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ABSTRACT

This study explored the effects of the use of laboratory activities on students' attitudes and retention in a community college preparatory mathematics course. It also examined whether the use of numerical, analytical, and graphical methods of solution in preparatory classes would affect student retention in the succeeding algebra course. The study took place on two campuses of a metropolitan community college. Faculty on each campus taught a four-hour college preparatory mathematics course with a required one-hour laboratory component. At one campus, commercially produced puzzles, group activities, experiments, and data collection activities were used in the laboratory hour; at the other campus, a faculty-produced packet of activities that included skill worksheets and some group activities were used. At the end of the semester, students' attitudes about mathematics and their mathematical abilities were measured. Performance on a 20-question test measured to what extent the material was retained by the students. Findings included: the addition of the one-hour lab to the math class increased course retention rates; no differences were found in retention rates or student attitudes toward mathematics between the students that used the different types of laboratory materials; and the use of laboratory activities in the preparatory mathematics course improved retention rates in the subsequent algebra course. Five appendices are attached. (CAK)

A STUDY OF STUDENT RETENTION AND ATTITUDES IN A COMMUNITY COLLEGE PREPARATORY MATHEMATICS COURSE

by

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ABSTRACT

This research explored the effects of the use of laboratory activities on students' attitudes and retention in a community college preparatory mathematics course, College Preparatory Mathematics II. The study also examined the possible effects of the use of numerical, analytical, and graphical methods of solution in the college preparatory mathematics course on retention in the college-level mathematics course, College Algebra.

This study took place on two campuses of a metropolitan community college. Faculty on each campus taught a 4-hour college preparatory mathematics course with a mandatory 1-hour laboratory component. One campus used a commercial product for the laboratory hour which included puzzles, group activities, experiments, and data collection activities. The other campus used a packet of activities developed by instructors on the campus which included skill worksheets and some group activities. At the end of the semester, students' attitudes about the usefulness of mathematics, attitudes towards confidence in mathematics, and motivation towards mathematics were measured using the Fennema-Sherman Mathematics Attitudes Scales. Performance on a 20-question test measured what material was learned and retained by the students on each campus.

Retention rates of the students, in the college preparatory mathematics course, were compared by campus and gender. Retention rates in the succeeding course, College Algebra, were compared by campus and previous mathematics course attended at the community college.

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CHAPTER 1

INTRODUCTION

Mathematics educators are continually in search of techniques to improve the learning of mathematics. In Goals for School Mathematics: The Report of the Cambridge Conference on School Mathematics (1963), the recommendation is made that "Mathematical education, to fulfill the needs of an advanced and advancing community, must be under continual scrutiny and undergo constant change, and it is the responsibility of all mathematicians, working in university, school, or industry, to concern themselves with the problem of keeping mathematical education vital and up-to-date." (p. 1) Since 1983, with the publication of A Nation at Risk (National Commission on Excellence in Education, 1983), many recommendations have been made for curricular, instructional and assessment changes throughout all levels of mathematics education.

The National Council of Teachers of Mathematics (NCTM, 1989) published the Curriculum and Evaluation Standards that provided comprehensive recommendations for innovative approaches to curriculum and instruction. This document led the way for curricular reform in grades K-12. The Standards describe classrooms as "places where interesting problems are regularly explored using important mathematical ideas. The premise is that what a student learns depends to a great degree on how he or she has learned it." (p. 5) Several goals are listed in the Standards. These include: (1) learning to value mathematics, (2) becoming confident in one's own ability to do mathematics, (3) becoming a mathematical problem solver, (4) learning to communicate mathematically, and (5) learning to reason mathematically. These goals are to be met by giving students an opportunity to explore the relationships between mathematics and other disciplines as well as an opportunity to realize that mathematics is a part of everyday life. In the process of solving problems, students should be encouraged to make conjectures and to use varying methods to try to find solutions. Classroom activities should provide students with opportunities to read, write, and speak mathematics.

In 1995, the American Mathematical Association of Two-Year Colleges (AMATYC) published Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus in an effort to specifically address the needs of college students who are either unprepared for college level mathematics or who do not plan to pursue careers that require calculus-level mathematics. This document sets standards for curriculum and pedagogy in introductory college mathematics courses. Several principles of this document are: (1) students should grow in their knowledge of mathematics while attending college, (2) the mathematics studied should be meaningful and relevant, and (3) mathematics should be taught as a laboratory discipline. These standards emphasize problem solving, intuitive understanding, the use of technology, and cooperative learning strategies throughout the mathematics curriculum. Recommendations include learning mathematics through modeling real-world situations, acquiring the ability to read, write, listen to, and speak mathematics, and using appropriate technology to enhance mathematical thinking. The NCTM and AMATYC standards suggest similar changes and improvements to the mathematics curriculum.

The NCTM (1991) Professional Standards for Teaching Mathematics recommend that a teacher of mathematics create a learning environment that encourages mathematical power in each student by providing the time needed to explore mathematics and work with important ideas and problems and by providing an environment that respects and values each student's ideas. The teacher should expect and encourage students to work independently and cooperatively on mathematics projects, to take risks by raising questions, and to display a sense of mathematical competence. These suggestions provide a basis for teachers who are trying to implement these standards into the classroom in order to have students think critically and actively participate in the learning process. They recommend that teachers include exploration, writing exercises and cooperative learning activities into courses to promote understanding of the concepts. There are similar suggestions in the AMATYC standards.

In order to implement the recommendations of AMATYC and NCTM, a mathematics teaching faculty must include instructional techniques such as cooperative learning, discovery methods, and laboratory activities into their teaching repertoire. Strategies to promote student understanding and success must be devised and implemented into the mathematics curriculum. For example, one recommendation of the AMATYC (1995) standards is that, "students will represent mathematical situations symbolically and use a combination of appropriate algebraic, graphical, and numerical methods to form conjectures about the problems."(p. 13)

The Research Problem

In a survey done by the Conference Board of the Mathematical Sciences in 1990, it was found that 56% of students studying mathematics in two-year college mathematics departments were studying at the remedial level (AMATYC, 1995, p. ix). At a central Florida metropolitan multi-campus community college, from 1996-1998, it was found that 67% of first-time in college students had enrolled in at least one college preparatory mathematics class. Withdrawal and failure rates from the college preparatory mathematics classes ranged from 50% to 60%. In an effort to improve retention and to implement the recommendations of the NCTM and AMATYC standards, the mathematics faculty undertook a major curriculum revision process.

This revision process began in late 1995 with a recommendation by a committee to examine the first college level course, College Algebra (MAC 1104). The committee suggested that the course could not be adequately revised unless all of the college preparatory mathematics courses also underwent revision. At that time, the curriculum consisted of three courses preceding the college-level courses: Introductory Mathematics (MAT 0003), Elementary Algebra (MAT 0024), and Intermediate Algebra (MAT 1033).

During the fall semester of 1995, it was determined by faculty that there were several problems with the curriculum. There was a large overlap in the content taught in each course, and sufficient time was not being spent on developing new skills and concepts. Additionally, the algebra and trigonometry courses did not seem to be adequately preparing students for the calculus sequence, which incorporated numerical, analytical, and graphical methods of solution. A college-wide meeting of the mathematics faculty determined that the curriculum should be rewritten from the beginning.

The new curriculum involves four courses which were designed by the Mathematics Task Force consisting of sixteen mathematics department faculty members representing all campuses of the institution. The task force determined what content should be in each course. During the spring of 1996, four sub-committees were formed to develop the course outlines for College Preparatory Mathematics I (MAT 0020), College Preparatory Mathematics II (MAT 0025), College Algebra (MAC 1105), and Precalculus (MAC 1142). In August 1996, a college-wide meeting was held to present the course outlines and vote on the implementation of the new courses. The results of this vote are shown in the table below.

Table 1

Results of the vote to implement the new mathematics courses

COURSE	YES	NO	ABSTAIN	TOTAL
MAT 0020	42	0	4	46
MAT 0025	42	0	4	46
MAC 1105	41	3	2	46
MAC 1142	44	0	2	46

All of the new course objectives incorporate the recommendations of the NCTM and AMATYC standards. The course outlines stress the importance of solving problems using numerical, analytical, and graphical methods. The objectives also include writing assignments, real data applications, and the use of appropriate technology. (See Appendices A and B.) The college preparatory courses include a required one-hour laboratory component to promote the use of data collection activities, cooperative learning, and discovery techniques into the curriculum.

Since a majority of students at the community college enroll in College Preparatory Mathematics II and these students must be prepared to take college-level courses, this research focused on the effectiveness of this particular course. The purpose of this study was to examine the implementation of new treatments in college preparatory courses to see if these treatments led to a higher retention rate among students in those courses and in the first college level course. Also, this researcher wanted to determine if students with laboratory experience have improved attitudes towards mathematics, as well as if the laboratory component allows students the opportunity to explore and make connections between mathematics, other disciplines, and the "real" world.

Research Questions

The researcher examined the following questions:

1. Does the use of laboratory activities influence student retention in a college preparatory mathematics class?
2. Does the use of laboratory activities and cooperative learning activities influence student attitudes in a college preparatory mathematics class?

3. Does the type of laboratory activities affect what a student learns and retains?
4. Does the addition of laboratory activities and the use of numerical, analytical, and graphical methods in the college preparatory mathematics classroom affect student retention in college level mathematics classes?

Significance of the Study

Analysts predict that, by the year 2000, three out of four jobs will require some form of post-secondary education. According to the report by the U.S. Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS, 1991), more than half of the United States young people leave high school without the knowledge or foundation to find and hold a good job. The SCANS report was designed to be used to help make courses relevant to the needs of a modern workforce and to help employers ensure that their employees possess up-to-date skills. A major emphasis of the SCANS (1993) documents is teaching skills in context. This implies that students should be provided with opportunities to apply knowledge in real life situations or simulations. Students should also work together on problems, be more actively involved, and be more responsible for their own learning in order to function as they will be expected to in the workplace (SCANS, 1991). In a survey of employers, it was found that academic skills, such as oral and written communications, reading, and basic mathematical computations and personal management skills, such as responsibility, dependability, enthusiasm , and teamwork skills were judged to be important employee characteristics (SCANS, 1993).

According to Vaughn (1995), the community college achieves its mission and gives meaning to its beliefs of open access, comprehensiveness, commitment to teaching and lifelong learning through college transfer programs, occupational-technical programs, developmental education, and community education programs. Community colleges offer the academic skills which facilitate the transition from classroom to workplace to meet the requirements of new jobs or the changing demands of employers. Because community colleges are operated locally, they can not only be sensitized to local job market needs, but they are also able to respond quickly to those needs (O'Banion, 1994). Many small businesses do not have their own training programs and rely on the community college to provide the training for their employees. Today's workers need "to possess an intellectual framework to which new knowledge can be added. This framework grows when learners on every level are offered access to ideas and not simply drilled in tasks: when they are led through mathematical experiences that require more than memorization; when they explore the meaning of what they read or do or design; when they are encouraged to write" (Griffith & Connor, 1994, p. 88).

There are several reasons to develop a successful college preparatory mathematics program. College preparatory mathematics courses help students to strengthen their basic academic skills which are fundamental for employment in the information age. Students need the opportunity to be successful in these courses since the demands for increased accountability has led the state of Florida to pass legislation that restricts enrollment in these courses to three attempts per student. Evaluation of developmental education is a strong component in the process of determining if programs and courses are accomplishing their goals. Weissman, Bulakowski, and Jumisko (1997) recommend examining several outcomes to access the effectiveness of a developmental program. These include: (1) Do students complete developmental education successfully? (2) Do students move from developmental education to college-level courses? and (3) Are students who have taken developmental courses completing college level courses successfully? This study examined these outcomes and others.

Definition of Terms

Analytic Scoring Rubric--An evaluation method that assigns point values to each of several phases of the problem solving process (Charles, Lester, & O'Daffer, 1987).

College Algebra (MAC 1105)--A lower division mathematics course offered at community colleges and universities in Florida. The course is taught through a functions approach to algebra. Topics include linear, quadratic, rational, radical, exponential, logarithmic, and power functions. Topics are taught through the use of numerical, analytical, and graphical methods. The course includes data collection and analysis. Graphing calculators are required at the institution in this study. (See Appendix A.)

Attitudinal survey--The survey referred to in this study consists of three Fennema-Sherman Mathematics Attitude Scales and additional questions developed by faculty at the community college of the study. (See Appendix C.)

College Preparatory Mathematics II (MAT 0025)-- A continuation of College Preparatory Mathematics I. Algebraic skills for MAC 1105 are presented. Topics include operations on polynomials, linear equations, quadratic equations, rational expressions and equations, radical expressions, computation and approximation using a scientific calculator, and an introduction to functions. Applications emphasizing connections with other disciplines and the "real" world are included. This course is not applicable toward mathematics requirement in general education or toward any associate degree. (See Appendix B for course outline.)

Effectance Motivation-- The student's attitude toward solving problems. "Effectance motivation is similar to problem solving attitude, an attitude not believed to be associated as highly with women as with men" (Fennema-Sherman, 1976, p.5).

Evaluation--The systematic collection of evidence to determine whether, in fact, certain changes are taking place in the learners, as well as to determine the amount and degree of change in individual students (Hart, 1994).

Laboratory activities--Activities that are completed in the one-hour laboratory component of MAT 0025. These may include worksheets, cooperative group projects, experiments, application problems, or other activities determined by the instructor of the course.

Regular classroom sections--Sections that do not include the use of computer-assisted instruction, self-paced classes, or classes that were employing other experimental techniques.

Retention (Successful)--Enrollment that continues until the conclusion of a course (Jones, 1992). In this study success refers to students completing the course with a grade of A, B, or C.

Retention (Success) rate--the percentage of students that complete a course with the required grade to continue to the next higher course.

Limitations

1. There was only one institution involved in the study. The course outlines were specific to the institution.
2. Faculty teaching the course were learning how to implement the new teaching techniques.
3. Faculty were still experimenting with different laboratory activities to determine which were appropriate and useful in the instruction process.

Assumptions

1. The use of the Fennema-Sherman Attitude Scales was appropriate for community college students.
2. Faculty trained to use the analytic scoring rubric assessed the exam questions consistently.
3. Faculty on each campus used the materials provided for the laboratory section of the course.
4. Students had no preconceived opinions about the use of laboratory activities.

CHAPTER II

LITERATURE REVIEW

COMMUNITY COLLEGES

Community colleges began in the early 1900's as extensions of high schools (O'Banion, 1989; Vaughn, 1995; Witt, et al., 1994). The initial purpose of these early institutions was two-fold. The populists wanted to have better access to higher education and the elitists wanted to guard the entrance to the universities by having students complete general education requirements before being admitted. Both groups realized that these new institutions could provide vocational skills and general education to a large segment of the population.

During the 1960's, community colleges experienced a period of rapid growth. The open-door concept became a very important policy for those wishing access to higher educational opportunities. This led to a new group of post-secondary students which included high school dropouts, adult students returning to college, and students with marginal academic achievements. The wide diversity of the students forced most community colleges to develop remedial programs in basic mathematics, grammar, and study skills to meet the students' needs (Witt, et al., 1994).

Community colleges have a three-part mission: preparing students for transfer to a four-year institution, providing vocation training, and providing continuing education opportunities for the community they serve. According to Vaughan (1995), the missions of community colleges are shaped by the following:

- a commitment to serving all segments of society through an open-access admissions policy that offers fair and equal treatment to all students;
- a commitment to a comprehensive educational program;
- a commitment to serving its community as a community-based institution of higher education;
- a commitment to teaching; and
- a commitment to lifelong learning (p. 3).

The majority of community college students attend part-time, are employed, are older than their university counterparts, are first-generation college attendees, and are often underprepared for college-level courses (O'Banion, 1994). Many come from the lower socio-economic levels, score lower on measures of self-esteem, and are unsure about their educational goals (O'Banion, 1994). The community colleges commitment to open-access requires that remedial courses be offered to those students who enroll and do not have the basic skills necessary to pursue their educational dreams.

Although most community colleges teach many levels of mathematics courses, well over half the enrollments are in courses teaching pre-algebra, introductory algebra, college algebra and/or at the developmental or remedial level (Cohen, 1985). These courses can be instrumental in assisting students to meet their educational goals.

Tucker (1985) suggests that, "Two-year colleges suffer the most from the problems in the current curriculum and may be the best place to initiate change." (p.31) The question becomes, "How should the current curriculum be altered or adapted to meet the needs of students?"

CURRICULAR REFORM

In changing the mathematics curriculum at the college level, the faculty should "make introductory courses more attractive and effective, restore integrity to the undergraduate program, lecture less; try other teaching methods, link scholarship to teaching" (National Research Council, 1989, p. 94). Mathematics instruction has been studied by cognitive scientists, mathematics educators, and mathematicians to find a means to positively impact the educational practices used in teaching mathematics to make the process more effective (Jones, 1992). Professional organizations such as the National Research Council, Mathematical Association of America (MAA), National Council of Teachers of Mathematics (NCTM), and the American Mathematical Association of Two-Year Colleges (AMATYC) have made suggestions for changes at all levels of the mathematics curriculum.

Background

During the early 1900's, research in algebra focused primarily on the relative difficulty of solving various kinds of linear equations. Researchers gave the subjects timed equation-solving tests and then reported the number of attempts and the number of correct solutions. This research was based on Thorndike's prescriptions for teaching algebra, which included consideration of which connections should be made, the amount of practice students should have, and how the practice should be distributed (Kiernan & Wagner, 1989).

