute Value Functions-Graphically

Absolute Value Functions-Analytically

Statistics

Exponents

Reciprocal of Integer Exponents

Solving Power Equations

Rational Exponents

Exponential Functions

Exponential Functions from a Numerical Perspective

Graphing Exponential Functions

Quadratic Functions

Graphs of Quadratic Functions

Solving Quadratic Equations

Factors, Solutions and the Discriminant

Nonlinear Systems and Inequalities

Functions

Function and Notation

Required Text: An Intermediate Course in Algebra: An Interactive Approach, 1st edition, by Warr, Curtis and Slingerland, Harcourt Brace, Publishing.

Required Materials: Ruler, graph paper, a scientific programmable graphing calculator such as the TI-83 Plus (Do NOT buy a TI-81, TI-82, TI-85, TI-86, TI-89 or TI-92). Colored pencils are optional.

Homework: Homework assignments will be given daily. Graded calculator activities will be assigned throughout the semester.

Other Assessments: Each class will have other assessments totaling 50 points that will be determined and provided on a handout from your instructor.

Attendance: Students are expected to attend every class session. If an occasion arises where you need to be absent, contact your instructor as soon as possible. Absences include anytime you are not present for a scheduled class as well as any penalties for lateness and leaving early. During the Fall and Spring semesters, any student who has missed the equivalent of twenty percent of the class time will fail the course. In extraordinary circumstances, students may petition to the mathematics division chair to be exempted from this policy. Students who are affected by this policy should consult with their advisors and financial counselors as to whether they should withdraw.

Grading: Graded calculator activities will be collected and graded for a maximum of 50 points. No calculator activities will be accepted after graded assignments are returned.

There will be four unit exams, each worth 100 points. If, due to a verifiable emergency, a student misses the exam on the day it's given, the student must inform the instructor and arrange to take the exam before the next class session or a grade of 0 will be given.

One exam may be taken to improve a grade, with a possible maximum score of 85% on the second test. The second score will replace the first. This second chance feature may be used only once during the semester to improve a grade or replace a 0.

A comprehensive final, worth 200 points, will be given during Final

Exam Week.

Point Breakdown:

4 Unit Tests	400 pts.
Calculator Activities	50 pts.
Other Assessments	50 pts.
Final Exam	200 pts.
Total	700 pts.

Grading Scale:	630-700	A
	560-629	B
	490-559	C
	489 or below	F

An "I" grade can be given in case of an emergency, if a student has successfully completed 75% of the course objectives as determined by the instructor after consulting the course coordinator.

Other Course Information

Credits awarded for the completion of this course do not fulfill degree requirements in any degree or certificate program and are not transferable to four-year colleges.

Academic honesty, as defined by the Student Handbook, is required of all students.

APPENDIX D

Administrative Request for Permission to Conduct Research

November 2, 2002

Mr.

Vice President of Academic Affairs

, Maryland

Dear

I am requesting your permission to conduct my dissertation research with mathematics faculty and students during the Spring semester 2003 as partial completion of my doctoral requirements at the University of Maryland, College Park. My purpose is to investigate the relationship (if any) of prior computer-based instruction on students' subsequent success in intermediate algebra.

I hope to conduct my investigation in the following manner:

1. Describe the research to the intermediate algebra faculty in face-to-face meetings.
2. Seek written permission from the faculty on their willingness to have data from their sections of intermediate algebra included in the study.
3. Schedule classes and students to reduce the influence of the teacher as a confounding variable.
    - An equal number of students coming from Math-067 teacher-directed sections and Math-067 computer-based sections need to be assigned to each class included in the study. By scheduling parallel sections of intermediate algebra in the spring 2003 schedule, students who completed Math-067 in Fall 2002 and are registered for a given timeslot of Math-070 in the spring can be clustered into

one of the two parallel sections. A trial-run with 2001-2002 data indicates that the necessary information can be obtained in a timely fashion.

4. Collect informed consent forms from all participating students.
5. Assess end-of-course knowledge in Intermediate Algebra using a standardized instrument as part of the final exam.
6. Use institutional data to evaluate student retention at the 10th week.
7. Use institutional data to investigate the relationship of achievement in Math-067 with achievement in Math-070.
8. Provide written feedback to involved math faculty and the Vice President of Academic Affairs.

All information gathered in the study concerning individuals will remain confidential. Names of subjects will be removed from the data instruments and replaced with a code. Confidentially will be further protected by not using names of individuals in any publications that may result from this research project. All participation is voluntary; refusal to participate will involve no penalty to faculty or students.

Hopefully you will feel this project will provide an opportunity for us to investigate the effectiveness of our computer-based program and will be a positive benefit for the college.

Thank you, for your consideration of this request. If you are willing to support this research, please return the accompanying permission slip in the envelope provided.

Sincerely,

Bernadette Sandruck
Doctoral Candidate

CC: Dr. Patricia Campbell.

Doctoral Dissertation Approval

I give my approval for Bernadette Sandruck to conduct research at Community College under the aforementioned conditions during the Spring 2003 semester.

Signature

Position

Date

DOCTORAL RESEARCH FACULTY PARTICIPATION CONSENT FORM

As a faculty member at ____________ Community College, I have been informed of the Intermediate Algebra Research Project to be conducted by Bernadette Sandruck as part of her doctoral requirements at the University of Maryland, College Park. I voluntarily agree to participate in this project and to have my class data included in the analysis. I understand that participation includes teaching two sections of the course, asking students to sign a consent form at the beginning of the semester, using the standardized curriculum including unit exams and a validated standardized final exam at the end of the semester.

____
Faculty Signature

____
Date

Effects of Interactive Computer-based Instruction In Elementary Algebra
On Community College Achievement In Intermediate Algebra

INFORMED CONSENT FORM

Many of the students at this college in intermediate algebra have completed a prior elementary algebra course using either computer-based instruction or teacher-directed instruction. This semester a research study will investigate if students' prior educational experience in elementary algebra has any effect on their success in intermediate algebra. This letter is designed to tell you about this study and to seek your permission for involvement.

I state that I am over 18 years of age and wish to participate in this study being conducted by Ms. Bernadette Sandruck who is completing her doctoral studies with the Department of Curriculum and Instruction at the University of Maryland, College Park in collaboration with Community College. As a participant in this study, I understand that my only responsibility is to participate as usual in my intermediate algebra course. I understand that this study will seek information such as attendance records, examination grades, and final grades for all students enrolled in intermediate algebra this semester. All information collected is confidential and identification numbers designated just for this study will be used to label all data. I understand that the data provided by my instructor will be grouped with demographic data from my college records and that for reporting and presentation purposes my name will not be used.

There is no risk involved in participating in this project. I understand that this research is not designed to help me personally, but to help the investigator learn more about the effectiveness of various instructional modes on success in subsequent coursework. I am free to ask questions or withdraw from participation at any time and without penalty.