The influence of the socio-economic conditions during the Great Depression and World War II caused the largest number of changes to the algebra curriculum from 1930 to 1950. The curriculum became more practical and vocationally oriented. A growing interest of psychologists in individual differences led to a more child-centered focus in the classroom. Compulsory school attendance led to high schools lessening graduation requirements and developing more elective courses. Consumer mathematics was developed during this time to appeal to the majority of the population and enrollment in traditional mathematics courses dropped.

After the war, it became apparent that the mathematics preparation of many adults was inadequate to meet the needs of industry. The demand for people highly trained in mathematics was present in many areas: government, engineering, skilled trades, retail businesses and all facets of industry (NCTM, 1970). Many sources have cited the launching of Sputnik in 1957 as the beginning of a time of change in mathematics courses. Although this event focused the public attention on the need for change, the curriculum reform movement had already begun (NCTM, 1970). The University of Illinois Committee on School Mathematics (UICSM), started in 1951, was the first large scale project begun to prepare materials for secondary school mathematics which expressed the modern view and role of mathematics (NCTM, 1970). The precedents set by this project became a pattern for other projects to follow.

In 1963, the spiral method of teaching the same concept on several occasions was recommended in order to provide several approaches to a topic (Cambridge Conference on School Mathematics, 1963). It was suggested that different aspects of a concept are emphasized by each approach and that each approach may show the relevance of different topics to the one being taught. The NCTM (1970) recommended that "problems should be devised as to foster discovery and creativity and also to supply the variability necessary to provide for individual differences." (p. 293)

The "New Math" curriculum, introduced in the 1970's, emphasized process rather than product. The active engagement of students in the thinking of mathematics was central to the theme of this movement. By the end of the 1970's, it was apparent that American students continued to score very low on achievement tests compared to students from other nations. Therefore, the late 1970's brought a major backlash against this movement, and the population began a call for a back-to-basics approach to mathematics. This movement was based on students performing a limited set of skills with minimum mastery. After a decade where the primary focus was basic skills, problem-solving once again became the focus of mathematics instruction.

In 1977, the National Council of Supervisors of Mathematics issued the first major call for the curriculum to change in the direction of thinking and problem solving skills. This group redefined the meaning of basic skills to include geometry, problem solving, and other important topics in mathematics. This was followed by the National Council of

Teachers of Mathematics (1980) Agenda for Action. Problem-solving was declared the focus of mathematics curriculum for the 1980's.

Throughout the 1980's and 1990's, there have been many suggestions and standards written which recommend improvements to the mathematics curriculum. These recommendations have been made by professional organizations, such as the National Research Council, Mathematical Association of America (MAA), National Council of Teachers of Mathematics (NCTM), and the American Mathematical Association of Two-Year Colleges (AMATYC).

Recommendations

The 1983 report, A Nation at Risk, and the use of minimum competency testing may have begun the recent standards movement, but many of the research articles point to two sets of standards which began the recent onslaught; these are Goals 2000 and the National Council of Teachers of Mathematics (NCTM) Curriculum and Professional Standards.

Goals 2000: Educate America Act (HR1804) was a $400 million bill created to establish national education goals and standards. It was signed by President Clinton on March 31, 1994. The law established eight national goals which prescribed that by the year 2000:

1. All children will start school ready to learn.
2. At least 90 percent of students will finish high school.

3. Students will leave grades 4, 8, and 12 with demonstrated competence in English, mathematics, science, foreign language, civics and government, economics, arts, history, and geography.
4. Teachers will have access to programs for the continued improvement of their skills.
5. The United States will be first in the world in math and science.
6. Every adult will be literate and possess the skills to compete in a global economy.
7. Every school will be free of drugs and violence.
8. Every school will promote involvement of parents in their children's education.

(Wells, 1994)

One of the important points of this legislation is the formal recognition that American education has much to learn from the educational systems and standards in use in other countries (Lewis, 1994).

The National Council of Teachers of Mathematics (NCTM) published the Curriculum and Evaluation Standards for School Mathematics in 1989. This document led the way to mathematics reform in kindergarten through grade 12. The Standards describe ways to teach the traditional topics with a different emphasis. They recommend that mathematics be taught from a constructive, active view. Teaching should include project work, group and individual assignments, discussions between the teacher and students and among students, practice on mathematical methods, and exposition by the teacher. Students must develop their ability to solve problems individually, in small groups, and as an entire class. In the process of solving problems, students should be encouraged to make conjectures and to use varying methods to try to find solutions. Classroom activities should provide students with opportunities to read, write, and speak mathematics. The first four standards at every level of the curriculum are problem solving, communication, reasoning, and mathematical connections. This reflects the belief that the curriculum should make a deliberate attempt to connect ideas and procedures from different mathematical topics and with different content areas.

In the introduction to the NCTM Curriculum and Evaluation Standards for School Mathematics (1989), it says, "Students need to experience genuine problems on a regular basis. A genuine problem is a situation in which, for the individual or group concerned, one or more appropriate solutions have yet to be developed. In sum, we believe that learning should be guided by the search to answer questions. This constructive, active view of the learning process must be reflected in the way much of mathematics is taught." (p. 10) The idea is that if students formulate their own solutions they will recall these techniques in the future, even if specific rules are forgotten.

The NCTM Standards focus on the K-12 curriculum. Crossroads in Mathematics (1995), by the American Mathematical Association of Two-Year Colleges (AMATYC), was developed to similarly address the needs of college students who plan to pursue careers that do not require calculus or are underprepared for calculus. This document set standards for curriculum and pedagogy in introductory college mathematics courses. Crossroads in Mathematics (1995) has three sets of standards. These are standards for intellectual development, standards for content, and standards for pedagogy. Several of the basic principles are:

- the mathematics that students study should be meaningful and relevant

- mathematics must be taught as a laboratory discipline where projects using genuine data should be used to promote student learning through guided, hands-on investigations
- the use of technology is an essential part of an up-to-date curriculum.

The standards for intellectual development include problem solving, modeling, reasoning, connecting with other disciplines, communicating and using technology. The standards for pedagogy are based on the constructivist viewpoint. The standards recommend strategies that provide student activities and provide opportunities for students to structure and apply knowledge. These strategies include:

- faculty should model the use of appropriate technology
- faculty should foster interactive learning through student writing, reading, speaking, and collaborative activities so that students can effectively work in groups and communicate about mathematics
- faculty will actively involve students in problems that build upon their experiences, focus on themes, and build connections to other disciplines and real life
- faculty will model numerical, graphical, symbolic, and verbal approaches to problem solving
- faculty will provide projects that require sustained effort and time so that students can form conjectures and draw conclusions.

The National Research Council (1989) suggested seven transitions that need to be made to meet the challenges of today's technological world. These include:

- shifting mathematics from an authoritarian model based on "transmission of knowledge" to a student-centered practice featuring "stimulation of learning"
- public attitudes about mathematics need to shift from indifference and hostility to recognition of the important role that mathematics plays in today's society
- teaching mathematics needs to shift from preoccupation with inculcating routine skills to developing broad-based mathematical power
- teaching mathematics needs to shift from emphasis on tools for future courses to greater emphasis on topics that are relevant to students' present and future needs
- public perception of mathematics needs to shift from that of a fixed body of arbitrary rules to a vigorous, active science of patterns.

The Mathematical Association of America (1990) states, "Mathematics instruction should provide students with a sense of the discipline--a sense of its scope, power, uses, and history. As a result of their instructional experiences, students should learn to value mathematics and to feel confident in their ability to do mathematics." (p. 2) Other recommendations include: providing students the opportunity to explore a broad scope of problems, ranging from exercises to open-ended problems and exploratory situations; providing students a broad variety of approaches and techniques; helping students develop precision in both written and oral presentation; and preparing students to become independent learners, interpreters, and users of mathematics.

All of the recommendations agree that classrooms of passive students need to give way to learning environments that encourage students to explore, show students that many mathematical questions have more than one right answer, and build confidence in all students that they can learn mathematics. Teachers need to have classes that focus on seeking patterns, exploring patterns, and formulating conjectures.

Implementation

Research in learning shows that students construct their own understanding based on new experiences that expand their intellectual framework (Driscoll, 1994; Joyce & Weil, 1996). Mathematics becomes useful to a student only when it has been developed through personal experiences that create new understanding (National Research Council, 1989). Gagne's theory stresses that problem solving must be based on knowledge and recall of the principles to be combined to form a solution and that without these there is little chance of finding a successful solution (NCTM, 1970). Evidence from many sources shows that the least effective mode for learning mathematics is lecturing and listening. It has been shown that students do not retain for long what they learn by imitation from lectures, routine homework problems, and skill worksheets. According to the constructivist theory of learning, the learners must construct knowledge by making sense of their experiences and not by passively receiving knowledge (Driscoll, 1994; Joyce & Weil, 1996). Therefore, new instructional methods need to be implemented into the mathematics classroom.

The NCTM Professional Standards for Teaching Mathematics (1991) recommend that a teacher of mathematics create a learning environment that encourages mathematics power in each student by providing the time needed to explore mathematics and work with important ideas and problems, and an environment that respects and values each student's ideas. The teacher should expect and encourage students to work independently and cooperatively on math projects, to take risks by raising questions, and to display a sense of mathematical competence. This document provides a basis for teachers who are trying to implement these standards into the classroom in order to have students think critically and actively participate in their learning. The NCTM recommends that teachers include exploration, writing exercises and cooperative learning activities into courses to promote understanding of the concepts.

There are several reasons stated in the literature for using cooperative learning procedures. These include: increased knowledge due to the sharing of resources, low anxiety in the learning process, and the active participation of all members of the group. Cooperative learning strategies are supported by the research of Johnson and Johnson, Slavin, and Sharan (Joyce & Weil, 1996). These researchers have studied whether cooperative tasks and reward structures have positively affected learning outcomes. It has been found that "the shared responsibility and interaction produce more positive feelings toward tasks and others, generate better intergroup relations, and result in better self-images for students with histories of poor achievement " (Joyce & Weil, 1996, p.68). Students need encouragement and help in solving problems collaboratively. Many students have never worked in groups in mathematics classes and need guidance on how to be a successful member of a group.

Howden (1990) describes mathematics as the study of patterns. She states, "Recognizing, extending, and creating patterns all focus on comparative thinking and relational understanding. These abilities are integral components of mathematical reasoning and problem solving and of the study of specific concepts, such as percentage, sequence and limit, and function." (p. 9) In the teaching process, teachers must guide, listen, question, discuss, clarify, and create an environment in which students become active learners who explore, investigate, validate, discuss, represent, and construct mathematics.

Glatzer and Lappan (1990) suggest the use of physical investigations, applications to real-world problems, and reversing the directions as methods to develop and maintain algebraic skills. They suggest that teachers should represent situations in different ways so that students can see the interaction of the different forms of presentation. "Graphical representation and its interplay with both symbolic and tabular information deserve special highlighting" (Glatzer & Lappan, 1990, p. 41). The AMATYC standards (1995) also state that a variety of tools and techniques should be used in a mathematics classes, so that the classroom can become a laboratory for mathematical experimentation and learning.

The use of appropriate technology is recommended by both sets of standards. Appropriate technology may include the use of computers, videos, graphing calculators, and other technology used by practitioners in mathematical fields. The AMATYC standards (1995) suggests that the technology have graphics, computer algebra, spreadsheet, interactive geometry, and statistical capabilities. The use of calculators or computers in mathematics courses was advocated by many (American Mathematical Association of Two-Year Colleges, 1995; Demana & Waits, 1990; Dion, 1990; Ellis Jr., 1988; National Council of Teachers of Mathematics, 1989; National Research Council, 1989; Tucker, 1985; Wagner & Kiernan, 1989). Demana and Waits (1990) suggest the use of technology helps students understand mathematical processes, develop and explore mathematical concepts, and create algebraic and geometric representations of problem situations. The graphing calculator can provide an opportunity to check solutions, experiment with graphs of lines, and analyze real data that the class collects. It can provide the visual link between the solution of equations and the roots of the graph of the equation (Dion, 1990). The calculator can be used to remove the dependence on computation so that students could concentrate on problem-solving (Ellis, Jr., 1988). Demana and Waits (1990) have found that the use of graphing calculators in the classroom has caused the students to become more involved, more exploratory when confronted with new problems, and more enthusiastic. Graphing calculators can provide methods of solving interesting and realistic problems that are not practical with standard pencil-and-paper techniques. This technology allows teachers to use a guided-discovery approach to learning mathematics and can be used to turn the mathematics classroom into a laboratory where students become active participants in the learning process. The students can view mathematics as relevant because they will be able to solve realistic, "real" world problems.

The NCTM and AMATYC standards say that word problems should be an integral part of each class period. All problems do not need to have an algebraic solution. Students must first be able to identify the relevant information and learn how to approach a problem that they do not know how to solve. Students should make charts, draw pictures, suggest and test solution techniques, and discuss other methods of solution when trying to solve the problems. Only after students have experience in using the steps to problem solving can they feel confident in their abilities to solve other problems. Many students combine the numbers given in a problem in many ways until they stumble upon the correct answer. Trial and error is a good way to begin looking for solutions, but most teachers would prefer that students use higher level problem solving skills. Li (1990) suggests that problems give students extra information, so that the students must identify the information needed to solve the problem before they begin. This requires students to analyze exactly what they are trying to find, and perhaps, the kind of calculations necessary to solve the problem.

Schoen (1988) provides six recommendations to be followed when teaching a course focused on word problems. These are: (1) build new learning on students' existing knowledge and understanding, (2) lead gradually from verbalization to algebraic symbolism, (3) introduce algebraic topics with applications, (4) teach algebraic topics from the perspective of how they can be applied, (5) teach specific strategies as aids in understanding and solving word problems, and (6) hold students accountable for solving word problems.

Writing assignments can be used to help students summarize their understanding of the material, allow the instructor to view the material through the eyes of the students in the class, and give the students an opportunity to reflect on the learning that has occurred. LeGere (1991) provides many suggestions for using collaboration and writing in mathematics. These include analysis questions that can be used to have students describe how problems are solved and open-ended writing assignments.

Research Findings

Research shows that algebra students have difficulty in procedural conceptions. Greeno found that beginning algebra students had haphazard procedures when dealing with tasks involving algebraic expressions. In his study, students' procedures had unsystematic errors which indicated an absence of knowledge of the structural features of algebra (cited in Kiernan, 1992). Greeno found that algebra students were not consistent in their approach to testing the conditions before performing an operation nor were they consistent in their process of performing the operations. Carry, Lewis, and Bernard (cited in Kiernan, 1992) studied the equation-solving processes of college students. They found that some students overgeneralized certain mathematically valid operations which lead to incorrect results. An example of a common type of overgeneralization is the "deletion" error . A typical deletion error is simplifying 32x - 4 to 28x.

In solving equations, students often begin by using numerical substitution. This process of using substitution can be very time consuming and can require students to keep a systematic record of their trials. Kiernan (1992) found that as soon as algebra students learned a formal technique they tended to drop the use of substitution as a problem solving technique. It was also found that these students did not use substitution as a means to verify their solutions. Research by Filloy and Rojano studied the effectiveness of concrete models in the teaching of formal equation-solving procedures. They used geometric and balance approaches to teach equation solving. The results of the study showed that the use of the concrete models did not significantly increase the students' abilities to operate at the symbolic level (cited in Kiernan, 1992). Chaiklin (1989) reviewed cognitive studies in algebra problem solving and found that students have considerable difficulty in specifying relations among variables. Slight differences in problems can have a large effect on the students' abilities to construct the algebra equations.

In a study of sixth- to ninth- grade students, Dreyfus and Eisenberg (1982) asked questions in three representational settings-graph, diagram, and table of ordered pairs. The study found that high-ability students preferred the graphical setting for questions and low-ability students preferred the tabular settings. This suggests that different groups of students could benefit from different forms of representation.

Massasoit Community College offered introductory algebra in three formats beginning in 1990 (Keating, Martin, & Soderbom, 1996). There was a traditional 3-hour course, a non-traditional 5-hour course, and a non-traditional Algebra Modules course. The Algebra Modules segments the course outline into three one credit parts taught by different teachers. Students were advised to take one of the non-traditional courses if they received a low score on the mathematics admissions test. The pass-fail rates of the three groups varied significantly. The students in Algebra Modules had the highest rate of success. The 5-hour course did not differ from the traditional course in terms of outcome but the demographics of the two groups of students varied. The students in the 5-hour course had the lowest scores on the admissions test and had a higher percentage of minorities than the other groups.

In a study on the use of cooperative learning in college algebra at the community college, it was found that sixty-five percent of the students using a cooperative learning model successfully completed the course compared to 35-45% of students taught using traditional techniques (Jones, 1992). The major difference in the groups was the instructional methods that were used. It was concluded that the emphasis on group activities, group problem-solving, and group study had a significant effect on retention. This study also found that the experimental group had a more positive attitude toward mathematics.

The University of Chicago School Mathematics Project (UCSMP) was begun in 1983 as an attempt to implement the recommendations of NCTM and other reports (Hirschhorn, 1996). The result was a six-year curriculum for grades 7 through 12. A study to determine the influence of the curriculum on mathematics course enrollment patterns found that the UCSMP curriculum led to slightly fewer students dropping out of mathematics but the results were not statistically significant. It was shown that students in the UCSMP curriculum showed significant achievement differences on standardized tests.

According to the National Research Council (1989), there are several modes of thought that need to be included when teaching mathematics. These are:

- modeling--representing worldly phenomena by visual or symbolic constructs that capture important features
- optimization--finding the best solution by exploring all possibilities
- symbolism--extending natural language to symbolic representation of abstract concepts
- inference--reasoning from data, premises, graphs, and from incomplete sources
- logical analysis--searching for first principles to explain observed phenomena

- abstraction--singling out certain properties common to many different phenomena for special.

There is a great deal of research on the implementation of the recommendations of NCTM. Much of the research was published three years after the publication of the standards documents. The publication of Crossroads in Mathematics (1995), by AMATYC, should generate research at the community college level as courses begin to implement the suggested changes.

The curriculum needs to shift toward logic, mathematical reasoning, conjecturing, inventing, problem solving, and connecting mathematics, its ideas, and its applications (NCTM, 1991). Suggestions to implement this curriculum shift include the use of technology, writing assignments, discovery learning activities, and relevant word problems, and cooperative learning techniques. Booth (1989) summarizes the changes succinctly as, "The essential dimension underlying current views on the nature of the algebra curriculum is the move from an emphasis on manipulative skills to an emphasis on conceptual understanding and problem solving, that is, a move from doing algebra to using algebra." (p.244)

RETENTION

Background

Many schools base their retention strategies on a model developed by Tinto. Tinto distinguished between involuntary and voluntary departure from college (Fralick, 1993). Involuntary departure was most often caused by academic difficulties and comprised only about 15% of college dropouts. Voluntary departures were made by students who often did not have clear academic or career goals or who lacked the commitment necessary to finish. Tinto also found that academic progress is only one factor determining degree completion; whereas, membership in a supportive community was also necessary (Naretto, 1995). According to Umoh, Eddy, and Spaulding (1994), factors include: student characteristics, academic aptitude and performance, level of motivation, and student involvement. Student involvement can be described as the development of a sense of belonging or degree of fit that results from student and institutional interactions.

Kerka (1995), in a survey of the literature, found that most leavers (students who attended less than 12 hours of class) stayed in school for only 2-3 weeks. Many felt that they did not receive enough teacher attention. Other causes for departure were a gap between learner expectations and reality, frustration over lack of progress, and lack of knowledge of the effort required to succeed. Tinto's model proposes that the social and academic integration of the student is the major factor in completion and retention. Ashar and Skenes found that small groups of peers at the same level of career maturity created a social environment that motivated adult learners to persist (Kerka, 1995).

In a study on the influence of internal and external communities on retention, Naretto (1995) found that adult students had a strong need to be attached to the institution in a psychological sense. Students who were more involved in the academic and social life of the campus were more likely to persist in their educational goals. The students that continued to persist in their education spent significantly more time on campus and had a perceived sense of integration with the college community. These college communities consisted of fellow students, faculty, and staff of the institution. Naretto's study suggests that socialization and connection with the college community play an instrumental role in the lives of adult students and affects their persistence in achieving their educational goals.

King (1993) stated, "Academic advising is perhaps the most critical service. Advisors play a key role in helping students become integrated within the academic and social systems on campus, which in turn contributes to student growth, satisfaction, and persistence." (p.22) Advisors and professors can provide reasons that students must take some courses and help the students relate the use of the material to life outside the institution. All faculty and staff need to help the students navigate the intricacies of college life and help the students to develop a realistic understanding of the demands of college life. Students need to see the relevance of the curriculum to their goals and need to provide the internal motivation that is necessary to continue and succeed.

The proper placement of students into mathematics courses is a very important step in the retention process. Placing students in courses that are too advanced can discourage them and cause them to drop out, while placing students in courses that are not challenging may bore them or lull them into careless habits that will cause problems in later courses (MAA, 1990).

Strategies

Kerka (1995) listed the following strategies for student retention: (1) develop comprehensive strategies for specific subpopulations, (2) have material that is challenging for adults, (3) give students an opportunity to succeed at something every class period, (4) provide personal attention and assistance with personal problems, and (5) provide flexible, convenient scheduling and frequent contact with caring faculty. According to Kerka (1995) and Tinto (1994), two of the strongest positive factors in student retention are the caring attitude of faculty and staff and high quality advising. Also, students need to be enveloped into the social and academic communities as soon as possible to promote a feeling of belonging.

Umoh, Eddy, and Spaulding (1994) found that most of the students in their study did not normally interact with the developmental mathematics faculty or with their fellow students to bring about the kind of social integration that is suggested by Tinto (1994). The majority of the students reported that they did not enjoy the classes, nor were they intellectually stimulated by the material covered. In their study, neither age, gender, grade point average, nor parents' education were statistically significant factors for student retention in developmental mathematics classes.

In a study of factors that predict student achievement, Robinson (1998) found that newly enrolled students at a community college were more successful in mathematics courses than students who had previously enrolled in a prior mathematics course. It was also found that females had higher grades and were more successful than males in the college preparatory mathematics classes. He states that proper placement can also affect a student's success and, perhaps, the overall retention of the student at the college.

The research suggests that interaction between teachers and students and among the students can have a positive effect on retention (Kerka, 1995; Roueche & Roueche, 1994;

Tinto, 1994; Umoh, Eddy, & Spaulding, 1994). Students are more likely to remain in class if they have a feeling of belonging to a community. Teachers need to have a caring and positive attitude when dealing with students. Students need to feel as if they are a productive, worthwhile member of the class and that they are learning relevant material.

ATTITUDES

It is important to study attitudes towards mathematics and the relationship of attitudes to the learning of mathematics. Students begin college with definite opinions concerning the nature of mathematics and the reasons to study it. There are many factors which can influence the attitudes of students. These include the use of cooperative learning, teacher attitudes, the relevance of the material being taught, and the use of different instructional techniques.

Background

Dubinsky identifies four categories of belief about the nature of mathematics. Mathematics is:

- a body of knowledge already discovered that must be passed on to future generations by transfer from teacher to student;
- a set of techniques for solving standard problems that must be practiced until mastered;
- a collection of thoughts and ideas that have been created and constructed and that students might be expected to also construct;

- a set of applications that stress only the power of mathematics to describe, explain, and predict (cited in Hagelgans, et al., 1995).

Garofalo (1989) identifies five commonly held beliefs that students have about mathematics. These are:

- almost all mathematics problems can be solved by the direct application of the facts, rules, formulas, and procedures given in the text or by the teacher;
- textbook exercises can and must be solved by the methods given in the text;
- only mathematics that is tested is important and worth knowing;
- mathematics is created by mathematical geniuses and handed down to others to learn;
- mathematics problems have only one correct answer, and these answers are obtained by using specific algorithms.

Influencing Factors

Research suggests that students in classes using cooperative learning can develop a more positive attitude toward themselves and mathematics (Jones, 1992; Joyce & Weil, 1996). Slavin (1991) stated that the positive effects of cooperative learning have been consistently found on outcomes such as self-esteem, intergroup relations, attitudes towards school and the ability to work cooperatively. He stressed that in order for cooperative learning to be successful there must be group goals and individual accountability; that is, the success of the group must depend on every member learning the material individually. Several studies found that the students who gain the most from cooperative work are those that give and receive elaborate explanations (Slavin, 1991).

In a cooperative learning project, respondents to a survey on cooperative learning wrote about changes in their attitudes towards mathematics. Students explained how they had gained confidence in their mathematical abilities, expressed the pleasure in solving problems in groups, and described the comfort in knowing that there were other students to consult when they were having a problem (Hagelgans, et al., 1995). Another benefit mentioned was that students became aware that their peers often had similar difficulties in mathematics.

Okebukola (1986) found that laboratory work and the cooperative aspects of laboratory work positively influenced the attitudes of students. Okebukola states, "It is in the laboratory that students acquire many process skills such as observing, experimenting, and manipulating variables which are important in the investigative phase of the scientific enterprise." (p. 582) One group of students participated in cooperative laboratory experiments while the control group did the experiments but did not have an opportunity to work collaboratively. It was found that the experimental group had more favorable attitudes towards laboratory work. Also, males had a more favorable attitude than females towards the laboratory work.

Stones, Beckmann, and Stephens (1983) examined student attitudes towards mathematics in pre-calculus college students. The researchers investigated how gender, high school mathematics background, size of graduating class, and the student's college grade level related to the student's attitude. The study found that overall students had a neutral attitude toward mathematics. The study also found that the size of the graduating class and gender were not significantly related to attitude. First year college students had a better attitude than sophomores and juniors. Students with above average high school backgrounds showed significantly more positive attitudes than those with an average or below average background.

A major reason that students continue in mathematics or avoid it is their perception of how good they are at mathematics (Armstrong & Kahl, 1979). If they believe that they have ability in mathematics, then they will continue to study mathematics. Therefore, a teacher must make opportunities to develop the self-confidence of the students. Taylor (1990) suggests that this can be done by teaching them how to learn mathematics and offering them motivating experiences in which they can have success. The NCTM (1991) Professional Standards for Teaching Mathematics agree that the teacher influences students' mathematical dispositions in the classroom. If teachers convey an interest and respect for students' thoughts, then the students are more likely to propose conjectures, strategies and solutions during class discussions.

In a meta-analysis by Sowell (1989), it was found that students' attitudes toward mathematics are improved when they have instruction with concrete materials provided by teachers who are knowledgeable about the use of these materials. This analysis examined the use of both concrete manipulatives and pictorial representations. Schoenfield (1989) found that students believe that good teaching practices in mathematics consist of making sure that students know the rules and of showing students different ways to look at the same question.

Schoenfield (1989) suggests that the most troubling aspect of his study is "students have come to separate school mathematics--the mathematics they know and experience in their classrooms--from abstract mathematics, the discipline of creativity, problem solving, and discovery, about which they are told but which they have not experienced." (p.349) Schoenfield also found the following contradiction. Students claim that "mathematics is mostly memorization" and "mathematics is a creative and useful discipline in which they learn to think." (p. 338)

A review of studies dealing with student attitudes towards mathematics suggests that the Fennema-Sherman Attitude Scales are widely used. Under a grant from the National Science Foundation, Fennema and Sherman (1976) developed nine domain specific Likert-type scales to measure important attitudes towards learning mathematics. Three of these scales will be used for this study to determine the attitudes of the students. The Mathematics Usefulness Scale was designed to determine a students' beliefs about the usefulness of mathematics currently and in relation to their future education or vocation. The Confidence in Learning Mathematics Scale measures the confidence that the student has in his or her ability to learn and perform well on mathematical tasks. The Effectance Motivation Scale is used to measure the student's attitude toward is solving problems. "Effectance motivation is similar to problem solving attitude, an attitude not believed to be associated as highly with women as with men" (Fennema-Sherman, 1976, p. 5). The dimension of effectance measured by the Effectance Motivation Scale ranges from lack of involvement to active enjoyment and seeking of challenge.

Competition has been found to enhance motivation and motivation has been known to be predisposing to the development of favorable attitudes (Okebukola, 1986). The research shows that students with self-confidence in their mathematical abilities have more positive attitudes. Attitudes can be affected by the use of relevant problems, cooperative learning strategies, and manipulatives in the classroom.

RUBRICS

Assessment can be used to evaluate process or product. Assessment at the end of a program is usually focused on the product. The learners have presumably had the opportunity to develop their skills and then can show what they know how to do. A rubric is an evaluative tool designed to lay out a continuum of product quality from very excellent to very poor (Educators in Connecticut's Pomperaug Regional School District 15, 1996). Rubrics are used to enable two or more evaluators to view the performance in the same way. There are many types of rubrics.

As part of many state-level programs (e.g., California Assessment Program, Commission on Student Learning for the State of Washington), students are being asked to solve nonstandard problems and to write about their problem-solving strategies (Taylor & Bidlingmaier, 1998). The scoring methods used in the state assessment programs fall into one of three categories. The categories are holistic scoring, trait scoring, or item-by-item scoring (Taylor & Bidlingmaier, 1998).

Holistic scoring is a process of reading the student's responses to all parts of a task and then assigning a single score. The score is an overall judgment of the quality of the response. Trait scoring, or focused holistic scoring, is based on the model used in the assessment of writing. This method ensures that multiple dimensions of mathematical power are assessed (Taylor & Bidlingmaier, 1998). Item-by-item scoring assigns points on the basis of how well students fulfill the expectations of a given step. Points vary depending on the difficulty or complexity of the response at that stage of the response. This method assumes that each step can be assessed, at least in part, independently of the other steps in the task (Yen, 1993).

Similarly, analytic scoring is an evaluation method that assigns point values to each of several phases of the problem-solving process (Charles, Lester, & O'Daffer, 1987). The analytic scoring scale is created in two steps. The first step is to decide which phases of the problem solving process are important. The second step is to specify a range of possible scores for each phase. A three point range is sufficient. This allows 0 points for no answer or a wrong answer based on an inappropriate method of solution, 1 point for a partially correct solution, and 2 points for the correct answer.

There are several advantages to using analytic scoring scales. These are:

- they consider several phases of the problem solving process, not just the answer;
- they provide a means to assign numerical values to students' work;
- they provide specific information about the effectiveness of various activities;

- they help the teacher pinpoint specific strengths and weaknesses in the problem solving process (Charles, Lester, & O'Daffer, 1987).

When assessing the responses to questions, teachers must meet and discuss what kinds of activities the students should be doing in order to be successful. These activities need to be measured by the analytic scoring scale or rubric being used.

Rubrics and analytic scoring scales are used to assess the open-ended questions on many standardized tests, such as the CLAST and AP placement exams. The use of these scoring mechanisms helps different teachers to assign similar scores when assessing students' work. According to Moran (1997), the use of these instruments help evaluators to score performances adequately, objectively, reliably, and validly.

SUMMARY

Educational research offers compelling evidence that students learn mathematics by constructing their own mathematical understanding. This happens when students work in groups, engage in discussions, make presentations, and take charge of their own learning (National Research Council, 1989). Cooperative learning, relevant problems, and a caring faculty have been shown to positively effect students' attitudes. Furthermore, students' attitudes have an effect on motivation, retention, and learning.

According to the National Research Council (1989), undergraduate mathematics is the linch pin for revitalizing mathematics because students who prepare to teach mathematics acquire attitudes about mathematics, styles of teaching, and knowledge of content from their undergraduate experiences. Lawson (1990) stated "every student deserves the opportunity to learn algebra--it is a key element of know-how. In many instances, knowledge of algebra may be the key that unlocks curiosity, creativity, and ambition in the classroom, and later, success in a mathematically oriented technological world." (p. 6)

CHAPTER III

METHODOLOGY

Introduction

Changes in curriculum can affect more than what is being taught in the classroom. These changes can also affect rates of retention and student attitudes toward mathematics. This research study examined the new course, College Preparatory Mathematics II (MAT 0025), to determine the effectiveness of the course in terms of student retention, student attitudes, and material learned by the students. The researcher hypothesized that the use of multiple methods of solutions and real world data had the potential to improve student perceptions about mathematics. Additionally, the use of numerical, algebraic, and graphical solution methods had the potential to improve student understanding and retention in both College Preparatory Mathematics II and the succeeding course, College Algebra. If this occurs, the students' attitudes and scores on the test questions should reflect these ideas.

College Preparatory Mathematics II was first offered in the summer of 1997, and this research studied students enrolled in the course on the two major campuses of the community college during the 1997-98 school year. Textbooks were adopted college-wide for this course. The course was a 5 contact-hour course. Four hours were spent with the instructor, and one hour was spent in a laboratory setting. The instructor determines what activities the students will complete during the laboratory section. The choice may depend on the material covered in class or the students' understanding of the material.

The laboratory component of College Preparatory Mathematics II used different materials on each campus of the study. One campus used a commercial product, Activities for Beginning and Intermediate Algebra (Garrison, Jones, and Rhodes, 1997) in the laboratory hour. This book consisted of data collection activities, experiments, activities using technology, and other activities that incorporate meaningful learning experiences. The laboratory hour was taught by instructional assistants on this campus. The other campus used a packet of materials developed by instructors on that campus. It included materials which stress drill and practice as well as some activities which used cooperative learning and data collection. Instructors usually taught the laboratory hour of the course on this campus.

The study was conducted at two campuses of a multi-campus metropolitan community college in Central Florida. The research focused on students enrolled in College Preparatory Mathematics II in the fall of 1997 and the spring of 1998 and students enrolled in College Algebra in the spring of 1998.

The researcher examined the following research questions:

1. Does the use of laboratory activities influence student retention in a college preparatory mathematics class?
2. Does the use of laboratory activities and cooperative learning activities influence student attitudes in a college preparatory mathematics class?

3. Does the type of laboratory activities affect what a student learns and retains?

4. Does the addition of laboratory activities and the use of numerical, analytical, and graphical methods in the college preparatory mathematics classroom affect student retention in college level mathematics classes?

Subjects

There were three groups of subjects selected for this study. The first group included all students enrolled in regular classroom sections of College Preparatory Mathematics II (MAT 0025) on two major campuses of a metropolitan community college in central Florida in the fall of 1997. Regular classroom sections are defined to be those that do not include the use of computer-assisted instruction, self-paced classes, or classes that were employing other experimental techniques. This sample included approximately 20 sections on each campus for a total of 40 sections and approximately 1,000 students. The second group included all students enrolled in MAT 0025 in the spring of 1998 on each of the two major campuses. This sample included approximately 25 sections on each campus for a total of 50 sections and approximately 1,300 students. These students participated in the Fennema-Sherman attitudinal survey. The students in the spring semester were surveyed twice, once at the beginning of the semester and again at the end of the semester.

Retention information was gathered on all students enrolled on all campuses of the community college in College Preparatory Mathematics II (MAT 0025) during the fall and spring terms through the use of the college computer database. This group consisted of approximately 75 sections each term with a total enrollment of 4,100 students. This data was also categorized by campus, gender, and age group.