STUDENT NAME: ________________________________

SIGNATURE: ____________________________________

DATE: __________________________

Doctoral Student:
Bernadette Sandruck

Advisor:
Dr. Patricia Campbell

APPENDIX E

SURVEY FOR MAY FOCUS GROUP

How busy are you?

Students frequently have many demands on their time in addition to their schoolwork. As part of this project we would like to include an assessment of the outside factors that affect students' study time. Please take a minute to answer the following.

Name ____________________________ Section: _____________

1. This semester, I am taking:

a) only 3 credits b) 4 – 11 credits c) 12 – 15 credits d) more than 15 credits

2. I spend about ______hours each week studying and doing assignments for all of my classes.
3. On average, I work…. _______hours each week
4. List any other responsibilities (family or social) that effect your study time.

5. I am sure we forgot something, so please describe any other factors that affect your study time, which we may not have considered.

APPENDIX F

ADDITIONAL STATISTICAL TABLES

Correlations of Independent Variables with Percent Score in Intermediate Algebra (n = 109)

	% IA	Abs.	Age	AA	Other	D/E	Gender	Crds	% EA	CBI/ TLI
					Pearson Correlations					
% IA.	1.000									
Absence	-.435	1.000								
Age	.190	-.051	1.000							
African American	-.121	.076	.136	1.000						
Other	.021	.144	.005	-.178	1.000					
Day or evening	-.204	.128	-.234	.036	.017	1.000				
Gender	-.040	.243	.154	-.027	-.123	-.069	1.000			
Credits	-.067	.068	-.148	.025	.092	.142	.006	1.000		
% EA	.418	-.151	.291	.117	-.032	-.124	.125	-.089	1.000	
CBI/TLI	.205	-.054	.277	.093	.054	-.289	-.076	.047	.167	1.000
					Significance (1-tailed)					
% IA.	.									
Absence	.000	.								
Age	.024	.299	.							
African American	.105	.217	.079	.						
Other	.412	.068	.481	.032	.					
Day or evening	.016	.093	.007	.355	.430	.				
Gender	.341	.005	.055	.389	.102	.238	.			
Credits	.243	.241	.062	.398	.170	.071	.473	.		
% EA	.000	.058	.001	.113	.369	.100	.097	.180	.	
CBI/TLI	.016	.290	.002	.167	.288	.001	.217	.314	.041	.

Elimination & Retention of Independent Variables in the First Run of the Multiple Regression Using Backward Elimination

Dependent Variables:	% in IA	1st Unit Exam	2nd Unit Exam	3rd Unit Exam	4th Unit Exam
	Independent Variables Removed (F to remove > = .100)				
	Gender Credits Day – 3 or more mtgs/wk Ethnicity = other Age Day – twice/week	Ethnicity = other Gender Credits EA Format Day – twice/ wk Day – 3 or more mtgs/wk	Gender Age Credits Ethnicity = other Absence	Absence Credits Gender Day – 3 or more mtgs/wk EA Format Ethnicity = other	EA Format Gender Credits Ethnicity = African Amer. Age
	Variables Retained				
	Ethnicity = African American EA Format % EA Absence	Ethnicity = African American Absence % EA Age	Day – 3 or more mtgs/wk Ethnicity = African American EA Format % EA Day – twice/ wk	Ethnicity = African American % EA Age Day – twice/ wk	Day – 3 or more mtgs/wk % EA Absence Day – twice/ wk
n =	109	112	108	105	99

Coefficients, Correlations and Collinearity Statistics for Predictor Variables with Dependent Variable % Score in Intermediate Algebra

	Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	-13.463	13.759	-.220	-.978	.330	-40.778	13.853
Absence	-1.012	.351	.095	-2.881	.005	-1.709	-.315
Age	.416	.354	.042	1.175	.243	-.287	1.119
Other	1.643	2.952	-.214	.556	.579	-4.218	7.504
African American	-9.077	3.273	.510	-2.774	.007	-15.574	-2.580
% EA	1.018	.156	-.076	6.542	.000	.709	1.328
Day or evening	-2.565	2.683	.141	-.956	.341	-7.891	2.761
Format	4.113	2.319	.141	1.774	.079	-.490	8.716

	Correlations			Collinearity Statistics	
	Zero-order	Partial	Part	Tolerance	VIF
(Constant)					
Absence	-.354	-.283	-.211	.913	1.096
Age	.290	.120	.086	.820	1.220
Other	.041	.057	.041	.937	1.067
African American	-.158	-.274	-.203	.895	1.118
% EA	.577	.557	.478	.880	1.137
Day or evening	-.237	-.098	-.070	.851	1.175
Format	.283	.179	.130	.847	1.180

Correlations between Independent Variables and Each Dependent Variable

	% IA	First Exam	Second Exam	Third Exam	Fourth Exam
	Pearson Correlations				
Absence	-.435	-.319	-.268	-.107	-.338
Age	.190	.275	.254	.334	.304
Other	.021	.001	-.068	.102	.002
African American	-.121	-.155	-.223	-.090	-.053
% EA	.418	.378	.475	.560	.481
Day/evening	-.264	-.274	-.362	-.150	-.338
Format	.205	.197	.270	.179	.174
Gender	-.040	-.006	.050	.138	-.024
Credits	-.067	-.114	-.041	.070	-.056
	Significance (1-tailed)				
Absence	.000	.000	.003	.139	.000
Age	.024	.002	.004	.000	.001
Other	.412	.445	.242	.151	.491
African American	.105	.051	.010	.182	.301
% EA	.000	.000	.000	.000	.000
Day/evening	.016	.002	.000	.063	.000
Format.	.016	.019	.002	.034	.043
Gender	.341	.476	.304	.080	.408
Credits	.243	.116	.335	.239	.292
n	109	112	108	105	99