The third group consisted of all students college-wide in College Algebra (MAC 1105) in the fall of 1997 and the spring of 1998. During the fall term, there were approximately 60 sections and 1300 students. There were approximately 70 sections enrolling 1900 students during the spring term of 1998.

From the students enrolled in the spring of 1998 in MAT 0025, a convenience sample of at least 6 classes from each campus was selected to participate in a study of what material the student retained throughout the course MAT 0025 by administering a 20 question exam which incorporated topics from the course outline. These data were categorized by campus.

Design

The attitudinal surveys were administered by the instructors or the instructional assistants of each regular classroom section of the course (See Appendix C). The surveys were given to the fall semester students during the last two weeks of the course. The spring semester surveys were given twice, once during the first two weeks and again during the last two weeks of the course.

All retention data were collected through use of the college computer database. The students were considered successfully retained if they received an A, B, or C in either MAT 0025 or MAC 1105. These data were categorized according to the background preparation and gender of the students.

The students participating in the achievement portion of the study were administered twenty questions as part of their final exam in the course (See Appendix D). These questions were administered and graded by the classroom instructor according to a rubric, then the scores were reported by the instructor to the researcher (See Appendix E).

Instruments

The survey consisted of 50 questions. The survey had three subparts. These subparts included four questions to categorize the students, thirty-six questions from the Fennema-Sherman Mathematics Attitudes Scales, and 10 questions directly related to the course and the accompanying laboratory. The first four questions determined the gender, age category, previous course and grade in that course. All other questions used a Likert scale to measure student attitudes. The Fennema-Sherman Mathematics Attitudes Scales (1976) used are the Confidence in Learning Mathematics Scale, the Usefulness of Mathematics Scale, and the Effectance Motivation in Mathematics Scale. Each scale consists of six positively stated and six negatively stated items with five response choices: strongly agree, agree, undecided or neutral, disagree, and strongly disagree. Each response was given a weight of 1 to 5, with 5 being given to the response that had the highest positive effect on the learning of mathematics. Higher scores represented more positive attitudes. Means on each question and each individual scale were calculated by gender. Reliability and validity of these scales were determined by Fennema and Sherman. The additional ten questions were included to determine how the student felt about the text, lab activities, and the course in terms of relevance, applicability, and usefulness. These ten questions were developed by a team of four mathematics instructors at the community college involved in the study.

An additional open response survey was administered to students in MAT 0025 each semester of the study in order to gather more specific data about the types of activities the students found most relevant and the topics that were perceived to be the most understood by the students (See Appendix C). This survey was constructed by three mathematics faculty and reviewed by five additional mathematics faculty members. The responses to the survey were used to provide more detailed descriptions of the activities that students felt were relevant or activities that students felt were not useful to their learning processes. Also, responses provided reasons why those activities were beneficial or not beneficial to the students' learning processes. Trends of the responses are reported by campus. Reliability and validity of this instrument was not a concern because the reporting procedures use only descriptive statistics and no comparisons were made between groups. Responses to this portion of the survey were optional.

The 20 question exam was developed collaboratively by several faculty teaching the course. Fifteen of the questions were multiple choice and five questions dealt with graphing, multiple methods of solutions, and application problems. The test had 10 course appropriate basic skills questions. The other 10 questions tested the student's ability to solve problems numerically, analytically, and graphically as well as the student's ability to analyze data. Reliability and validity of the test was determined through a pilot study in the fall of 1997.

Methods of Analysis

The data were analyzed using both quantitative and survey statistics. For the information gathered from the student surveys, means on each question were found according to gender and campus. Analysis of variance (ANOVA) was used to compare the means to determine if there were differences between the mean scores of males and females, and the mean scores of the two campuses. ANOVA was used to determine if there were differences in the sample means, and if these differences were due to a difference between the population means or to the variation within the populations. Overall scores on each of the three Fennema-Sherman Attitudes Scales were averaged. The overall scores on each scale were compared by gender and campus using ANOVA to determine any differences in the means.

In the analysis of the survey data from the spring of 1998, the results on the attitudinal survey given at the beginning of the semester were used as a covariate to determine any differences in the attitudinal scores between the campuses at the pre-test stage. The means on the pre-test and post-test attitudinal surveys were compared using ANOVA to determine if there were any significant changes in the attitudes of any group.

The retention rates of students in College Preparatory Mathematics II (MAT 0025) and College Algebra (MAC 1105) on each campus were reported using descriptive statistics. The students were grouped by campus and by gender. The retention rates of students in both courses were compared between the campuses and also by gender using 2-sample proportion confidence intervals. Comparisons in retention rates in MAC 1105 were made between students who were previously enrolled in MAT 0025 or MAT 1033. Hypothesis tests were used to determine any differences between the proportions.

In order to determine if the new courses have improved retention, retention rates in MAT 0025 and MAC 1105 during fall and spring of 1997-98 were compared to retention rates in Intermediate Algebra (MAT 1033) and College Algebra (MAC 1104) during fall and spring of 1996-97 using two-proportion confidence intervals.

The scores on the 20-question exam were compared using a hypothesis test to determine possible differences between treatments. Statistics on individual questions were described using percentages by campus.

The responses to the open-response questions were categorized and summarized by the researcher. Positive and negative trends were described by campus. Sample responses from students on each campus were included. Short descriptions of the activities that the students found most relevant were given to provide more detail about those activities.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to examine the effectiveness of a new course, College Preparatory Mathematics II (MAT 0025). The study also examined the extent to which the course and its accompanying laboratory component affected student attitudes and performance in both that course and the succeeding course, College Algebra (MAC 1105). Four research questions were formulated to provide focus for the study. Data were collected from student surveys to determine student attitudes towards the relevance and usefulness of mathematics, the course, and the laboratory activities. Retention rates in College Preparatory Mathematics II and College Algebra were determined from enrollment information in the college computer database.

Results of the statistical analysis of data gathered in the experiment are presented in this chapter. Responses to the survey instruments were obtained from students enrolled in College Preparatory Mathematics II (MAT 0025) on two major campuses of a Central Florida metropolitan community college. For reporting purposes, the campus using the commercial product for the laboratory section is Campus A, and the campus using materials developed by the instructors is Campus B. Response totals are labeled by campus, gender, or age. Varying methods of statistical analysis were used in the tabulation process. Tabulation methods included the use of the data analysis tools of Microsoft Excel®, the use of the statistical features of the Texas Instruments TI-83 graphing calculator®, summary statistics performed by the institutional research department of the community college, and hand tabulation by the researcher. The content that follows contains narrative, tabular, and graphical presentations related to the following research questions:

1. Does the use of laboratory activities influence student retention in a college preparatory mathematics class?
2. Does the use of laboratory activities and cooperative learning activities influence student attitudes in a college preparatory mathematics class?
3. Does the type of laboratory activities affect what a student learns and retains?
4. Does the addition of laboratory activities and the use of numerical, analytical, and graphical methods in the college preparatory mathematics classroom affect student retention in college level mathematics classes?

Retention Rates of Previously Offered Courses and New Courses

The newly offered courses, College Preparatory Mathematics II (MAT 0025) and College Algebra (MAC 1105), were taught using numerical, analytical and graphical methods of solutions. To determine if retention had improved in the new courses compared to the previously offered courses data were obtained on enrollment and the retention rates in Intermediate Algebra (MAT 1033) and College Algebra (MAC 1104) during the 1996-97 school year, the academic year prior to this study. Retention is defined as enrollment that continues until the conclusion of a course which results in a grade of A, B, or C. Comparisons between the retention rates in the previously offered courses (MAT 1033 and MAC 1104) and the new courses (MAT 0025 and MAC 1105) were made using 2-sample confidence intervals. Table 2 contains the retention rates of the old courses, MAT 1033 and MAC 1104 during the fall and spring terms of 1996-97. Students passed if they received an A, B, or C in the course. Students failed if they received a D, F, or withdrew from the course.

Table 2

Retention rates in Intermediate Algebra (MAT 1033) and College Algebra (MAC 1104) prior to implementation of the new courses

	Fall Term 1996-97		Spring Term 1996-97	
	Pass	Fail	Pass	Fail
MAT 1033	1105 (47.3%)	1231 (52.7%)	1036 (48.1%)	1116 (51.9%)
MAC 1104	1121 (48.8%)	1174 (51.2%)	983 (52.1%)	905 (47.9%)

The total enrollment in Intermediate Algebra (MAT 1033) during the fall and spring terms of 1996-97 was 2336 and 2152 students, respectively. The table shows that the retention rates in Intermediate Algebra (MAT 1033) were 47.3% and 48.1% during the two terms. The total enrollment in College Algebra (MAC 1104) during the fall and spring terms of 1996-97 was 2295 and 1888, respectively. The retention rates in MAC 1104 were 48.8% and 52.1% during the same terms.

In comparison, Table 3 contains the retention rates of the newly offered courses, College Preparatory Mathematics II (MAT 0025) and College Algebra (MAC 1105) during the fall and spring terms of 1997-98.

Table 3

Retention rates in College Preparatory Mathematics II (MAT 0025) and College Algebra (MAC 1105)

	Fall Term 1997-98		Spring Term 1997-98	
	Pass	Fail	Pass	Fail
MAT 0025	1009 (60.5%)	659 (39.5%)	1318 (53.1%)	1165 (46.9%)
MAC 1105	677 (52.1%)	622 (47.9%)	1013 (53.5%)	882 (46.5%)

The table shows that the retention rates in College Preparatory Mathematics II (MAT 0025) were 60.5% and 53.1% during the two terms. Total enrollment was 1668 students in the fall term and 2483 students in the spring term. The retention rates in College Algebra (MAC 1105) were 52.1% and 53.5%. Total enrollment in MAC 1105 was 1299 students during the fall term and 1895 students during the spring term.

In order to determine if there were differences between the retention rates in Intermediate Algebra (MAT 1033) and College Preparatory Mathematics II (MAT 0025), two-sample confidence intervals were constructed for the data. Confidence intervals were also constructed to compare the retention rates in MAC 1104 and MAC 1105. All confidence intervals are at a 90% confidence level. These are shown in Table 4.

Table 4

Confidence Intervals for the retention rates in MAT 1033 and MAT 0025.

	Fall Term	Spring Term
MAT 1033 and MAT 0025	(-0.1579, -0.1059)	(-0.0736, -0.0252)
MAC 1104 and MAC 1105	(-0.0613, -0.0042)	(-0.0406, 0.0128)

If there is a significant difference in the retention rates, the confidence interval will not contain zero. The 90% confidence intervals comparing the retention rates for Intermediate Algebra (MAT 1033) and College Preparatory Mathematics II (MAT 0025) for both terms do not contain zero which indicates a significantly higher retention rate in College Preparatory Mathematics II than in Intermediate Algebra. The 90% confidence interval for the fall term indicates a significantly higher retention rate in College Algebra (MAC 1105) than in College Algebra (MAC 1104). There was not a significant difference in retention during the spring terms between the two College Algebra courses.

Retention Rates in College Preparatory Mathematics II

College Preparatory Mathematics II was a five contact-hour course. It included four hours with the instructor and one hour in a laboratory setting. Faculty on both campuses in this study taught the course from the same textbook. The use of laboratory activities varied by campus with the instructors choosing what activities were appropriate for their class. Instructional assistants facilitated the laboratory hour on campus A. This campus used a commercial product, Activities for Beginning and Intermediate Algebra

(Garrison, Jones, and Rhodes, 1997), for the laboratory hour. This book consisted of puzzles, data collection activities, activities using technology, and other activities that incorporate meaningful learning experiences. On campus B, the laboratory hour was usually taught by the instructor of the course. This campus used a packet of materials developed by instructors on that campus. It included materials which stressed drill and practice as well as some activities which used cooperative learning and data collection.

Retention rates were compared by campus in College Preparatory Mathematics II (MAT 0025) during the fall and spring terms of the 1997-98 school year. The overall percentage of students retained in each course during each term of the study are shown in Figure 1.

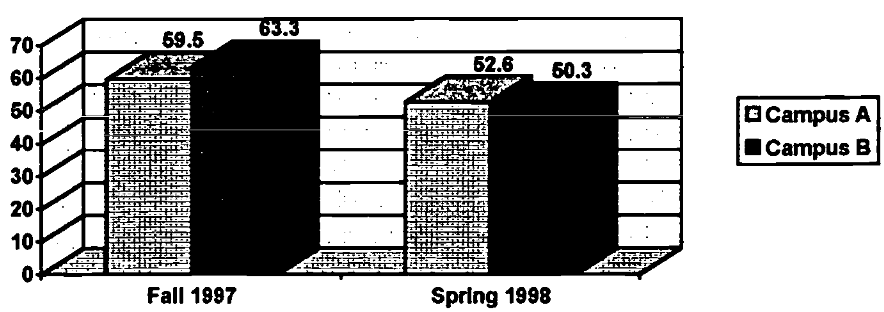


Figure 1: Retention rates in College Preparatory Mathematics II (MAT 0025) by campus

According to Figure 1, campus A had a retention rate of 59.5% and campus B had a retention rate of 63.3% during the fall term of 1997. During the spring term of 1998, campus A had a retention rate of 52.6% compared to campus B's retention rate of 50.3%. Comparisons among the proportions were made using 2-proportion hypothesis tests. The null hypothesis was that the proportions were equal. The tests used a 90% significance level. Statistical analysis showed that there was no significant differences between the retention rates in College Preparatory Mathematics II between the campuses in the fall term ($p = 0.167$) or in the spring term ($p = 0.295$).

Students' Attitudes in College Preparatory Mathematics II

To study student attitudes in College Preparatory Mathematics II (MAT 0025), students were administered three of the Fennema-Sherman Mathematics Attitude Scales as part of a survey during the fall and spring terms of 1997-98. The scales used as part of this study were the Confidence in Learning Mathematics Scale, the Usefulness of Mathematics Scale, and the Effectance Motivation Scale. Each scale consisted of twelve questions. The Likert scale of 1 to 5 (with 1 being the lowest and 5 being the highest) was used to rate each response. A numerical score for each student was identified by totaling responses on the twelve questions that represented each scale. The scores could range from a low score of 12 to a high score of 60 points. A student who answered neutral or undecided on every question would have a score of 36 points. The data were categorized by campus and gender.

During the fall term of 1997, 15 course sections on campus A and 7 course sections on campus B participated in the survey. There were 206 respondents on campus A and 99 respondents on campus B. The average score for each scale by campus is shown in Table 5.

Table 5

Average Score on Fennema-Sherman Mathematics Attitudes Scales by campus, MAT 0025

Fall 1997	Campus A	Campus B
Usefulness of Mathematics	40.30	41.30
Confidence in Learning	44.14	43.60
Effectance Motivation	35.65	35.75

The average scores on each scale were calculated by campus. Higher scores represent more positive attitudes. Table 5 shows that the average scores on the Usefulness of Mathematics Scale were 40.30 on campus A and 41.30 on campus B. The average score on the Confidence in Learning Mathematics Scale for campus A students was 44.14 points and for campus B students it was 43.60 points. The average scores on the Effectance Motivation Scale were 35.65 on campus A and 35.75 on campus B. The average scores on the Effectance Motivation Scale were slightly below the neutral score of 36. The average scores on the other scales were above the neutral score of 36. This indicates that the attitudes measured by these scales were more positive than negative.

A one-way analysis of variance with two treatments was used to determine if the students' scores on each scale were in part a result of the method of teaching on each campus. Tables 6, 7, and 8 show the ANOVA results for difference in attitude by campus as measured by the three Fennema-Sherman Attitude Scales. The results on the comparison between students' attitudes on the usefulness of mathematics is shown in Table 6.

Table 6

ANOVA results for attitude toward the usefulness of mathematics, MAT 0025

Source	Sum of Squares	df	Mean Square	F	Sig
Between Groups	19.8474	1	19.847	0.244	0.621
Within Groups	24600.756	303	81.191		
Total	24620.603	304			

Students' attitudes overall toward the usefulness of mathematics was not significantly different on campus A and campus B. Table 6 summarizes the ANOVA findings with a result of $F = 0.244$ with a significance of 0.621. The results of the comparison of students attitudes towards confidence in mathematics are shown in Table 7.

Table 7

ANOVA results for attitude toward confidence in mathematics, MAT 0025

Source	Sum of Squares	df	Mean Square	F	Sig
Between Groups	67.141	1	67.141	0.592	0.442
Within Groups	34346.249	303	113.354		
Total	34413.390	304			

Overall attitudes of students' confidence in mathematics was not significantly different between the campuses. Table 7 summarizes the ANOVA findings with a result of $F = 0.592$ with a significance of 0.442. The results of the comparison between campuses of the effectance motivation scale scores is shown in Table 8.

Table 8

ANOVA results for attitudes towards motivation in mathematics, MAT 0025

Source	Sum of Squares	df	Mean Square	F	Sig
Between Groups	0.694	1	0.694	0.009	0.924
Within Groups	22971.818	303	75.815		
Total	22972.511	304			

Table 8 shows that there was no significant difference between campuses with respect to effectance motivation. The ANOVA findings resulted in $F = 0.009$ with a significance of 0.924.

Histograms were constructed to provide a clearer picture of the distribution of scores on the three attitudinal scales for MAT 0025. These are shown in figure 2.