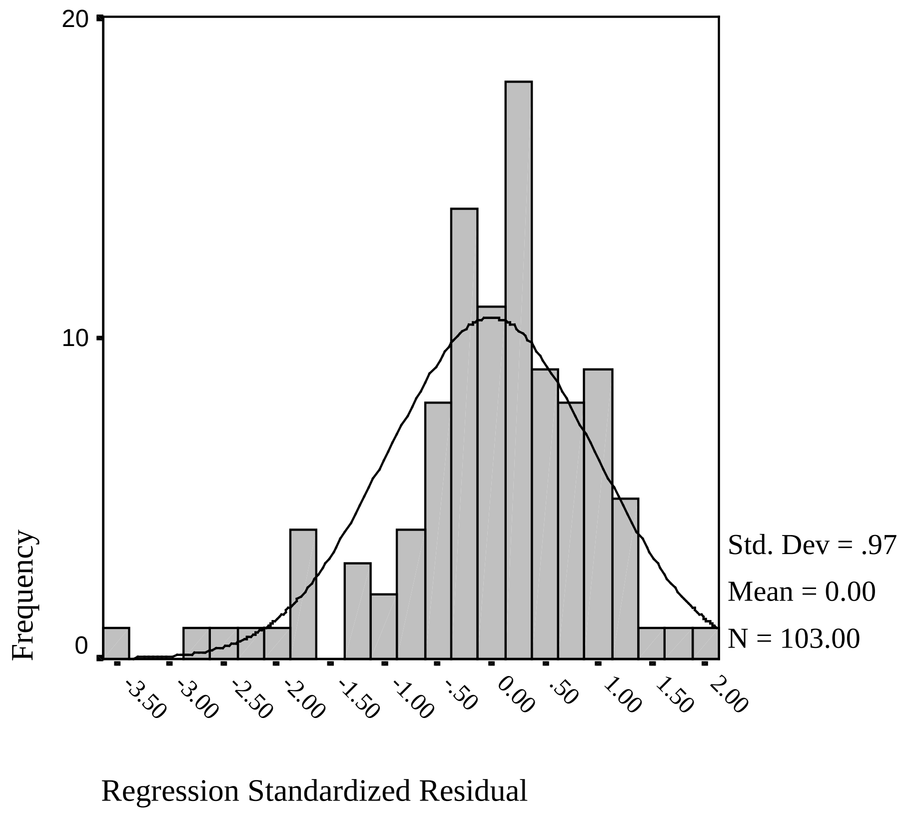
APPENDIX G

GRAPHS OF REGRESSION STANDARDIZED RESIDUALS

Dependent Variable: PERCENT SCORE IN INTERMEDIATE ALGEBRA

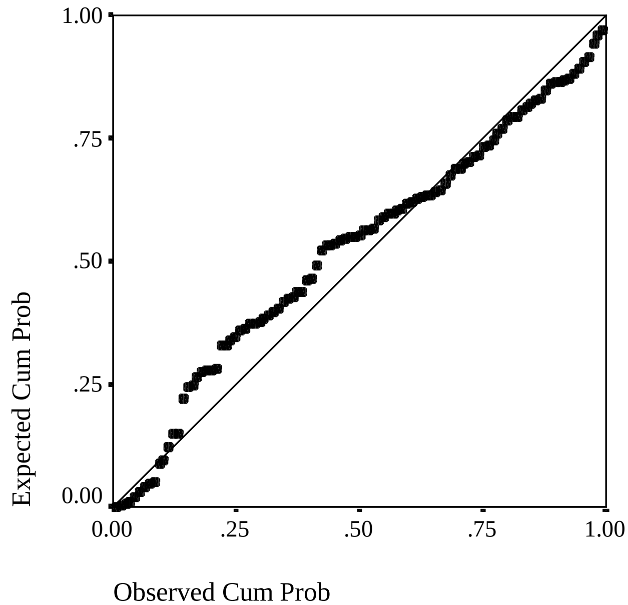
Independent Variables: Absence at 8th Week, Age, %EA, Day/Evening, Ethnicity, Format of EA Instruction

HISTOGRAM

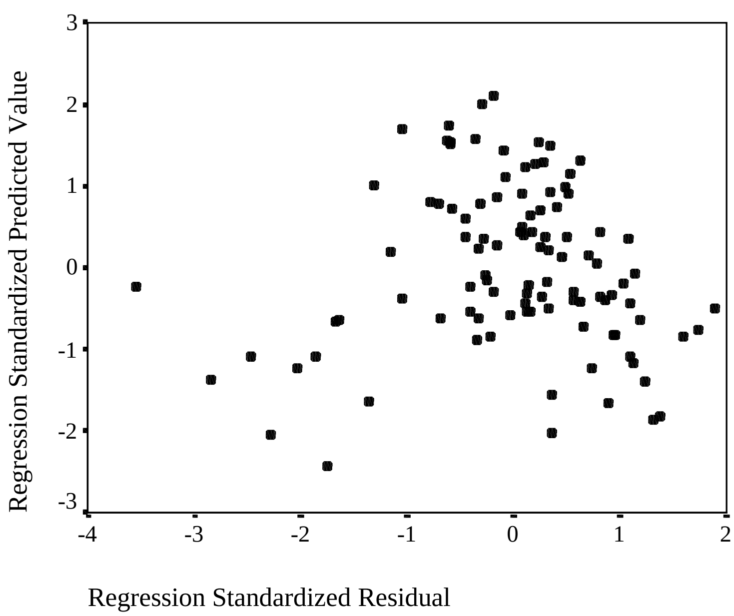


Dependent Variable: Percent Score in Intermediate Algebra

NORMAL P-P PLOT OF REGRESSION STANDARDIZED RESIDUAL



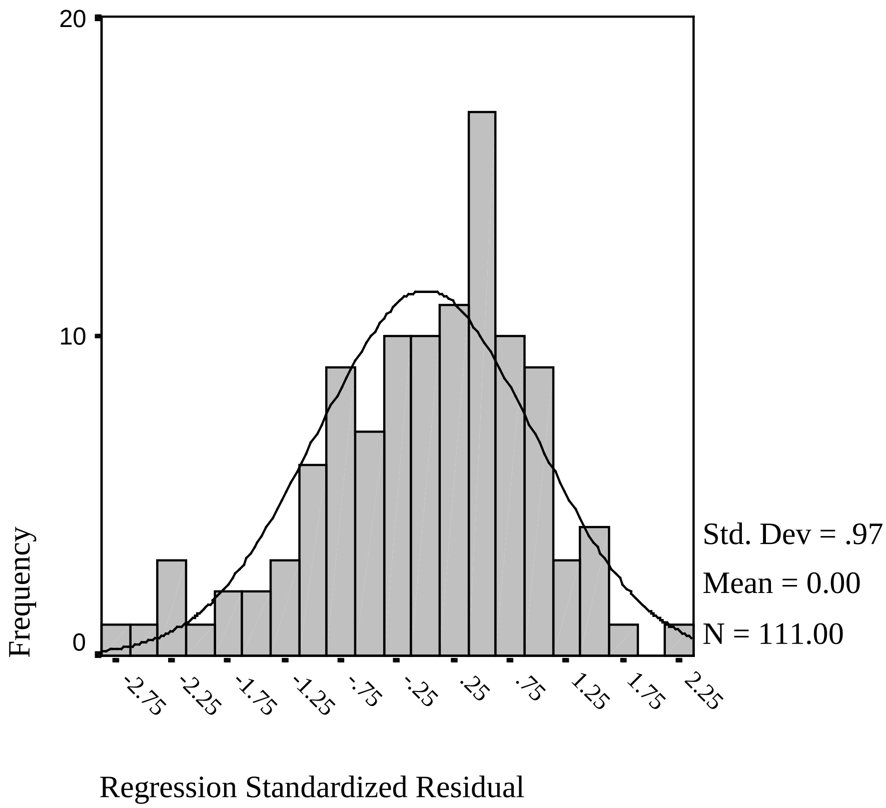
SCATTERPLOT



HISTOGRAM OF REGRESSION STANDARDIZED RESIDUALS

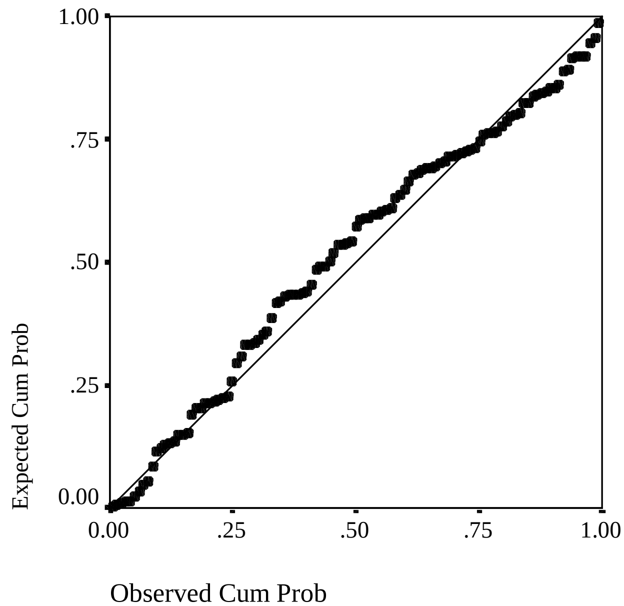
Dependent Variable: PERCENT SCORE ON FIRST EXAMINATION

Independent Variables: Absence at 8th Week, Age, %EA, Day/Evening, Ethnicity, Format of EA Instruction

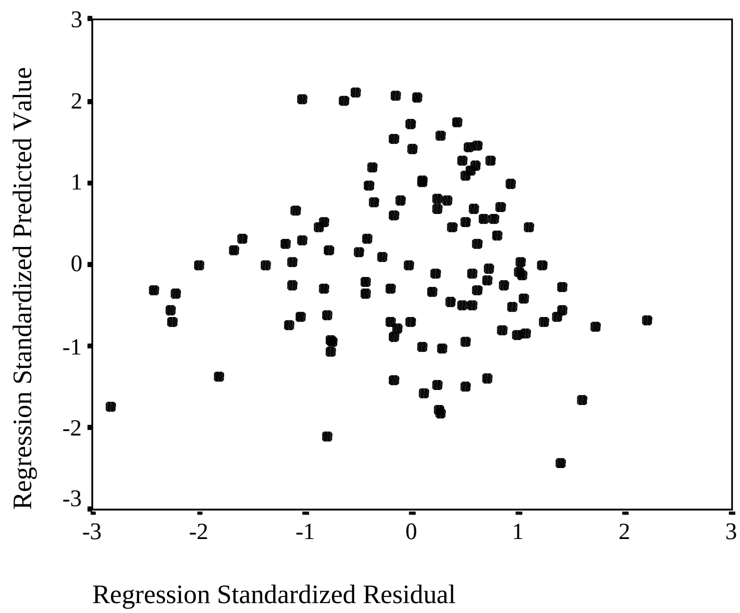


Dependent Variable: Percent Score on First Unit Examination

NORMAL P-P PLOT OF REGRESSION STANDARDIZED RESIDUAL



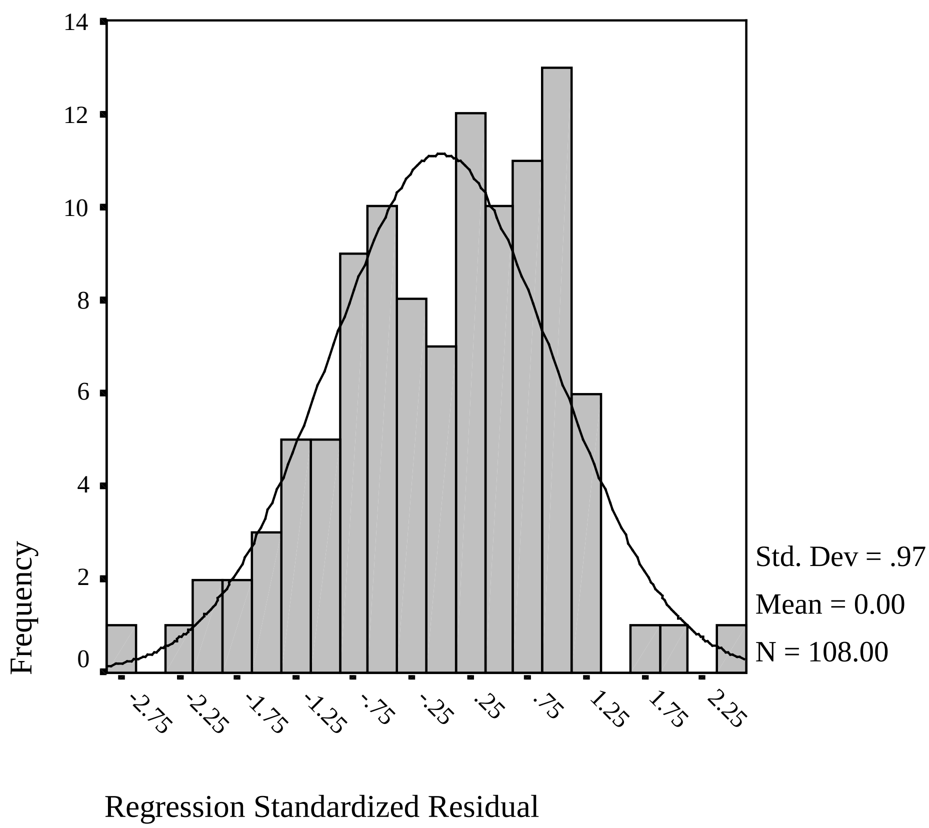
SCATTERPLOT



HISTOGRAM OF REGRESSION STANDARDIZED RESIDUALS

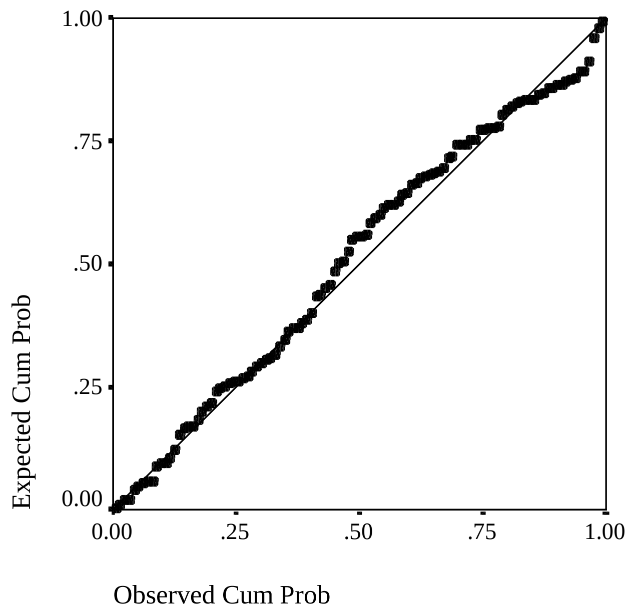
Dependent Variable: PERCENT SCORE ON SECOND UNIT EXAMINATION

Independent Variables: Absence at 8th Week, Age, %EA, Day/Evening, Ethnicity, Format of EA Instruction