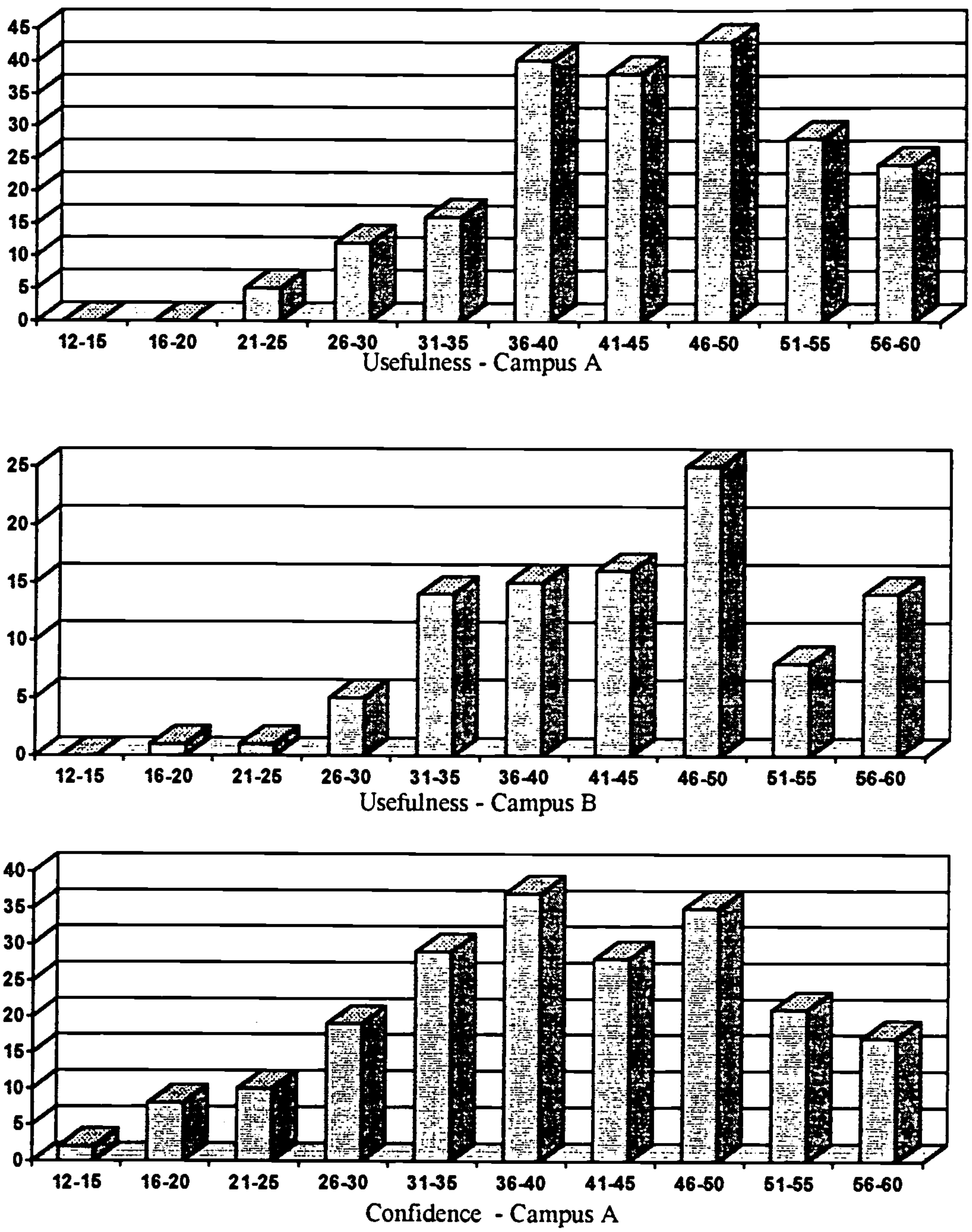
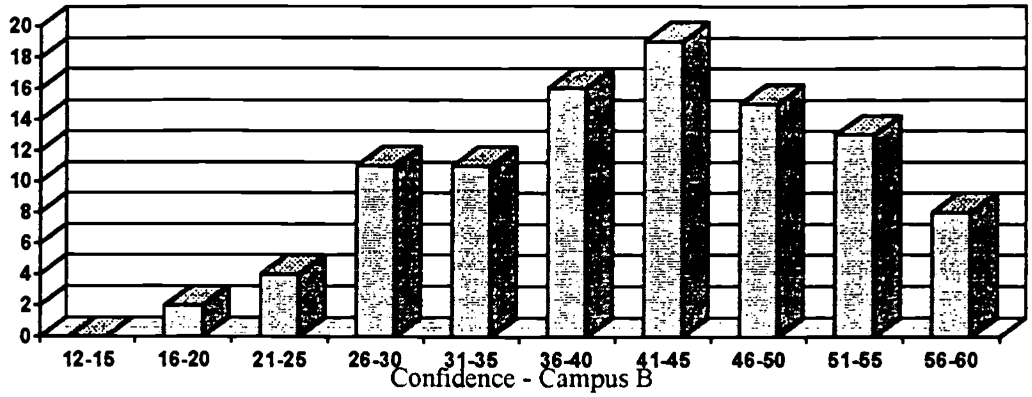
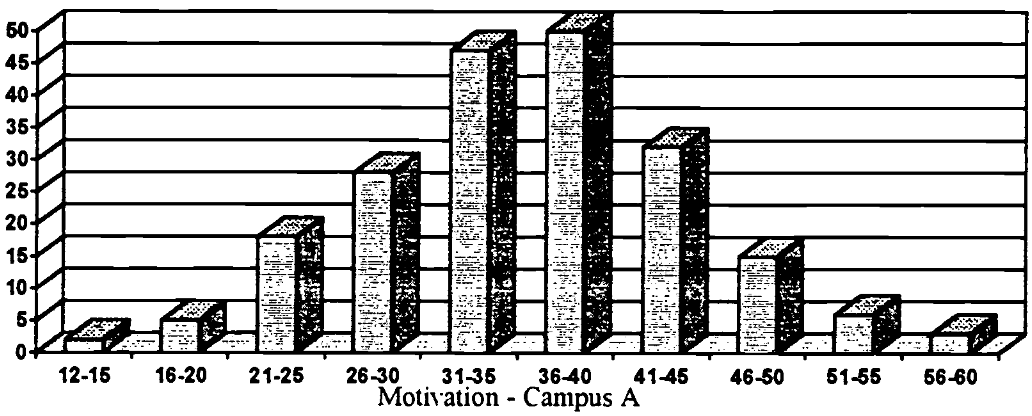


Figure 2: Histograms for attitude survey distributions for fall 1997, MAT 0025





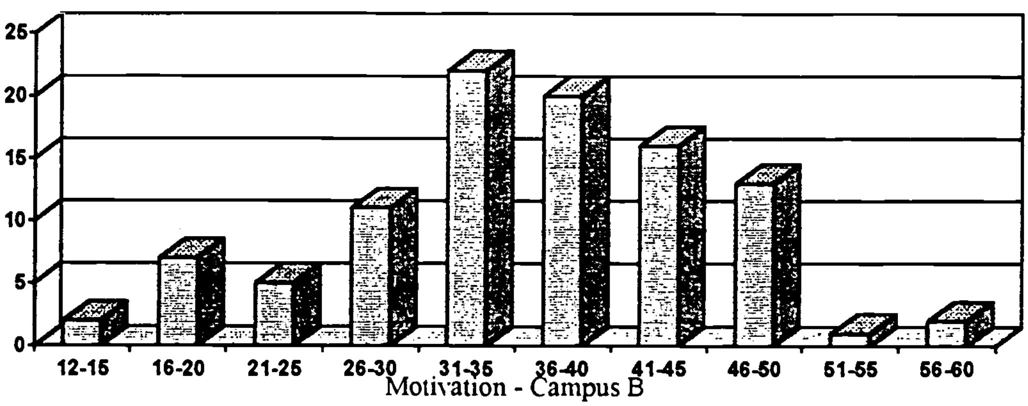


Figure 2 continued: Histograms for attitude survey distributions for fall 1997, MAT 0025

On both campuses, Figure 2 shows that the distributions on the Usefulness of Mathematics Scale are skewed left. The highest number of responses were between values of 46 and 50 points. These are considered positive scores since a student who answered neutral to all questions would score thirty-six points. Scores on the Confidence in Mathematics Scale are more evenly distributed but are still skewed left. The majority of the scores on this scale on both campuses are between 36 and 50 points. Scores on the Effectance Motivation Scale have a mounded distribution with more scores in the 31 to 35 range and the 36 to 40 range than other ranges. The distribution of scores on the campuses is similar on each scale.

During the spring semester of 1998, students in College Preparatory Mathematics II (MAT 0025) took the survey twice. The survey was administered during the first two weeks of the semester and again during the last two weeks of the semester. Twenty-five sections of the course on campus A and fourteen sections of the courses on campus B participated in the surveys. There were 379 respondents on campus A and 257 respondents on campus B to the surveys given at the beginning of the semester. Due to withdrawals, there were 279 and 113 respondents to the end of semester surveys. The distribution of scores on each scale for the spring term were similar to the distributions of scores for the fall term. The average scores by campus on both surveys are shown in Table 9.

Table 9

Average Scores on Fennema-Sherman Mathematics Attitudes Scales by campus on the pre-survey and the post-survey, MAT 0025

Spring 1998	Campus A		Campus B	
	Pre	Post	Pre	Post
Usefulness of Mathematics	39.433	38.703	38.556	39.248
Confidence in Learning	43.979	43.477	44.972	44.319
Effectance Motivation	35.823	34.946	34.911	35.513

On campus A, Table 9 shows that the average score on the post-surveys decreased on each attitude scale compared to the pre-surveys. On campus B, the average score on the post survey on the confidence in learning scale decreased to 44.319 from 44.972. Average scores on the other scales, usefulness in mathematics and effectance motivation, increased on campus B. Figure 3 shows the change in students' attitudes on each scale by campus.

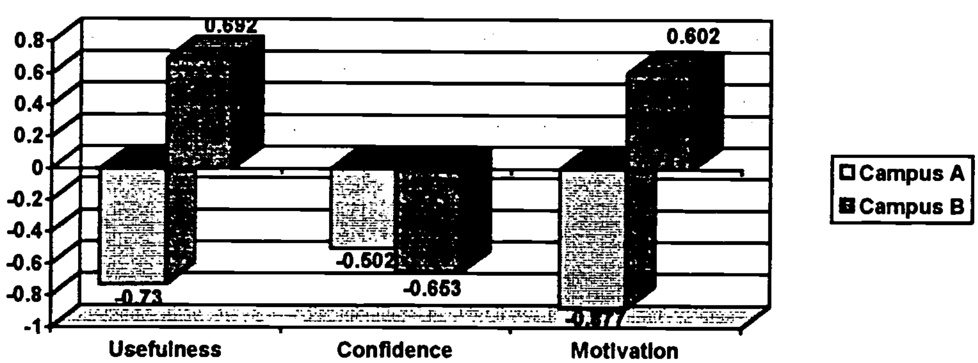


Figure 3: Changes in students' attitudes on the Fennema-Sherman Attitude Scales

Although the average scores on the attitude scales varied from the pre-surveys to the post-surveys, the largest variation was -0.877 points on the effectance motivation scale on campus A. The smallest variation was -0.502 on the usefulness of mathematics scale on campus A. A one-way analysis of variance to determine if the change in students' attitudes from the beginning of the term compared to the end of the term found no significant differences between the average scores.

Fennema and Sherman (1976) found that males and females scored differently on the attitude scales used in this study. For this reason, average scores on each scale were calculated by campus and gender on the surveys given at the end of the fall and spring terms. During the spring term, 117 males and 162 females on campus A and 44 males and 80 females on campus B were surveyed at the end of the course. The average scores on each scale are shown in Table 10.

Table 10

Average scores on the Fennema-Sherman Attitude Scales by gender for spring 1998, MAT 0025

	Campus A		Campus B	
	Males	Females	Males	Females
Usefulness of Mathematics	44.350	42.846	45.977	43.261
Confidence in Learning Mathematics	41.137	36.944	42.205	37.362
Effectance Motivation	36.077	34.130	36.273	35.029

Table 10 shows the average score on each scale was higher for male respondents than for female respondents. On the usefulness of mathematics scale, males had average scores of 44.350 and 45.977 compared to female average scores of 42.846 and 43.261. On the confidence in learning mathematics scale, males had average scores of 41.137 and 42.205 compared to female average scores of 36.944 and 37.362. On the effectance motivation scale, males had average scores of 36.077 and 36.273 compared to female scores of 34.130 and 35.029. This suggests that males have higher attitudes towards mathematics than females. A one-way analysis of variance was used to determine if the overall attitudes of males were different than the overall attitudes of females on the three attitude scales. The results of the three ANOVA procedures are shown in Table 11.

Table 11

ANOVA results for differences between male and female average scores on the Fennema-Sherman Attitude Scales, MAT 0025

Usefulness - Source	Sum of Squares	df	Mean Square	F	Sig
Between Groups	316.109	1	316.109	3.553	0.060
Within Groups	34691.02	390	88.951		
Total	35007.13	391			
Confidence - Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Between Groups	1802.963	1	1802.963	16.638	0.0000549
Within Groups	42262.32	390	108.365		
Total	44065.28	391			

Motivation - Source	Sum of Squares	df	Mean Square	F	Sig
Between Groups	284.663	1	284.663	3.377	0.067
Within Groups	32875.62	390	84.296		
Total	33160.28	391			

Table 11 shows that there is a significant difference between the male and female scores on the Usefulness of Mathematics Scale. The ANOVA findings resulted in F = 3.553 with a significance level of 0.06. There was also a significant difference between the male and female scores on the Confidence in Mathematics Scale. The ANOVA findings resulted in F = 16.638 with a significance level of 0.0000549. Male scores were significantly higher than female scores on the Effectance Motivation Scale at the 0.067 significance level.

The surveys included ten questions that applied to the material in the course MAT 0025, material in the laboratory, and the relevance of the materials taught. The Likert scale of 1 to 5 (with 1 being the lowest and 5 being the highest) was used to rate each response. A numerical score for each student was identified by totaling responses on the ten questions that represented this scale. The highest possible score was 50 points. A student who answered neutral or undecided on every question would have a score of 30 points. The data were categorized by campus. The overall scores on this scale for the fall surveys and the spring pre-surveys and post-surveys are shown in Table 12.

Table 12

Average scores on the course and laboratory scale, MAT 0025

	Fall 1997	Pre -surveys Spring 1998	Post-surveys Spring 1998
Campus A	32.3447	34.6658	32.8136
Campus B	33.0707	33.7237	31.6637

During the fall term, campus B students had an average score of 33.0707 compared to campus A students who scored an average of 32.3447 points. Campus A students had higher average scores, 34.6658 on pre-survey and 32.8136 on post-survey, compared to campus B students' scores, 33.7237 on pre-survey and 31.6637 on post-survey. During the spring term, the scores on both campuses decreased on the post-survey when compared to the pre-survey results.

A one-way analysis of variance was used to determine if there were significant differences between the average scores by campus. The results of the ANOVA findings are reported in Table 13.

Table 14

ANOVA results for differences between pre and post scores on the course and laboratory scale, MAT 0025

Campus A - Source	Sum of Squares	df	Mean Square	F	Sig
Between Groups	557.376	1	557.376	11.508	0.00073
Within Groups	32256.86	666	48.4337		
Total	32814.24	667			
Campus B - Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Between Groups	333.0827	1	333.0827	9.0886	0.00275
Within Groups	13486.61	666	36.64839		
Total	13819.69	667			

Comparing the pre-survey and post-survey average scores on campus A, the ANOVA findings resulted in F = 11.508 with a significance level of 0.00073. This indicated that the pre-survey scores were significantly higher than the post-survey scores. On campus B, the ANOVA findings were F = 9.0886 with a significance level of 0.00275. This indicated that the pre-survey scores were significantly higher than the post-survey scores on this scale.

The questions on the course and laboratory section of the survey were related to the course, laboratory, materials, and the relevance of the laboratory to the course. For this reason, average scores on each question were found for the end of semester surveys. These average scores are shown in Table 15 by campus.

Table 15

Average scores on individual questions on the course and laboratory scale, MAT 0025

	Fall 1997 Campus A	Fall 1997 Campus B	Spring 1998 Campus A	Spring 1998 Campus B
The material in the text has practical applications	3.30	3.03	3.09	2.99
The lab activities will contribute to my understanding of the material in the course	2.74	3.09	3.06	3.02
The previous course helped to prepare me for this course	3.44	3.22	3.51	3.35
The material in the labs will have practical applications.	2.94	3.06	3.08	2.92
The mathematics learned in this course will be used in the future.	3.61	3.43	3.45	3.35
I will be more comfortable solving word problems after taking this course.	3.00	3.10	3.11	2.92
I think that I have the ability to go on in mathematics.	3.76	3.82	3.54	3.50
I will not use the skills in this course outside of the classroom.	3.33	3.49	3.26	3.27
The material in the labs will contribute to the understanding of the classroom material.	2.83	3.27	3.21	3.11
Solving application problems will be easier after taking this course.	3.41	3.55	3.46	3.26

Table 15 shows that campus A had higher average scores than campus B both terms on the following statements: (1) the material in the text has practical applications, (2) the previous course helped to prepare me for this course, and (3) the mathematics learned in this course will be used in the future. Campus B had a higher average score than campus

A during both terms on the statement "I will not use the skills in this course outside the classroom". All other average scores varied between the campuses depending on the term of the survey.

Students' responses on the open-ended survey varied. Data were categorized by campus. An analysis of the response trends found the following to be the most common negative and positive responses. On both campuses, positive aspects of the laboratory included provided more practice, provided reinforcement of concepts, helped students to understand the class work, and the laboratory or laboratory assistant provided a different perspective. Campus A students also stated that the laboratory included practical applications, made the course more enjoyable, and allowed for group work and hands on approaches. On both campuses, negative aspects of the laboratory included the use of boring material and that the laboratory did not relate to the course or chapters. Campus A students also stated that the laboratory instructor did not provide enough help, worksheets could have been done at home, and the laboratory activities were done too late after the material was covered in class. Campus B students stated that some activities did not make sense and that there was not enough time to complete the activities in class.