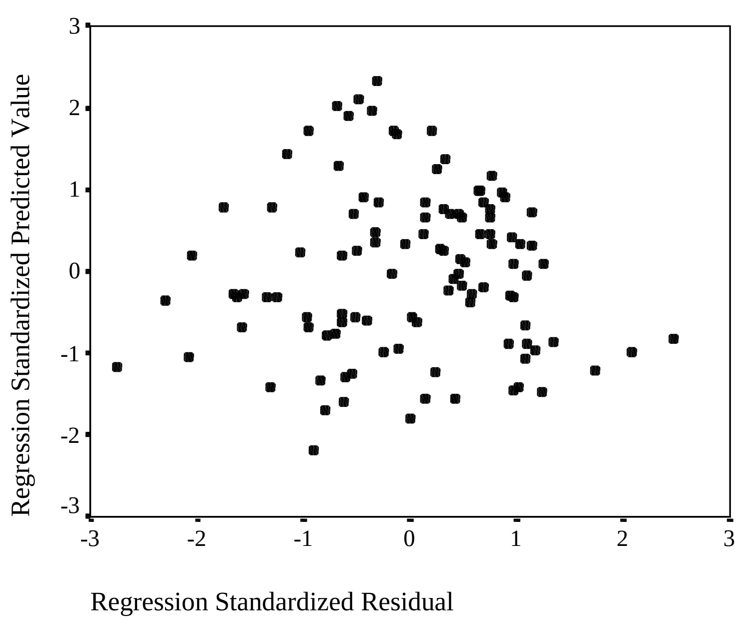


Dependent Variable: Percent Score on Second Unit Examination

NORMAL P-P PLOT OF REGRESSION STANDARDIZED RESIDUAL



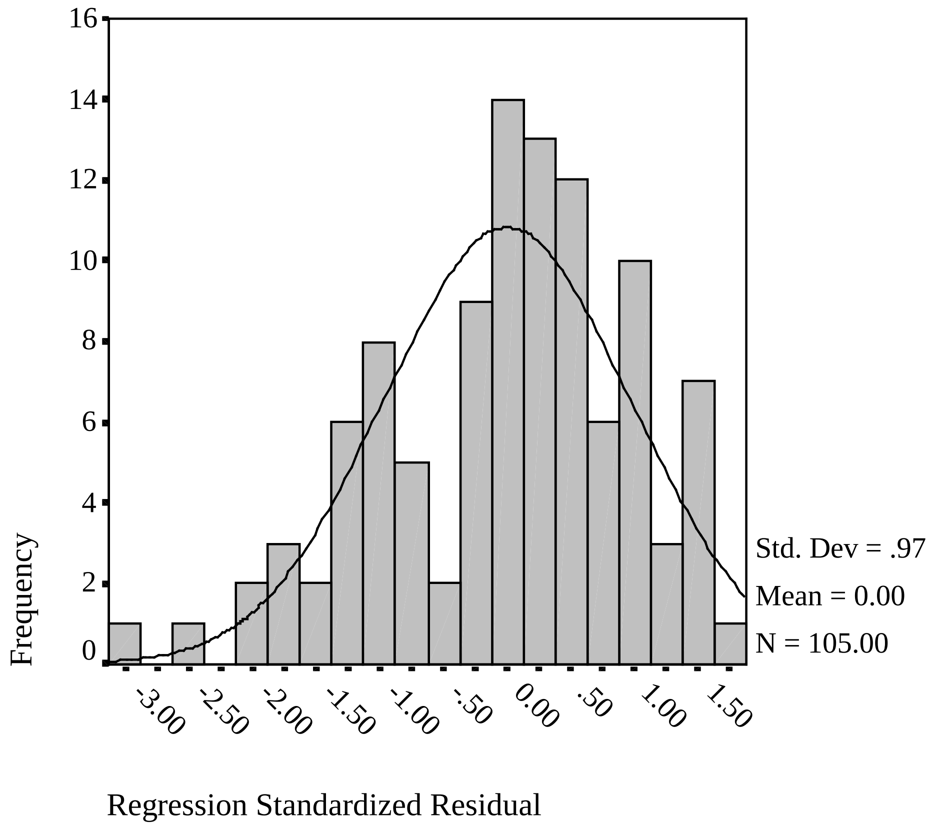
SCATTERPLOT



HISTOGRAM OF REGRESSION STANDARDIZED RESIDUALS

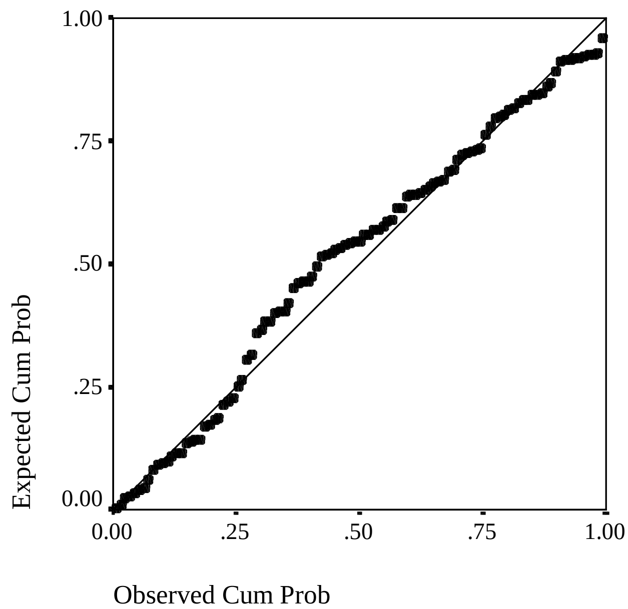
Dependent Variable: PERCENT SCORE ON THIRD UNIT EXAMINATION

Independent Variables: Absence at 8th Week, Age, %EA, Day/Evening, Ethnicity, Format of EA Instruction

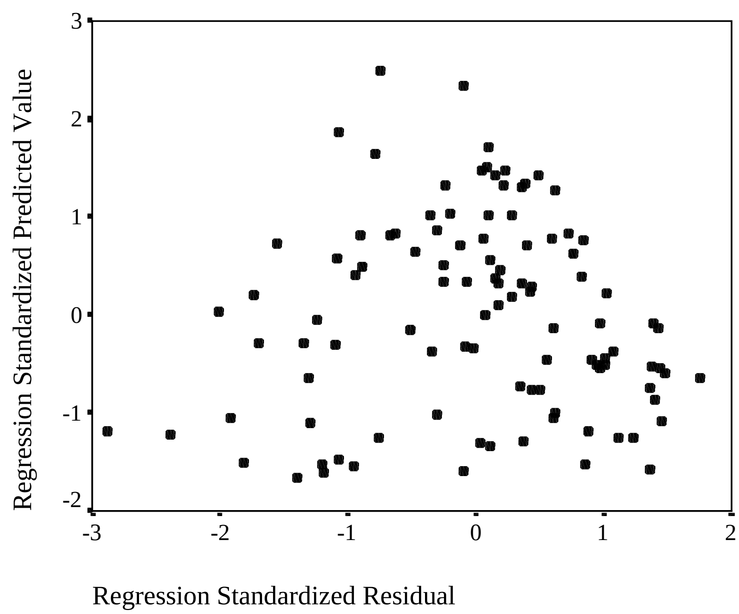


Dependent Variable: Percent Score on Third Unit Examination

NORMAL P-P PLOT OF REGRESSION STANDARDIZED RESIDUAL



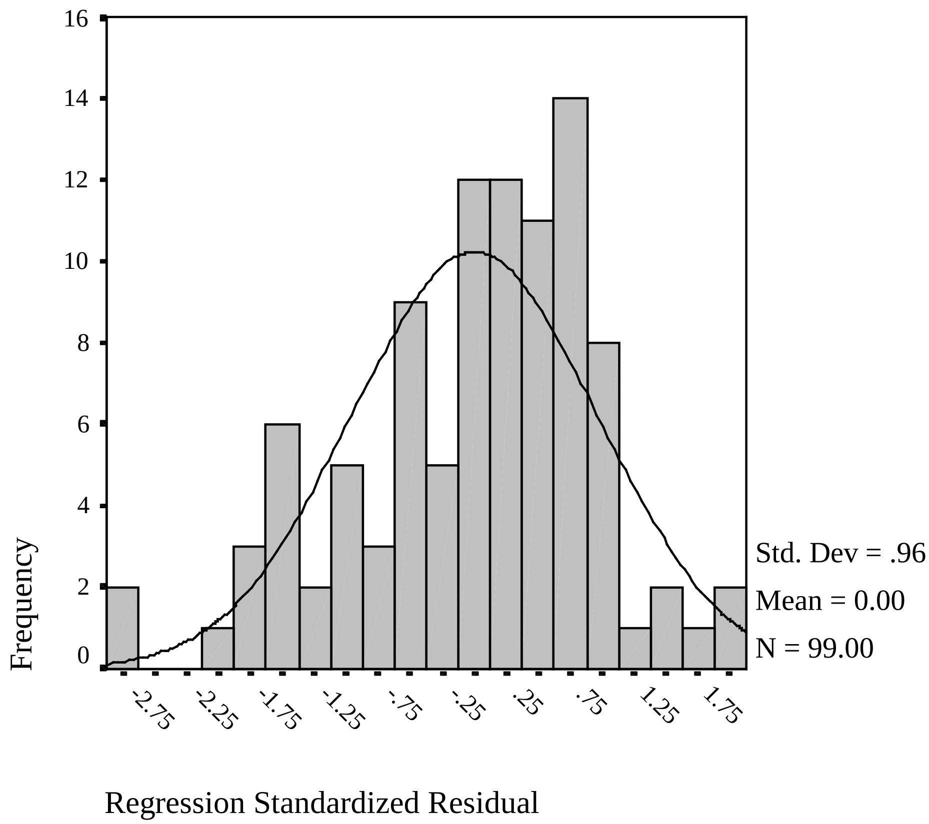
SCATTERPLOT



HISTOGRAM OF REGRESSION STANDARDIZED RESIDUALS

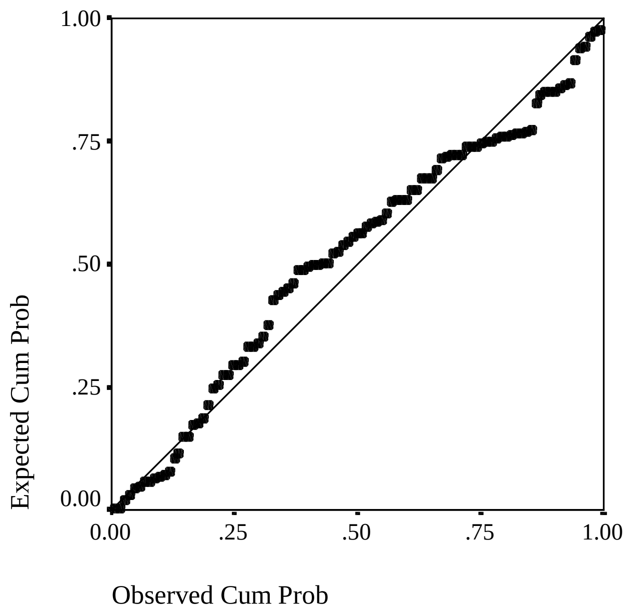
Dependent Variable: PERCENT SCORE ON FOURTH UNIT EXAMINATION

Independent Variables: Absence at 8th Week, Age, %EA, Day/Evening, Ethnicity, Format of EA Instruction

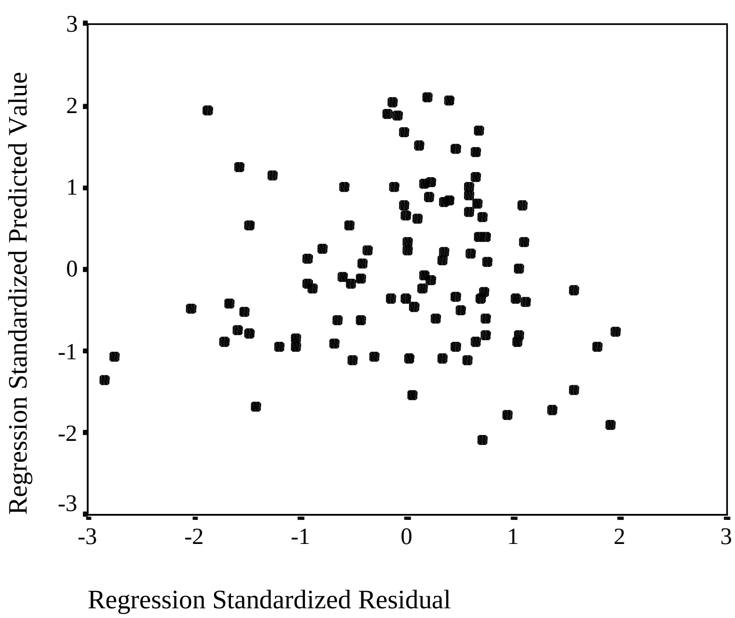


Dependent Variable: Percent Score on Fourth Unit Examination

NORMAL P-P PLOT OF REGRESSION STANDARDIZED RESIDUAL



SCATTERPLOT



APPENDIX H

WRITTEN RESPONSES FROM THE JULY

INTERMEDIATE ALGEBRA FOCUS GROUP

1. **Circle the classes you completed in a computer-based instructional class.**

   Three students had not taken a CBI class.

   Many students had multiple responses. Ten students completed the survey.

   060 (n = 2) 061 (n = 3) 064 (n = 4) 065 (n = 4) 067 (n = 2)

2. **What do you think were some of the benefits of computer-based instruction?**

   - You can go at your own pace. (3 responses)
   - Easy to go back and review. It explains your mistakes and step-by-step instructions.
   - *Ability to take quizzes more than once.*
   - Was not as happy with the computer-based programs.