On campus A, positive responses to the question, "Do you feel that the laboratory activities were a beneficial part of this course? Why or why not?" included the following: "yes, because practicing mathematics is the easiest way to understand it", "they made the class a little more interesting because it was a more interactive way to learn math", "yes, because it helped us to work as a group and share different ways to solve", "it gave me better details of understanding in real life situations", "it put a fun twist on the subject", "practiced what we did in class", "it gives us a hands-on approach", "group work is the key in math and life and what I did not understand in class, the lab refreshes", "yes, because it changed the same old, same old of lecture and question", and "yes, because it gives the students opportunities to explore and expand their knowledge about a particular topic and apply it to every day life. It also shows students how to use it in practical ways and proves to them that math has a significant use in their lives". Negative responses to the same question on campus A included: "I don't feel that the lab was very beneficial . If the lab teacher had more knowledge of the lab activities and how to do them, then the lab would have been more beneficial", "No! No! No! Because most of the labs did not pertain to what we were doing in class", " I felt rushed to complete the material in 55 minutes", "I never really understood the labs and the lab teacher didn't help at all", " there were not enough labs on the difficult material", and "no, they were just more of the same thing. Nothing new was expressed".

On campus B, positive responses to the question, "Do you feel that the laboratory activities were a beneficial part of this course? Why or why not?" included the following: "yes, because we worked on things beneficial to us taking our test", "because we talked about math and discussed it, so I understood its application", " they really reinforce what we were trying to do throughout the chapters", and "they allowed students to practice in order to understand the chapter better". Negative responses included: "what we did in lab was not related to what we did in class", "we had to do the lab for a chapter before we had been able to read it", "no, because it was a waste of time", and "no, we did nothing and the material in the packet was not relevant at all".

The use of a commercial product allowed the students on campus A to easily identify the activities that were most relevant, the activities that they enjoyed the most, and the activities that helped them to have a better understanding of the material. Students tended to choose the same activities for all of these categories. The four activities that were cited the most by students were Factoring Crossword, Good Tasting Ratios, Off to Work We Go, and Let's Decorate the Classroom. Short descriptions of these activities are given below.

- Factoring Crossword: A crossword puzzle where the clues are polynomials that must be factored completely.
- Good Tasting Ratios: A paired activity that uses candy to provide practice with ratios and proportions.
- Off to Work We Go: A group activity that uses beads in a "real-life" work problem.
- Let's Decorate the Classroom: A group activity which requires students to measure the classroom and calculate areas.

Several students on campus B listed test reviews in the category of the most relevant activity. Many students left the questions about relevant activities, enjoyable activities, and the activities that helped them to better understand the material blank or stated that they could not remember a specific activity. Some students listed the instructor lectures, worksheets, or pretests as answers to these questions.

Retention by Gender in College Preparatory Mathematics II

Due to the differences in students' attitudes by gender, the researcher determined that there might be a difference in retention by gender if attitude plays a role in retention. Enrollment data for College Preparatory Mathematics II was gathered by gender for the spring term of 1998. Figure 4 shows the enrollment percentages by gender.

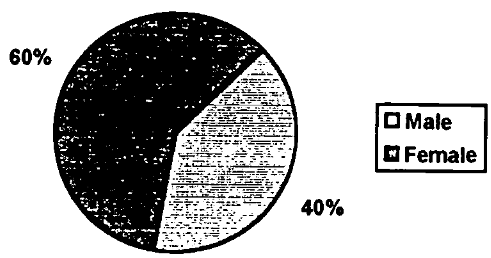


Figure 4: College Preparatory Mathematics II, MAT 0025, enrollment by gender

Figure 4 shows that 60 percent of the students enrolled in College Preparatory Mathematics II during the spring term of 1998 were female. Table 16 shows the college-wide retention rates by gender during the spring term. Students who received an A, B, or C passed. Students who received D, F, W, WP, or WF failed.

Table 16

Retention rates for College Preparatory Mathematics II, MAT 0025, by gender

	Males		Females	
	Pass	Fail	Pass	Fail
MAT 0025	520 (51.9%)	482 (48.1%)	798 (53.9%)	683 (46.1%)

The retention rate for females was 53.9%, and the retention rate for males was 51.9%. A hypothesis test to determine whether the difference in retention rates was significant found that the difference was not significant at the 90% level ($p = 0.33$).

In a further analysis of this data, retention rates were examined by campus. Figure 5 shows the percent of students retained in College Preparatory Mathematics II in the spring of 1998 for campus A and campus B categorized by gender.

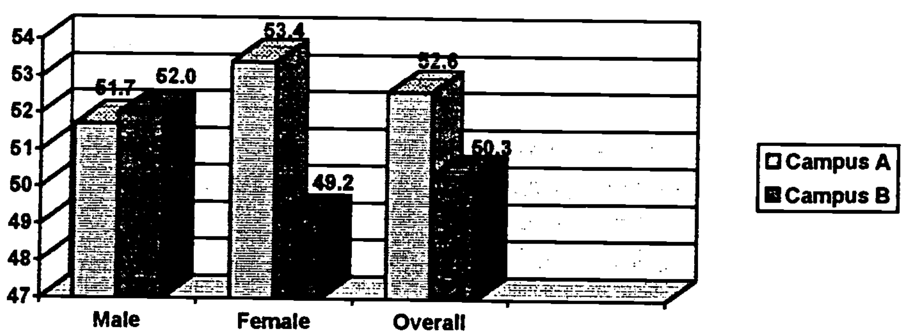


Figure 5: Percent of students retained in MAT 0025 by gender and campus

The group with the highest retention rate, 53.4%, was females on campus A. The group with the lowest retention rate, 49.2%, was females on campus B. Hypothesis tests showed that there were no significant differences in the retention rates between the campuses according to gender.

Retention by Age in College Preparatory Mathematics II

Students of different ages may be affected differently by the use of laboratory activities. In an effort to determine whether the age of students had an effect on retention in College Preparatory Mathematics II, the students were categorized into the following groups: 19 or under, 20-29, 30-39, and 40 or up. Figure 6 shows the percentage of students in age category enrolled in MAT 0025 during the spring of 1998.

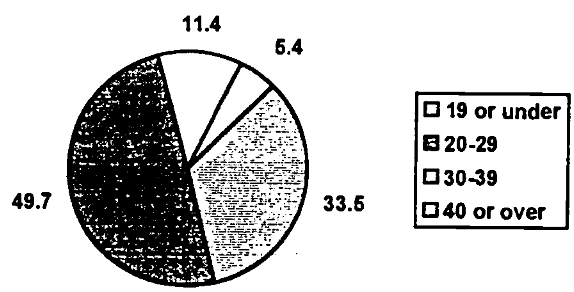


Figure 6: Percentage of students college-wide in MAT 0025 by age group

The largest percentage (49.7%) of students enrolled in MAT 0025 in the spring of 1998 are in between 20 and 29 years old. Thirty-three percent of the students are under 20 years old, 11.4 percent are between 30 and 39 years old, and 5.4 percent of the students are 40 or older.

Table 17 shows the retention rates of each age group by campus A, campus B, and college-wide. This data represented students enrolled in College Preparatory Mathematics II (MAT 0025) during the spring of 1998.

Table 17

Retention rates in MAT 0025 by age according to campus and college-wide

	Campus A		Campus B		College-wide	
Age	Pass	Fail	Pass	Fail	Pass	Fail
19 or under	212 (57.1%)	159 (42.9%)	160 (50.6%)	156 (49.4%)	456 (54.7%)	377 (45.3%)
20-29	309 (50.7%)	300 (49.3%)	208 (50.6%)	203 (49.4%)	636 (51.5%)	599 (48.5%)
30-39	40 (44.9%)	49 (55.1%)	53 (46.9%)	60 (53.1%)	148 (52.5%)	134 (47.5%)
40 or over	27 (62.8%)	16 (37.2%)	23 (53.5%)	20 (46.5%)	78 (58.6%)	55 (41.4%)
Total	588 (52.6%)	529 (47.4%)	444 (50.3%)	439 (50.3%)	1318 (53.1%)	1165 (46.7%)

Table 17 shows that the pass rate for all groups except the 30-39 year old group on both campuses had above a 50% retention rate. The highest retention rate of 62.8% was the 40 or over group on campus A. A chi-square test was done to determine if there were a difference between the retention rates by according to age group by campus. The null hypothesis was that no association existed between retention of the age group and the campus. The chi-square test statistics were $\chi^2 = 9.223$ and $p = 0.0264$. Therefore, the null hypothesis can be rejected, and there was a significant difference between the retention of different age groups on the campuses at the 95% significance level.

Results of Final Test in College Preparatory Mathematics II

In an effort to determine if students who used different laboratory materials learn and retain different material, students from 10 sections of MAT 0025 on campus A and 6 sections of MAT 0025 on campus B took a 20 question test over topics from the course outline. The test had 15 multiple choice questions and 5 open-ended questions. The results on the multiple choice section of the test are shown in Table 18.

Table 18

Number of multiple choice questions missed on a final test

	Campus A (n = 15)	Campus B (n = 15)
Mean, $\bar{x}$	10.1	10.3
Standard deviation	2.55	2.51
Sample size, n	207	97

The table shows that the students from both campuses missed approximately ten problems out of fifteen on the multiple choice section of the test. A 2-sample t-Test with a null hypothesis that the means were different had a p-value of 0.52. Therefore, there was no significant difference between the number of problems missed by campus.

To further analyze this data, the percentage of students who correctly answered individual multiple choice questions was analyzed by campus. These percentages are shown in Table 19.

Table 19

Percentage of multiple choice correct answers on a final test by campus

Question	Campus A	Campus B
1	80	78
2	68	77
3	92	92
4	69	75
5	68	68
6	56	52
7	64	61
8	47	65
9	43	48
10	77	79
11	66	60
12	80	69
13	49	54
14	93	94
15	55	59

Table 19 shows the percentage of students on each campus that correctly answered each question. A chi-square test to determine if there were no association between the rows and the columns yielded $\chi^2 = 5.452$ and $p = 0.978$. This means that the null hypothesis can not be rejected, and there are not significant differences overall in the percentage of students correctly answering the questions between the campuses.

An examination using two proportion hypothesis tests of individual questions found only three questions that have significant differences in the proportion of correct answers by campus. The questions, percentages, z-values and p-values of the questions are given in Table 20.

Table 20

Differences on selected questions by campus

Question	Campus A percentage	Campus B percentage	z-value	p-value
2	68	77	$z = -1.674$	$p = 0.0941$
8	47	65	$z = -2.905$	$p = 0.0037$
12	80	69	$z = 2.114$	$p = 0.0340$

Campus B had a significantly higher percentage of students than campus A answer questions 2 and 8 correctly. These questions were: (2) evaluate $y^2 - 2xy + 1$ for $x = 4$ and $y = -3$ and (8) simplify $(x^{-2}y)^{-3}$. Campus A had a significantly higher percentage of students than campus B answer question 12 correctly. Question 12 was: The table below gives the payment due on a charge balance at the end of the month. What is the payment due if you charge $380?

Input: Charge Balance	Output: Payment due
$0 to $20	Full amount
$20.01 to $500	10% or $20, whichever is greater
$500.01 or more	$50 plus the amount in excess of $500

The open-ended questions were analyzed as a group. First, the average points correct on each question by campus were computed. These data are shown in Table 21.

Table 21

Average points correct on final test open-ended questions

Question	Possible Points	Campus A	Campus B
16	7	3.871	3.964
17	4	2.228	1.907
18	4	1.092	1.68
19	4	1.481	1.938
20	7	2.682	2.572
Total	26	11.354	12.062

As shown in Table 21, campus A had a higher average score on questions 17 and 20. Campus B had a higher average score on questions 16, 18, and 19. A two sample z-test for means found no significant difference ($p = 0.20$) between the mean scores on the open-ended questions of the two groups.

Retention rates in College Algebra

Students seeking an Associate in Arts degree enroll in College Algebra after successfully completing College Preparatory Mathematics II. An analysis of retention rates in College Algebra was done to determine if the use of laboratory activities and multiple forms of representation in College Preparatory Mathematics II affects the retention in College Algebra. Retention rates in College Algebra (MAC 1105) for fall and spring terms of 1997-98 were computed for campus A and campus B. These retention rates are shown in Figure 7.

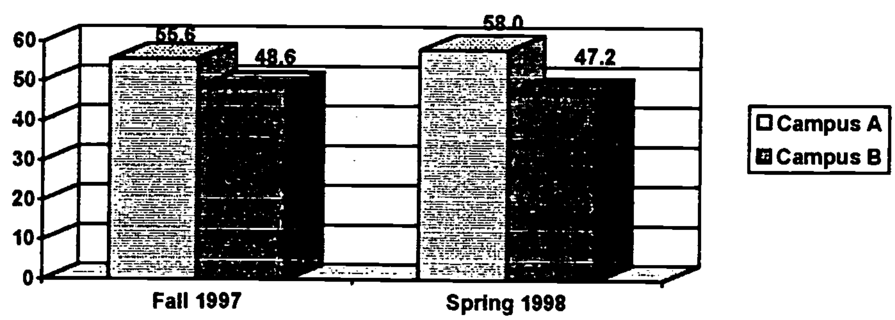


Figure 7: Retention rates in College Algebra (MAC 1105) by campus

Figure 7 shows that campus A had a higher retention rate than campus B during both terms of the study. The retention rate on campus A was 55.6 % compared to the retention rate on campus B of 48.6% during the fall term of 1997. Campus A also had a higher retention rate (58.0%) than campus B (47.2%) during the spring term of 1998. Two-sample proportion hypothesis tests found that there was a significant difference between the retention rates by campus during both terms in College Algebra. During the fall term the significance value was 0.021 and during the spring term the significance value was 0.000012.

Students in College Algebra may have various background mathematical preparation. During the terms of this study, students that had previously taken either the old course of Intermediate Algebra (MAT 1033) or the new course of College Preparatory Mathematics II (MAT 0025) were enrolled in College Algebra (MAC 1105). College Preparatory Mathematics II was taught using the numerical, analytical, and graphical methods of representation. Students also participated in laboratory activities. Intermediate Algebra was taught from primarily an analytical view and did not include a laboratory hour. Data from these groups of students were examined to determine if retention rates were affected by the use of laboratory activities and multiple forms of representation in the previous course.

During the fall term, there was a total of 1299 students enrolled college-wide in College Algebra. There were 71 students enrolled in College Algebra that had been successful in College Preparatory Mathematics II, and there were 406 students that had been successful in Intermediate Algebra. The retention rates of these students in College Algebra are shown in Table 22.

Table 22

Retention rates in College Algebra (MAC 1105) according to prerequisite course taken for fall 1997

Prerequisite Course	Success in MAC 1105	Percent successful
MAT 0025	26 students (n = 71)	36.7%
MAT 1033	189 students (n = 406)	46.6%

Due to the very small percentage of students (5.5%) enrolled in College Algebra that were successful in College Preparatory Mathematics II, no further statistical analysis was performed on this data.

During the spring term of 1998, there were 636 students enrolled in College Algebra that had successfully completed College Preparatory Mathematics II, and 525 students who had successfully completed Intermediate Algebra. Total enrollment in College Algebra college-wide was 1895 students. The retention rates of these two groups of students in College Algebra are shown in Table 23.

Table 23

Retention rates in College Algebra (MAC 1105) according to prerequisite course taken for spring 1998

Prerequisite Course	Success in MAC 1105	Percent successful
MAT 0025	386 students (n = 636)	60.7%
MAT 1033	262 students (n = 525)	49.9%

As can be seen in Table 23, the students who had previously completed College Preparatory Mathematics II (MAT 0025), had a retention rate of 60.7% in College Algebra. Students from Intermediate Algebra (MAT 1033) had a retention rate of 49.9% in College Algebra. A two-proportion hypothesis test to determine if there was a difference in the proportions resulted in $z = 3.68$ and a significance value of 0.00023. This indicates a significant difference in the retention rates in College Algebra between students in the two courses.

Because the treatment in the laboratory sections of campus A and campus B varied, retention in College Algebra of students who had previously enrolled in College Preparatory Mathematics II was computed for campus A and campus B. These retention rates are shown in Table 24.

Table 24

Retention rates in College Algebra (MAC 1105) by campus

Prerequisite Course	Campus A	Campus B
MAT 0025	67.1%	65.3%

The retention rate in College Algebra for students previously enrolled in College Preparatory Mathematics II was 67.1% on campus A and 65.3% on campus B. A two-proportion hypothesis test resulted in $z = 0.446$ and a significance level of 0.655. This indicates that there was not a significant difference between the retention levels of these students by campus. It should be noted that the retention rates for the students on both campuses of this study were higher than the college-wide retention rate of 60.7%.

In order to determine if the grade received in College Preparatory Mathematics II affects the grade received in College Algebra, cross tabulations were computed. These values are shown in Table 25.