3. **What experiences in elementary algebra (064/5 or 067) best prepared you for intermediate algebra?**

   - Functions & Statistics [a local high school class]
   - The classes are both review classes so I have seen the material before, but I need to freshen up with it in my head.
   - They covered some of the material that is also in intermediate algebra.
   - Review of everything that we are learning now.
   - The hardest sections, i.e. word problems, complex fractions, and equations with multiple variables.
   - Material
   - Quadratic equations/linear functions

4. **Was there anything about the instructional strategies used in elementary algebra (064/5 or 067) that you didn't like and are there any changes you would recommend?**
   - I like the problems to go slow so I can figure them out step by step.
   - It would be nice if the instructors would take time to lecture on the most difficult sections.
   - I would bring more helpers or instructors to help with questions.
   - Did not like the fact that you could not go back over work on computer as you can in a teacher-based class. Did not like the computer classes at all. Not enough staff – should not have to wait to have questions answered.
   - Yes – most of the quiz questions were not on the test.
   - Keep practicing problems (CBI) – some problems making transition.

5. **What adjustments did you make (if any) to adapt to MATH-070?**
   - I took this class last semester and I went into the final with a C but the final had questions that I had never seen so I failed.
   - Minimum studying. I had to study to freshen up on basic math and learn some stuff I didn't remember. I had to learn to use a graphing calculator.
   - I did not have time to adapt to 070 because 065 and 070 came so close together.
   - More notes than any previous class.
   - Lack of computer-based lessons.
   - None. Math 070 is much easier to understand because it's taught all the way through by staff member.
   - Lot of study since no computer.

6. What aspects of the intermediate algebra course did you have difficulty with?

- Exponents, using the calculator.
- Graphing and forming equations by the paragraph.
- The section on exponential powers, graphing.
- The compacted work/class schedule makes absorbing the information difficult.
- Summer course so it just went by too quickly.
- Functions/domain/range.

Were these difficulties related to the instructional format of MATH-070?

No (for all above responses).

APPENDIX I

WRITTEN RESPONSES FROM STUDENTS IN THE SEPTEMBER FOCUS GROUP ON COMPUTER-BASED INSTRUCTION.

1. For each class that you have taken indicate whether it was computer-based instruction.

a. 060 (*n* = 2 CBI)
b. 064 (*n* = 10 CBI)
c. 067 (*n* = 2 CBI)
d. 061 (*n* = 12 CBI)
e. 065 (*n* = 4 CBI)
f. 070 (*n* = 3 TLI)
g. 131 (*n* = 1 TLI)

Comments: Students starting in 060 or 061 take 064 & 065 and then 070 (intermediate algebra). 067 was a review course for students who place at the elementary algebra level.

2. What do you think are some of the benefits of computer-based instruction?

- Work at own pace
- If your teacher is not in you can always use the computer.
- You can go back to the lesson
- I think it might be a little bit more easier to concentrate.
- Self taught; your own pace
- The benefits of computer-based instructions was(sic) that if you did not understand directions you were able to replay the computer again and again till u understand.
- That you can go over the material over and over again if you didn't understand it. Work at your own pace.
- You can go at your own pace

- It lets you go at your own pace, to a degree
- If you can't understand the work from the computer instruction, you also have a teacher to explain, so you have 2 ways of looking at the problem.
- Student can work at their own pace
- You can move at your own pace
- You get to finish on your own time and work as long as you need to.
- The reviews they give after you study a lesson is perfect.

  Comment: The same reviews are given to the TLI classes.

3. **Do you think each math course prepares you for the next math course? Can you think of any examples?**
   - Yes, I think so.
   - Yes
   - I have taken 061, 064 and 065 and all of them have prepared me for the next level.
   - Yes, every class is a building block for the next.
   - I think it prepares you for the simple fact in 061 I saw we had to stop at chapter 13, because the next chapters were for the next class you would be taking next year.
   - I took 061 during the spring semester now I am in 064 this fall and I had forgotten a lot of what I had learned in 061 so I think that before 064 starts there needs to be a review.
   - Yes, somewhat b/c the beginning of the next math class starts off from the end of the previous class.
   - No…most things I learn I tend to have to re-learn next semester.
   - Yes, gives you every formula.
   - I think the math courses do prepare you for the next course.
   - Yes, 061 prepares me for 064 cause it got me used to working on the computer.

- 060 prepared me for 061 very well.
- Yeah! Because when I finish 061 and started 064, it use some of the example in 064 from 061 to help me.
- Yes, they started where the last one ended

4. What changes would you make to your math courses?

- That you should have a teacher teaching all classes except for a computer. Because the computer cannot tell you specific details.
- That it wouldn't be so many developmental classes.
- I would not make any changes
- A mixture of student self-taught on the computer / teacher instruction!!
- I think that there needs to be a review when you go from 061 to 064 because things are forgotten and it's frustrating.
- I guess you just add a little bit more time to the class period.
- Move away from 'deadlines' make the schedule more open-ended so people get time to actually learn things before we have to rush to take the next exam.
- More time
- I would like to change the math quizzes for computer-based
- None
- The certificates you have to do.
- No
- Maybe you can have a half-hour after class that you can stay if you want and work with the teacher.

5. What changes did you have to make to do well in the computer-based class?

- Work in lab on Fridays, get a tutor.

- Get help from the teacher.
- None = 3
- I really did have (not) to make any changes.
- More studying!! Notetaking. More of everything!
- Spend time in lab.
- Just try to stay on task but go at a fast enough pace where can learn and get through it fast enough to stay on task.
- Not many…just got to liking the systems and its open-ended approach.
- Put in more class time.
- I had to get used to coming in on open lab days to catch-up on what I missed.
- Study more, put more time in to complete lessons.
- Come to class on time and do everything by the time of the deadline

6. What changes did you make to do well in a teacher-led class?

- Get a tutor
- Stay after for more help
- I have to try to stay more focused
- N/A = 3
- I haven't took a teacher-led class since high school
- Haven't been in one of those classes yet.
- Come to class on time and be prepared to listen to what the teacher is saying.

REFERENCES

ACCUPLACER: Computerized Placement Tests (1997, Version 5.31R) [Computer Software] Princeton, NJ: College Entrance Examination Board and Educational Testing Service.

Adelman, C. (1998). The kiss of death? An alternative view of college remediation. *National Crosstalk, 6*(3), 11.

Bailey, C., & Chambers, J. (1993). Interactive learning and technology in the US science and mathematics reform movement. *British Journal of Educational Technology, 27*(2), 123-133.

Bloom, B. (1968). *Mastery learning.* (Evaluation Comment 1, Occasional Report #2). Los Angeles. University of California at Los Angeles, Center for the Study of Evaluation of Instructional Programs.

Boylan, H.R. (2002). *What works: Research-based best practices in developmental education.* Boone, NC: Continuous Quality Improvement Network with the National Center for Developmental Education, Appalachian State University.

Boylan, H.R. (1999). Developmental education: demographics, outcomes, and activities. *Journal of Developmental Education*, *23*(2). 2-9.

Bracey, G. W. (1999). Getting along without national standards. *Phi Delta Kappan, 80*, 548-549.

Cavalier, J.C. & Klein, J.D. (1998). Effects of cooperative versus individual learning and orienting activities during computer based instruction.

Educational Technology Research & Development, 46(1), 5-17.

Culross, R. (1996). Remediation: real students, real standards. *Change, 38*(6), 50-52.

Data summary of the May and September 2002 bridge goals test administrations. (2003, February 3). Paper presented at the Bridge Goals Task Force Meeting, Baltimore, MD.

Feldman, M.J. (1995). The relationship between passing basic skills courses and passing regular college courses. *Journal of Applied Research in the Community College, 3*(1), 55-64.

Fletcher, J. (1990). *Effectiveness and cost of interactive videodisc instruction in defense training and education.* Washington: Institute for Defense Analyses I.D.A. Paper D-2372.

Gerlic, I., & Jausovec, N. (1999). Multimedia differences in cognitive processes observed with EEG. *Educational Technology Research & Development, 47*(3), 5-14.

Gurney, P.J. (1996). Grade 9 mathematics in the computer lab: An introductory study. *McGill Journal of Education, 30*, 83-101.

Hinkle, D.E., Wiersma, W., & Jurs, S.G. (1998). *Applied statistics for the behavioral sciences.* Boston, MA: Houghton Mifflin.

Ikenberry, S. O. (1999). The truth about remedial education. *Community College Journal, 69*(5), 8.

Johnson, L.F. (1996). Developmental performance as a predictor of academic success in entry-level college mathematics. *Community College Journal of Research and Practice, 20,* 333-344.

Kalman, R. (1994). Future classrooms: a personal vision. *Mathematics Teacher, 87,* 486-487.

Keller, F. S. (1968). Good bye teacher… . *Journal of Applied Behavioral Analysis, 1*(1), 79-89.

King, M.C., & Crouse, T.T. (1997). Opening the bottleneck – using computer-mediated learning to increase success and productivity in developmental algebra. *Community College Journal, 67*(7), 18-22.

Kinney, D.P. (2001). Developmental theory: Application in a developmental mathematics program. *Journal of Developmental Education, 25*(2), 10-18.

Kinser, P.A., Morris, Jr., C.C., & Hewitt, C.L. (1997). *A demonstration and discussion of computer-based instruction designed to enhance student success and retention*. Mountain View, CA.: Academic Systems.

Kitz, W. R., & Thorpe, H.W. (1995). A comparison of the effectiveness of videodisk and traditional algebra instruction for college-age students with learning disabilities. *Remedial and Special Education, 16,* 295-306.

Kulik, C., & Kulik, J.A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior, 7,* 75-94.

Kull, K.R. (1999). A developmental education survey: results of a national survey of program design and mathematics instruction. *Education, 120,* 69-78.

Levin, H., & Koski, B. (1999). Raising the bar in developmental education.

Change, 31(1), 57-61.

Lomax, R.G. (1998). *Statistical concepts: A second course for education and the behavioral sciences*. Mahwah, NJ: Erlbaum.

Maryland Business Roundtable For Education (2001). *Maryland workforce educational needs assessment survey*. Retrieved November 15, 2002, from http://www.mbrt.org/workfcsurv2001.htm

Maryland State Department of Education (2003, August 26). *State board refines plans for high school assessments: Board in December will discuss making HSA passage a graduation requirement for class of 2009.* Retrieved October 8, 2003, from http://www.msde.state.md.us/pressreleases/ 2003/august/2003_0826b.htm

Mayer, R.E., & Moreno, R. (1998). A split-attention effect in multimedia learning: evidence for dual processing systems in memory. *Journal of Educational Psychology, 90*, 312-320.

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

ModuMath: Basic Math (2000,Version 1) [Computer Software]. Waunakee, WI: Wisconsin Technical College System Foundation

ModuMath: Algebra (2000,Version 2) [Computer Software]. Waunakee, WI: Wisconsin Technical College System Foundation

National Center for Education Statistics. (1996). *Remedial education at higher education institutions in fall 1995.* (NCES 97-584) by Laura Lewis and Elizabeth Farris. Project Officer, Bernie Greene. 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. (2000). *Principles and standards for school mathematics* . Reston, VA: Author.

One statistical measure of how a college education tends to repair damage from the past. (1996, Autumn). *The Journal of Blacks in Higher Education, 13*, 5.

Oxford, L., Proctor, K., & Slate, J.R. (1998). Computer-based instruction and achievement of adult learners. *The Michigan Community College Journal*, *4*, 77-84.

Pedhazur, E.J. (1997). *Multiple regression in behavioral research: Explanation and Prediction.* Orlando, FL: Harcourt Brace.

President's Committee of Advisors on Science and Technology. (1997). *Report to the President on the use of technology to strengthen K-12 education in the United States.* Washington, DC: Executive Office of the President of the United States.

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

Schrag, P. (1999). End of the second chance? *The American Prospect*, *10(44)*, 68-77.

Skinner, B.F. (1954). The science of learning and the art of teaching. *Harvard Educational Review*, *24*, 86-97.

Smith, S. (1999). Invisible Men. *Black Issues in Higher Education, 16*(9), 14-18.

SPSS 11.0 Online Tutorial (2001). Retrieved August 6, 2003, from file://C:\Program%20\SPSS\tutorial\spssapp\glmu_work_homslopes_01.htm

Stewart, C. (1999). *Comparison of Math-061 course performance for students using the ModuMath program versus students using the Prentice Hall Interactive Math program.* Unpublished manuscript, Howard Community College.

Szabo, M., & Poohkay, B. (1996). An experimental study of animation, mathematics achievement, and attitude toward computer-assisted instruction. *Journal of Research in Computing Education, 28*(2), 390-402.

Tabachnick, B., & Fidell, L. (2001). *Using multivariate statistics.* Needham Heights, MA: Allyn & Bacon.

The Institute for Higher Education Policy. (1998). *College remediation: What it is, what it costs, what's at stake.* Washington, DC: The Institute for Higher Education Policy, December.

Trilling, B., & Hood, P. (1999). Learning, technology and education reform in the knowledge age or "We're wired, webbed, and windowed, now what". *Educational Technology, 39*(3), 5–18.

Warr, A., Curtis, C., & Slingerland, P. (2001) *An intermediate course in algebra: An interactive approach.* Philadelphia, PA: Harcourt.

Welsh, T. M. (1999). Implications of distributed learning for instructional designers: how will the future effect practice? *Educational Technology 39*(2), 41-45.

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

Young, J.B. (1998, February 20). Students dislike Va. Tech math classes in which computers do much of the teaching. *The Chronicle of Higher Education*, p. A32-A33.

Zeiss, T. (1999). Skills certification: A major opportunity for community colleges. *Community College Journal*, *70*(1), 14-17.