Table 25

Cross tabulations of successful grade in MAT 0025 to grade in MAC 1105

MAC 1105 Grades	MAT 0025 Grades (n = 620)		
	A	B	C
A	75	22	3
B	61	59	27
C	30	66	43
D	4	23	22
F, W, WP, or WF	39	61	85

The frequencies in table 25 show that students who received an A in College Preparatory Mathematics II tended to get either an A (75 students) or a B (61 students) in College Algebra. Students who had received a B tended to get either a B (59 students) or a C (66 students) in College Algebra. Students who had received a C tended to get a C

(43 students). The number of unsuccessful students in College algebra was highest for the students who had received a C in the previous course. A chi-square test was done on this data. The null hypothesis was that the grade in MAC 1105 was not associated with the grade in MAT 0025. The results of the test were $\chi^2 = 141.89$ and a significance level of 9.57×10^{-27}. Therefore, the null hypothesis may be rejected which means that the grade in MAC 1105 is associated with the grade in MAT 0025.

Results of the statistical analysis components of the study have been described in detail in this chapter. The findings and discussion of those findings, including implications for further study, are presented in Chapter 5.

CHAPTER V

SUMMARY OF RESULTS AND DISCUSSION

Introduction

The purpose of this was to examine the effectiveness of College Preparatory Mathematics II (MAT 0025). The investigation into the effectiveness of the course was two-fold. First, it examined the effect of the use of laboratory activities in a college preparatory mathematics course on students' attitudes and retention. Campus A used a commercial product for the laboratory activities and the campus B used materials developed by instructors in the mathematics department of the campus. Secondly, it investigated whether the use of laboratory activities or the use of numerical, analytical, and graphical methods of solution in a college preparatory mathematics course would improve retention in the succeeding college-level course. This chapter summarizes the major findings of the study, and discusses the implications of the results. Suggestions for future research will also be discussed.

Study Overview

This study sought to investigate the use of different laboratory materials on students' attitudes towards: (1) the usefulness of mathematics; (2) their confidence in doing mathematics; (3) motivation in mathematics; and (4) the course and its accompanying laboratory hour. Another objective of this study was to determine if the use of different laboratory materials affected what course material the students learned and retained. Retention rates in both the college preparatory mathematics course, College Preparatory Mathematics II (MAT 0025), and the college-level course, College Algebra (MAC 1105), were examined for differences.

To accomplish these objectives, the researcher surveyed students in College Preparatory Mathematics II (MAT 0025) during the fall and spring terms of 1997-98 school year. Retention rates were analyzed in the two courses and compared to previously offered courses. The rates of retention in the college preparatory mathematics course were analyzed by campus, age, and gender. In College Algebra (MAC 1105), the retention rates were compared by campus and by previous course taken.

Results

The research questions follow with a discussion of the conclusions of the results in Chapter 4.

1. *Does the use of laboratory activities influence student retention in a college preparatory mathematics class?*

Retention was measured by successful completion of the course. Students were categorized as having been successfully retained if their final grade was an A, B, or C and unsuccessful if their final grade was a D, F, W, WP, WF, or I. The retention rates of the students enrolled in College Preparatory Mathematics II (MAT 0025) during the fall and spring terms of 1997-98 were compared to the retention rates of the previously offered course, Intermediate Algebra (MAT 1033) during the fall and spring terms of 1996-97. The new course, College Preparatory Mathematics II (MAT 0025), included a mandatory 1-hour laboratory component; whereas, the previous course did not include a laboratory component. Analysis indicated that the retention rates were significantly higher in College Preparatory Mathematics II (60.5% and 53.1%) than in Intermediate Algebra (47.3% and 48.1%) during both terms. Overall, students are more successful in the new course than in the previously offered course. This could be contributed to the additional time spent in class and in the laboratory hour.

Since the two campuses involved in the study used different types of laboratory activities, retention rates were investigated by campus to determine if one campus had a larger number of successful students than the other campus. During the fall term, campus B had a higher retention rate and, during the spring term, campus A had a higher retention. Neither difference in retention was statistically significant. It can not be concluded that retention was influenced by the type of laboratory activities.

Further analysis found no differences in the retention rate by gender. There was a statistically significant difference in the retention rates of different age groups between the two campuses. The 19 or under and 40 or over age groups had the highest retention rates on campus A. The 40 or over group had the highest retention rate on campus B with all other groups performing at approximately the same level. This could signify that different age groups prefer or are affected by different types of laboratory activities.

2. Does the use of laboratory activities and cooperative learning activities influence student attitudes in a college preparatory mathematics class?

There were no statistically significant differences between the students' attitudes on the Fennema-Sherman Attitude Scales by campus. Positive attitudes towards the usefulness of mathematics on both campuses were determined by the average scores on the Usefulness of Mathematics Scale. The average scores on the Effectance Motivation Scale found that the attitudes were very neutral. Fennema and Sherman (1976) had found that there was a difference between male and female attitudes as measured by the Fennema-Sherman Attitude Scales. This study agreed with those findings. Male attitudes were significantly more positive than female attitudes on all three attitudinal scales.

During the spring term, students' attitudes changed very little from the beginning of the term to the end of the term on the three Fennema-Sherman Attitude Scales. The least positive attitudinal scores were found on the course and laboratory scale. There was no significant differences between the campuses measured by the course and laboratory scale. There was a significant drop in attitudes from the survey given during the first week of the term compared to the survey given at the end of the term on this scale. This could be due to the fact that the students did not feel that the laboratory met their expectations. Some evidence of this could be found in responses to the open-ended survey which included: "this was a waste of time", "most of the labs did not pertain to what we were doing in class", and " the material in lab was done too late after the material was covered in class". Although the overall attitudinal scores were primarily neutral, many students expressed positive feelings about the laboratory on the open-ended survey. The responses on both campuses included that students felt that the extra practice and reinforcement of the material in the course provided in the laboratory was beneficial. Campus A students also felt that the laboratory helped to make the class more enjoyable, provided opportunities for group work, provided hands-on approaches, and practical applications. One notable difference was that the campus A students remembered particular activities that they thought were relevant or enjoyable while campus B students could not list single activities in these categories.

3. Does the type of laboratory activities affect what a student learns and retains?

Overall, the scores on the 20-question examination administered during the final exam period were not statistically different between the two campuses. Therefore, it can not be concluded that the use of different laboratory activities affected what the students learned or retained. There were significant differences on three individual questions. Campus B students scored significantly higher on two skill questions involving exponents and evaluating a polynomial. Campus A students scored significantly higher on a question involving calculating a credit card charge by interpreting a chart. These differences would be supported by the types of laboratory activities that the campuses used. Campus B students would have spent more time on skill worksheets than campus A students, and campus A students spent more time on application problems than campus B students.

4. Does the addition of laboratory activities and the use of numerical, analytical, and graphical methods in the college preparatory mathematics classroom affect student retention in college level mathematics classes?

The retention rates were compared in the new College Algebra course (MAC 1105) during the fall and spring terms of 1997-98 to the retention rates in the previously offered College Algebra course (MAC 1104) during the fall and spring terms of 1996-97. There was no difference between the retention rates during the fall terms. The retention rate in the new course was significantly higher during the spring term.

In an analysis of fall term retention rates in College Algebra (MAC 1105) by students who had previously enrolled in either Intermediate Algebra (MAT 1033) or College Preparatory Mathematics II (MAT 0025), it was found that students who completed Intermediate Algebra had a higher rate of retention than students from College Preparatory Mathematics II. As there were very few students (71) who had enrolled in College Preparatory Mathematics II during the summer term, most of the fall term students had previously enrolled in Intermediate Algebra (406) as the prerequisite course to College Algebra. Intermediate Algebra did not employ the use of laboratory activities or the use of numerical, analytical, or graphical methods. The fact that the students in the new course did not perform as well could be explained by the small number of students, or the fact that both the students and faculty were adjusting to the different approaches to teaching the new courses.

During the spring term, there was a similar number of students enrolled in College Algebra (MAC 1105) who had previously enrolled in College Preparatory Mathematics II

(MAT 0025) or Intermediate Algebra (MAT 1033). The students from College Preparatory Mathematics II had a statistically higher retention rate than the students from Intermediate Algebra. This result suggests that the use of laboratory activities or the use of numerical, analytical, and graphical methods in college preparatory course improves retention in the college-level algebra course. Also, the retention rates of the students from College Preparatory Mathematics II on the two campuses of this study were higher than the college-wide retention rate by at least five percent.

In further analysis, the retention rate of students in College Algebra, who had previously taken College Preparatory Mathematics II, was higher on campus A than on campus B, but the difference was not statistically significant. Also, an analysis to determine if the students' grades in College Algebra were associated with the grades received in College Preparatory Mathematics II determined that there was a very high correlation. This means that students receive similar grades in the two courses. This supports the fact that the students who are successful College Preparatory Mathematics II are well-prepared and tend to be successful in College Algebra.

Discussions and Recommendations

The type of laboratory activities did not significantly contribute to the overall retention rate of students. The female retention rate was higher than the male retention rate in the college preparatory course college-wide. Again, the female and male retention rates did not vary significantly by campus. The only significant difference between retention rates on the two campuses was among different age groups. This could be a result of the appeal of the different types of laboratory activities to different age groups.

There were no significant differences between the two campuses of the study on the scores on the attitudinal surveys. Male students had more positive attitudes than female students on both campuses. Although the Likert type questions found no differences between the campuses, the responses on the open-ended survey varied. The campus A students included group work, "real-world" applications, and relevance to the course and life as responses when describing why the laboratory was beneficial. These reasons were not mentioned by campus B students.

No significant differences were found on the students' overall performance on the examination questions. Several individual examination questions found differences between the campuses. Campus B students performed better on two skill questions and campus A students scored better on one application problem.

The new courses that were designed to implement the recommendations of the NCTM and AMATYC standards have significantly higher retention rates than the previously offered courses. Students in College Algebra who had taken the new college preparatory mathematics course, College Preparatory Mathematics II, were more successful than students who had completed the previously offered course, Intermediate Algebra.

Based upon these findings, the researcher makes the following recommendations:

- The college preparatory courses should continue to include the mandatory laboratory hour. The courses should also continue to use the numerical, analytical, and graphical methods. The success rates of students in the college preparatory course and the college-level course increased with the addition of these components.

- Because there were no significant differences between the campuses on overall attitudes and on overall performance on the examination questions, one type of laboratory activity can not be recommended. Based on students' responses to the open-ended questions, it is recommended that instructors of the college preparatory course include the use of group activities and applications of the material in the course. Also, the retention research showed that students are more likely to be retained if they feel a sense of belonging. The use of worksheets as reinforcement of the more difficult topics in the course is also recommended. Another recommendation is that the laboratory activities need to directly relate to the topics currently being covered in the course.

Implications for Further Study

Based on the findings of this study, the following recommendations are made for further research:

- A longitudinal study of the success rates of students who have taken College Preparatory Mathematics II should be undertaken. The purpose of the study would be to determine if the students continued to be successful in other college-level courses such as Precalculus, or the calculus sequence.

- This study examined all students enrolled in College Preparatory Mathematics II on the two campuses of the study. An assumption was that faculty used the materials provided for the laboratory hour but this was not guaranteed. An investigation of students in the classes of several core faculty who are committed to certain teaching techniques may find differences in students' attitudes or retention in the course.
- Because retention rates varied by age group, attitudes of the students in those groups may also vary. Studies have shown that improved attitudes can lead to improved retention. If the attitudes varied in the age groups, it might be a way to improve retention of certain age groups.
- The types of activities that different groups find useful, relevant, or beneficial. should be categorized. Preferences for different types of activities may vary by gender or age. This could provide a better basis to decide what types of activities should be included in the laboratory to improve retention of certain groups of students.
- The addition of Long's Reactive Behavior Patterns Checklist, the Myers-Briggs, or other similar instruments to this study may help to determine which types of activities improve students' learning. Students of certain personality types may have benefited more from the type of laboratory activities used on the other campus.

"There is no other decision that a teacher makes that has a greater impact on students' opportunity to learn and on their perceptions about what mathematics is than the selection or creation of the tasks with which the teacher engages the students in studying mathematics. Here the teacher is the architect, the designer of the curriculum" (Lappan & Theule-Lubbienski, cited in AMATYC, 1995, p. 47). If only for this reason, it is important for teachers to research what impact those decisions have on students' attitudes, learning, and success.

Appendix A

Community College Course Outline for College Algebra

COMMUNITY COLLEGE COURSE OUTLINE

Course Title:	College Algebra
Prerequisites:	College Preparatory Mathematics II with a grade of C or better or an appropriate score on entry placement test
Corequisite:	None
Credit Hours:	3
Contact Hours/Week:	3
Total Contact Hours Lecture/Discussion:	45
Terms offered:	1, 2, 3, 4, 5
Common Course Number:	MAC 1105

Catalog Course Description:
MAC 1105 credit hours 3 (3, 0)
College Algebra
Prerequisite: College Preparatory Mathematics II with a grade of C or better or an appropriate score on entry placement test. Course based on the study of functions and their role in problem solving. Topics will include graphing, the linear, quadratic, and exponential families of functions, and inverse functions. Students will be required to solve applied problems and communicate their findings effectively. Technology tools will be utilized in addition to analytical methods. Minimum grade of C is required if MAC 1105 is used to satisfy the mathematics requirement in general education.

Topics:

1. Functions
2. Graphs of functions
3. Families of functions
4. Inverses of functions
5. Systems of two variables
6. Technology
7. Communication

Effective Date: May, 1997 Review Date: No later than May, 2002

TOPICS

I. Functions
   A. Define function
   B. Model a function described in words
      1. as a set of ordered pairs
      2. as a table
      3. as an equation
      4. as a graph
   C. Identify the domain and range for a given function using set builder notation, interval notation, or a number line graph
   D. Determine whether or not a given relation is a function, using
      1. the definition of function
      2. the vertical line test as a graphical interpretation of the definition of function
   E. Use function notation
      1. f as a function name
      2. f(x) as a name for the range element (output) from function f associated with domain element (input) x
      3. (x, f(x)) as an ordered pair on the graph of function f
      4. find a function value given a table, graph, equation, or verbal description
      5. interpret expressions written in function notation in the context of applied problems (e.g. if g(x) gives amount of gas used in traveling x miles, interpret g(3) and/or g(5)-g(3))
   F. Translate the phrases "varies directly as" and "varies inversely as" into appropriate functions' equations

II. Graphs of functions
   A. Find intercepts
   B. Sketch the graph of a function manually and with the aid of an electronic device
   C. Predict the symmetry of a graph
      1. Complete the graph of a partially graphed function given that it is an even function
      2. Know that f(-x) = f(x) implies f is even
      3. Complete the graph of a partially graphed function given that it is an odd function
      4. Know that f(-x) = -f(x) implies f is odd
      5. Use (2) and (4) to determine whether or not a given function is even or odd
   D. Use graphical transformations
      1. Horizontal shifts

a. Recognize graphs which have the same shape but are positioned differently in the horizontal sense
b. Create the graph of $y = f(x - h)$ given the graph of f

2. Vertical shifts
   a. Recognize graphs which have the same shape but are positioned differently in the vertical sense
   b. Create the graph of $(y - k) = f(x)$ or $y = f(x) + k$ given the graph of f
3. Reflections through the x-axis
   a. Recognize graphs which have the same shape but are reflections of one another through the x-axis
   b. Create the graph of $y = -f(x)$ given the graph of f
4. Stretching and shrinking with respect to the x-axis
   a. Recognize graphs which are nonrigid transformations of one another
   b. Create the graph of $y = af(x)$ given the graph of f
5. The order of precedence of operations and its impact on graphing functions using multiple transformations

E. Estimate turning points by examining a graph (examples should include functions with multiple turning points)

F. Recognize the graphical relationship between a given linear function and the absolute value function which has the linear function as its argument

G. Graph rational functions with degree of denominator less than or equal to two and degree of numerator less than or equal to degree of denominator
   1. locate vertical asymptotes (include examples where denominator is zero when $x = c$, but $x = c$ is not a vertical asymptote)
   2. locate horizontal asymptotes

III. Families of Functions

A. Explore linear functions
   1. identify slope as the constant rate of change
   2. find an algebraic rule given a verbal statement about rate of change (e.g. $20 per day plus $0.25 per mile)
   3. identify $f(x) = mx + b$ as a linear function and determine the effect of m and b on the graph of f
   4. estimate the parameters m and b that fit a given data set (examine a scatter plot, pick two points to pass curve through, solve for m and b)
   5. classify as increasing, decreasing, or constant
   6. solve applied problems which are described by linear functions

B. Explore quadratic functions
   1. find axis of symmetry and vertex given parabola's algebraic form
   2. identify $f(x) = ax^2 + bx + c$ as a quadratic function and determine the effect of a and c on the graph of f

3. identify $f(x) = a(x - h)^2 + k$ as a quadratic function and determine the effect of a, h, and k on the graph of f
4. estimate the parameters a, h, and k that fit a given data set (examine a scatter plot, estimate h and k, pick one other point to pass curve through to find a)
5. transform standard form to vertex form
6. identify intervals of increasing behavior and intervals of decreasing behavior
7. solve applied problems that use quadratic functions (including maximum and minimum value problems)

C. Explore exponential functions
1. classify basic exponential functions as models of either exponential growth or exponential decay
2. interpret a constant percentage growth as an exponential function
3. contrast the growth rate of exponential functions with linear functions
4. identify $f(x) = A(b^x)$ as an exponential function and determine the effect of A and b on the graph of f
5. estimate the parameters A and b that fit a given data set (examine a scatter plot, pick two points to pass curve through, solve for A and B)
6. solve applied problems which are described by exponential functions
7. use logarithms as an analytical tool when dealing with exponential functions
   a. definition of logarithms
   b. three main properties of logarithms

D. Analytically and graphically solve equations and inequalities involving the families of functions studied, as well as equations and inequalities involving absolute value and rational expressions

IV. Inverses of Functions

A. Identify one-to-one functions graphically
B. Know that one-to-one functions have inverses which are functions
C. Recognize that the domain and range elements of inverses are reversed in each ordered pair, so that inverses are reflections of one another through the line $y = x$
D. Find a given one-to-one function's inverse, its inverse's domain, and its inverse's range
E. Use $f(f^{-1}(x))$ and $f^{-1}(f(x))$ to demonstrate the relationship between f and f^{-1}
F. Recognize logarithmic functions as inverses of exponential functions.

V. Systems in Two Variables

A. Solve linear and nonlinear systems of equations and inequalities graphically

B. Solve linear and nonlinear systems of equations by using the substitution method

C. Solve linear systems of equations by using the elimination method

VI. Technology

A. Demonstrate proficiency with a graphing calculator or computer as a support tool for problem solving

B. Distinguish between exact answers and approximations

C. Approximate the solutions to equations and inequalities graphically and/or numerically (examples should include equations which cannot be solved analytically)

VII. Communication

A. Express relevant mathematics in complete, clear sentences

1. verbally
2. in written form

B. Read and comprehend mathematical material at the MAC 1105 level in order to broaden knowledge independently

Appendix B

Community College Course Outline for College Preparatory Mathematics II

COMMUNITY COLLEGE COURSE OUTLINE

Course Title:	College Preparatory Mathematics II
Prerequisites:	College Preparatory Mathematics I with a grade of C or better or an appropriate score on entry placement test
Corequisite:	None
Credit Hours:	4
Contact Hours/Week:	5
Total Contact Hours Lecture/Discussion:	75
Terms offered:	1, 2, 3, 4, 5
Common Course Number:	MAT 0025

Catalog Course Description:
MAT 0025 credit hours 4 (4, 1)
College Preparatory Mathematics II
Prerequisite: College Preparatory Mathematics I with a grade of C or better or an appropriate score on entry placement test.
A continuation of College Preparatory Mathematics I. Presents algebraic skills for MAC 1105. Topics include operations on polynomials, linear equations, quadratic equations, rational expressions and equations, radical expressions, computation and approximation using a scientific calculator, and an introduction to functions. Applications emphasizing connections with other disciplines and the real world will be included. Not applicable toward mathematics requirement in general education or toward any associate degree at Valencia. A minimum grade of C is required in order to progress in mathematics. (Special Fee.)

Topics:

1. Mathematical competencies
2. Operations on Polynomials
3. Linear equations
4. Quadratic equations
5. Rational expressions and equations
6. Radical expressions
7. Introduction to functions
8. Communication

Effective Date: May, 1997 Review Date: No later than May, 2002

TOPICS

I. Mathematical competencies
   A. Articulate mathematical ideas
   B. Interpret and use appropriate mathematical terminology
   C. Determine if an answer is reasonable
   D. Demonstrate the efficient use of a calculator in solving problems
   E. Demonstrate the appropriate use of simplifying and solving processes taught in this course
   F. Justify results with logical explanations

II. Operations on polynomials
   A. Recognize and distinguish factors and terms
   B. Multiply binomials using FOIL
   C. Perform long division of polynomials
   D. Factor common factors, difference of squares, sum and difference of cubes, trinomials (CLAST guidelines for difficulty level), perfect square trinomials
   E. Develop a factoring strategy

III. Linear equations and inequalities
   A. Distinguish between linear and non-linear equations
   B. Solve any linear equation and inequality with real coefficients algebraically and graphically
   C. Use literal equations and formulas in applications
   D. Calculate the slope of a line and describe its meaning and uses
   E. Determine the slope and intercepts of a linear equation
   F. Graph a line using the slope and y-intercept
   G. Determine the equation of a line given
      1. slope and y-intercept
      2. two points
      3. point and slope
      4. a graph
      5. table
      6. collected data
   H. Describe the relationship between the graph, its points, and its equation
   I. Find the slopes of parallel and perpendicular lines and describe the relationship of the slopes
   J. Find the equations of lines parallel and perpendicular to a given line
   K. Graph inequalities in two variables
   L. Find an inequality in two variables given its graph
   M. Model and solve real world applications using linear equations in one or two variables
   N. Determine the units associated with the slope of a line used in a real world application

O. Model real data and interpret the results including appropriate units
P. Solve 2 X 2 linear systems graphically (equations and inequalities)
Q. Use input-output tables to describe linear relationships

IV. Quadratic equations
A. Distinguish between quadratic and non-quadratic equations
B. Solve quadratic equations by:
1. zero-product property
2. quadratic formula
3. graphical methods (rational roots only)
4. approximate irrational roots graphically
C. Determine the vertex of a quadratic equation
D. Graph quadratic equations (including $x = y^2$)
E. Identify the attributes (including the vertex, vertical intercept, line of symmetry, and concavity) of a parabola from its quadratic equation
F. Model and solve real world applications including appropriate units
G. Use literal equations and formulas in applications
H. Use input-output tables to describe quadratic relationships

V. Rational expressions and equations
A. Simplify
B. Multiply and divide
C. Find a common denominator
D. Add and subtract
E. Identify when rational expressions are undefined
F. Identify values which can not be solutions to a particular rational equation
G. Solve rational equations
H. Use input-output tables to describe rational relationships
I. Model and solve real world applications including appropriate units

VI. Radical expressions
A. Simplify radicals with real roots using real numbers
B. Simplify radicals with real roots (square and cube roots only)
1. variables
2. divide by monomial denominators
B. Approximate roots (no complex)
C. Multiply
D. Add and subtract
E. Evaluate for given values of variables
F. Use negative and fractional exponent rules to simplify
G. Convert between radical expressions and expressions with rational exponents

VII. Introduction to functions
A. Determine whether a relation is a function verbally, graphically and numerically

B. Recognize and interpret function notation
C. Evaluate a function algebraically and graphically
D. Make input and output tables of a function and interpret the input and output values mean in terms of the problem situation

VIII. Communication
A. Communicate their mathematical understanding of any given topic in written form.
B. Communicate their mathematical understanding of any given topic orally.
C. Read and learn mathematical material at a comparable level on their own.

Appendix C

Attitudinal Surveys

MAT 0025 Student Survey

The following survey is being given as part of a study. This is being used for research purposes; no one will know what your individual responses are.

Directions: The first several questions will help the researcher to classify the data collected. This is followed by a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed.

1. I am: A) Male B) Female

2. The math class that I took previous to this one at Valencia was:
   A) MAT 0003 B) MAT 0020 C) MAT 0024
   D) MAT 0025 E) None of these

3. The grade that I received in the last math class that I took was:
   A) A B) B C) C D) D E) other

4. I am _____ years old.
   A) Under 20 B) 20-29 C) 30-39 D) Over 39

Please mark the letter which describes the extent to which you agree or disagree with the following statements. If you strongly agree, blacken circle A. If you agree but with reservations, blacken circle B. If you disagree with the idea, indicate the extent to which you disagree by choosing D for disagree or E for strongly disagree. But if you neither agree or disagree or cannot answer the question, blacken circle C. Do not spend too much time with any statement, but be sure to answer every statement.

A = Strongly Agree
B = Agree
C = Neutral or Undecided
D = Disagree
E = Strongly Disagree

5. I'll need mathematics for my future work.

6. I study mathematics because I know how useful it is.

7. Knowing mathematics will help me earn a living.
8. Mathematics is a worthwhile and necessary subject.
9. I will need a firm mastery of mathematics for my future work.
10. I will use mathematics in many ways as an adult.
11. Mathematics is of no relevance to my life.
12. Mathematics will not be important to me in my life's work.
13. I see mathematics as a subject I will rarely use in my daily life as an adult.
14. Taking mathematics is a waste of time.
15. In terms of my adult life it is not important for me to do well in college preparatory mathematics.
16. I expect to have little use for mathematics when I get out of school.
17. Generally I have felt secure about attempting mathematics.
18. I am sure I could do advanced work in mathematics.
19. I am sure that I could learn mathematics.
20. I think I could handle more difficult mathematics.
21. I can get good grades in mathematics.
22. I have a lot of self-confidence when it comes to mathematics.
23. I am no good in math.
24. I do not think I could do advanced mathematics.
25. I am not the type to do math well.
26. For some reason even though I study, math seems unusually hard for me.
27. Most subjects I can handle okay, but I have a knack for flubbing up math.
28. Math has been my worst subject.
29. I like math puzzles.
30. Mathematics is enjoyable and stimulating to me.
31. When a math problem arises that I ca not immediately solve, I stick with it until I have the solution.
32. Once I start trying to work on a math puzzle, I find it hard to stop.

33. When a question is left unanswered in math class, I continue to think about it afterward.
34. I am challenged by math problems I can not understand immediately.
35. Figuring out mathematical problems does not appeal to me.
36. The challenge of math problems does not appeal to me.
37. Math puzzles are boring.
38. I do not understand how some people can spend so much time on math and seem to enjoy it.
39. I would rather have someone give me the solution to a difficult math problem than to have to work it out myself.
40. I do as little work in math as possible.
41. The material in the text has practical applications.
42. The lab activities contributed to my understanding of the material in the course.
43. The previous course helped to prepare me for this course.
44. The material in the labs has practical applications.
45. The mathematics learned in this course will be used in the future.
46. I am more comfortable solving word problems after taking this course.
47. I think that I have the ability to go on in mathematics.
48. I will not use the skills in the course outside of the classroom.
49. The material in the labs contribute to the understanding of the classroom material.
50. Solving application problems is easier after taking this course.

1. The most relevant laboratory activity was ________________________ because

2. The activity that I enjoyed the most was ________________________ because

3. The activity (or activities) that helped me to have a better understanding of a topic in the course was (were) ________________________ because

4. The activity that I disliked the most was ________________________ because

5. The method(s) of solving problems that I found the most helpful was (were) ________________________ because

6. The topic in the course that I understood the best is ________________________ because

7. Do you feel that the laboratory activities were a beneficial part of this course? Why or why not?

Appendix D

Final Exam Questions

MULTIPLE CHOICE: Put the letter of your answer in the blank on the answer sheet.

1. Simplify: $16x - 4(2x - 3)$

   a. $8x - 12$ b. $16x - 11$ c. $8x + 12$
   d. $24x + 12$ e. none of the above

2. Evaluate $y^2 - 2xy + 1$ for $x = 4$ and $y = -3$.

   a. 14 b. 16 c. 34
   d. 32 e. none of the above

3. Simplify: $(2x + 3)(x - 4)$

   a. $2x^2 - 11x - 12$ b. $2x^2 - 5x - 12$ c. $2x^2 - 5x + 12$
   d. $2x^2 - 12$ e. none of the above

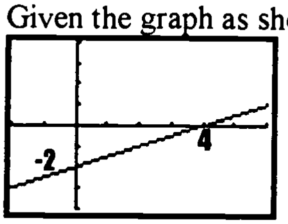
4. Solve: $\frac{1}{3}x + 2 = \frac{1}{2}x$

   a. $\{-12\}$ b. $\{2\}$ c. $\{-2\}$
   d. $\{12\}$ e. $\emptyset$

5. Solve: $-3x + 9 > 12$

   a. $x < -1$ b. $x < 1$ c. $x > -1$
   d. $x > 1$ e. $x > 7$

6. Given the graph as shown,



   the slope and y–intercept are:

   a. slope $= -\frac{1}{2}$, $(0, -2)$ b. slope $= \frac{1}{2}$, $(0, -2)$ c. slope $= 2$, $(-2, 0)$

   d. slope $= \frac{1}{2}$, $(-2, 0)$ e. none of the above

7. Simplify: $\sqrt{36t^{14}}$

a. $6\,|t^{14}|$

b. $6\,|t^{7}|$

c. $18\,|t^{7}|$

d. $\sqrt{6t^{7}}$

e. none of the above

8. Simplify: $(x^{-2}y)^{-3}$

a. $\dfrac{x^6}{y^3}$

b. $\dfrac{1}{x^5y^3}$

c. $\dfrac{x^6}{y^2}$

d. $\dfrac{-1}{x^5y^2}$

e. none of the above

9. Perform the operations indicated and reduce the answer to lowest terms:

$\dfrac{7}{x-3} - \dfrac{x+3}{x-3}$

a. $\dfrac{-x+4}{x-3}$

b. $\dfrac{-x+10}{x-3}$

c. $\dfrac{-4}{3}$

d. $\dfrac{-4x}{x-3}$

e. none of the above

10. Find the slope between the points (–2, 6) and (–3, –2)

a. 8

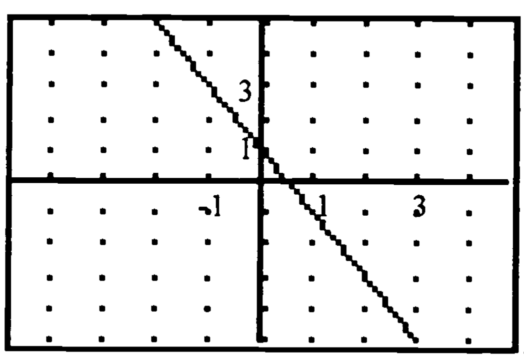
b. 1

c. $\frac{1}{8}$

d. $-\frac{4}{5}$

e. $\frac{1}{4}$

11. Given the graph as shown, when x = 2, y = ____________?



a. 0.5

b. –3

c. 1

d. 3

e. –0.5

12. The table below gives the payment due on a charge balance at the end of the month. What is the payment due if you charge $380?

Input: Charge Balance	Output: Payment due
$0 to $20 Full amount	
$20.01 to $500	10% or $20, whichever is greater
$500.01 or more	$50 plus the amount in excess of $500

a. $380
b. $20
c. $38
d. $50
e. $418

13. You have saved $5500 for living expenses at college. If you spend x dollars per month, the number of months that your money will last is:

a. 5500–x
b. 5500–12x
c. $\frac{5500}{x}$
d. 5500x
e. none of the above

14. Your phone company charges $20 per month and $.15 per minute for long distance. If you have x minutes of long distance calls in a month, your total charge will be:

a. $20.15
b. $20.15x
c. 20x + .15
d. 20 + .15x
e. 3x

15. The table below gives two points on a line which has slope of $\frac{-4}{3}$. Which of the following points is also on the line?

x	y
–1	9
2	5

a. (3, 1)
b. (–4, 8)
c. (5, 1)
d. (5, 9)
e. (6, 2)

PROBLEMS:
Show all work for the following problems for full credit.

16. Given $y = x^2 - 2x - 3$,
    A) Find the x-intercepts.
    B) Find the y-intercept.
    C) Find the vertex.
    D) Find the line of symmetry.
    E) Graph.

17. Solve the system of equations.
    $$\begin{cases} x - 2y = 10 \\ y = 3x + 5 \end{cases}$$

18. The world consumption of oil can be calculated by the use of the function: $C(t) = -0.1 t^2 + 2t + 58$ where C represents the consumption in millions of barrels daily and t is the number of years since 1985. ($t = 0$ corresponds to 1985.) Use algebra to calculate the following and be sure to include units.
    A) In what year will the consumption of oil reach a maximum value?
    B) How much oil will be consumed in that year?

19. A candy selection of 5 gumdrops and 8 caramels makes 511 calories. Another selection of 3 gumdrops and 10 caramels makes 525 calories. How many calories in a piece of each kind of candy?

20. A student prices the cost of cellular phone service. The cost of the service depends on the number of minutes included in the plan. The data is shown in the table below.

minutes	cost of plan
100	17.95
300	41.95
400	53.95
900	113.95

    A) Is the data linear? If it is, find the slope. Interpret what this represents in terms of minutes and cost.
    B) Find the cost of 0 minutes.
    C) Find an equation of the cost of cellular service in terms of the minutes.
    D) How much would it cost if you wanted a plan that has 600 minutes?

MAT 0025 FINAL EXAM Name ________________

Multiple Choice

Answer the multiple choice questions on the Scantron sheet provided. Use a number 2 pencil, only fill in one answer per question and erase any changed answers completely.

Problems

16.a) [2 pt]

b) [1 pt] y-intercept =

c) [1 pt] vertex:

d) [1 pt] line of symmetry:

e) [2 pts]

17. [4 pts]

18.a) [2 pts]

b) [2 pts]

19. [4 pts]

20.a) [3 pts]

b) [1 pt]

c) [2 pts]

d) [1 pt]

Appendix E

Scoring Rubric for the Final Exam Questions

Questions 1-15	Multiple Choice, No Partial Credit, 2 points each
Question 16	Part A - 2 points, 1 point for each x-intercept
	Part B - 1 point for the y-intercept
	Part C - 1 point for the vertex
	Partial credit may be given if only the x-coordinate is correct.
	Part D - 1 point for the line of symmetry
	Part E - 2 points for the graph (1 point for showing the complete graph and 1 point for a correct scale and plotting points correctly)
Question 17	2 points for using a valid method of solution
	2 points, 1 point for each correctly solved variable
Question 18	Part A - 2 points, 1 point for knowing that the maximum occurs at the vertex, 1 point for correctly finding the year
	Part B - 2 points, 1 point for finding C(10), 1 point for finding the correct solution
Question 19	2 points for finding the system of two equations
	1 point for using a valid method of solution
	1 point for writing the correct solution (including identifying the variables)
Question 20	Part A - Total of 3 points, 1 point for finding whether the data is linear, 1 point for finding the slope, 1 point for a correct interpretation of the slope in terms of minutes and cost
	Part B - 1 point
	Part C - 2 points, 1 point for writing an equation (y = mx + b) and 1 point for correctly identifying m and b.
	Part D - 1 point

There is a total of 56 points for the exam questions. Thirty points are for the multiple choice questions and 26 points are for the open-response questions.

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