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School of Education

ACADEMIC PERFORMANCE AND ENGAGEMENT OF EDUCATIONAL OPPORTUNITY PROGRAM STUDENTS IN A COLLEGE ALGEBRA EXTENDED CLASS AT THE STATE UNIVERSITY OF NEW YORK, NEW PALTZ

A Dissertation
Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
Courtney Anthony Pindling
March 2006
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ABSTRACT

ACADEMIC PERFORMANCE AND ENGAGEMENT OF EDUCATIONAL OPPORTUNITY PROGRAM STUDENTS IN A COLLEGE ALGEBRA EXTENDED CLASS AT THE STATE UNIVERSITY OF NEW YORK, NEW PALTZ

by

Courtney Anthony Pindling

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Name of researcher: Courtney Anthony Pindling

Name and degree of faculty chair: Jimmy Kijai, Ph.D.

Date completed: March 2006

Problem

The purpose of this study was to describe the academic performance of a group of Educational Opportunity Program (EOP) students in a College Algebra Extended Program (CAEP) at the University of New York, New Paltz. Generally, EOP students are admitted with low mathematics placement scores. In the past, they would have been required to do remedial math. However, since college remedial math is no longer available, the CAEP was implemented to remedy this problem. This study was conducted to examine how a small group of EOP students performed in this course.
Method

A descriptive research design was used to examine the performance of the EOP students in the CAEP class. Twelve students completed the course. Data collected included attitudes towards the course using both surveys and personal interviews, pretest and posttest algebra performance, homework, quizzes, midterm and final examinations, learning styles, and concept model application test. Parametric and non-parametric statistics were used to analyze quantitative data while content-analysis was used for the interview data.

Results

Students showed significant improvement between pretest and posttest scores (36% increase). There was no significant relationship between math performance and gender or race. Math Placement Level (MPL) was significant related with performance on workshop assignments while learning style was related significantly with performance on homework assignments. The workshop index score (measure of concepts mastery) and performance in quizzes, workshop, and midterm exam were significantly correlated with their performances on the final exam. Students preferred classroom and workshop learning environments to online pedagogy; however, they found online resources to be most helpful when rich in problem-solving examples.

Conclusions

Although a College Algebra Extended program can provide success in helping students pass college algebra, students may need more time to assimilate the large amounts of information covered. Knowledge of students’ MPL and mastery of math concepts may be used to better place EOP students in College Algebra course as well as indicate helpful pedagogical approaches to math instructions and learning.
Pedagogical approaches that allowed active learning and opportunity for group instruction and learning were major contributors to students’ success in learning college algebra.
To

Little Kimmy, my inspiration, and to all my EOP math students
who have taught me more than I have them
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Thanks to Jimmy Kijai for his profound insights and counsel during these past two tumultuous years. Ellen G. White in the book Education said, "The true teacher can impart to his pupils few gifts as valuable as the gift of his own companionship" (p. 212). Special thanks to Shirley Freed who opened my eyes to the rich quality and quantity of information that qualitative research can provide and Larry Burton who gave me the self-confidence to work outside of the boundaries of the possible to that of the probable where curriculum design was concerned.
CHAPTER ONE

INTRODUCTION

Foreword

The roots of the State University of New York (SUNY) at New Paltz go back to a school founded in 1828 to teach the classics, and it was later established as the New Paltz Academy in 1833. It became a Normal School in 1886, and joined SUNY in 1948 when the State University of New York was created. Today, SUNY New Paltz is a comprehensive institution that defines its essential character by its location in the mid-Hudson region, its commitment to the primacy of teaching, its ethnically and culturally diverse student population, and its emphasis on internationalism. Programs in the liberal arts and sciences serve as the foundation for professional programs in the fine and performing arts, business, health care, computer sciences, education, and engineering. New Paltz is one of only two public residential 4-year institutions between New York City and Albany, and the only one in the Mid-Hudson Valley corridor. New Paltz is deeply committed to serving the educational needs of the citizens of the mid-Hudson region and the greater New York metropolitan area, and this regional focus is particularly important in many of the graduate and professional programs (SUNY & SUNY New Paltz, 2000, p. 1).

An important facet of New Paltz’s commitment to diverse educational experiences involves both bringing international students to the campus and offering New
Paltz students opportunities to experience other cultures first-hand (SUNY & SUNY New Paltz, 2000, p. 1).

SUNY New Paltz had a total student population of 7,800 in 2000 (a steady state enrollment in recent years) with an undergraduate population of 6,200 students. African-American and Latino students make up 16% of its undergraduate population (SUNY New Paltz, 2001, p. 1). However, sustained growth in the number of new freshmen of color has continued throughout the decade. Overall growth during this period occurred primarily because of significant increases in the Latino student population. Along with the growth in minority student population at SUNY New Paltz the yearly cost of tuition and fees has increased by 49% from 1991 to 2000 whereas the state’s contributions to the college operating budget has dropped from 44% in 1991 to 37% in 1999 (SUNY New Paltz, 2001, p. 3).

The commitment to maintaining and enhancing the diversity of the student body to reflect the local community’s demographics was reflected in the class successfully recruited for fall 2000 (Table 1), including the largest number of students of color since the inception of the Multicultural Recruitment Program (MRP). MRP and Educational Opportunity Program (EOP) students (from traditionally underrepresented groups) increased by 31% and 12% respectively. Additionally, there was a 54% increase from 1999 (72 vs. 111) in the number of students who self-identified as African-American, the largest number since 1985 (SUNY New Paltz, 2001, p. 15).
Table 1

*State & Local Diversity Statistics (in Percentages)*

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<tr>
<td>African-American</td>
<td>15.9</td>
<td>7.2</td>
<td>6.6</td>
</tr>
<tr>
<td>Latino</td>
<td>15.1</td>
<td>7.8</td>
<td>7.7</td>
</tr>
<tr>
<td>Asian-American</td>
<td>5.5</td>
<td>1.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Total</td>
<td>36.5</td>
<td>16.7</td>
<td>18.0</td>
</tr>
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</table>

*From U.S. Census Bureau, Census 2000 Summary File 1, Matrix P8.*

The impact that diversity has on change in student population at SUNY New Paltz between 1991 and 2000 is as follows (SUNY New Paltz, 2001, p. 12):

1. The number of students from traditionally underrepresented groups has increased by 19%.

2. Students from traditionally underrepresented groups represent a growing proportion of student population, from 17% in 1991 to 22.8% in 2000.

3. The number of Latino students has increased by 35%.

4. The number of Asian students has increased by 35%.

Approximately 92% of the University’s entering students are residents of New York State. Of the remainder, approximately 4% are residents of other states and 4% are from foreign countries (SUNY New Paltz, 2001, p. 15).
SUNY New Paltz Campus Mission

The State University of New York at New Paltz is committed to providing high-quality, affordable education to students from all socio-economic backgrounds. SUNY New Paltz is a faculty and campus community dedicated to the construction of a vibrant intellectual/creative public forum that reflects and celebrates the diversity of its society and encourages and supports active participation in scholarly and artistic activity. SUNY New Paltz is an active contributor to the schools, community institutions, and economic/cultural life in its region. SUNY New Paltz strives to be an innovative teaching/learning community committed to diversity, affordability, and excellence (SUNY New Paltz, 1999, p. 2).

Educational Opportunity Program at SUNY New Paltz

About 20% of students at SUNY New Paltz are minority students (African-American [Blacks], Asian-American, Hispanics [Latinos]). Many of them are academically and financially disadvantaged. They possess high-school diplomas or its equivalent, but do not meet general admission criteria; they are often accepted with low SAT scores.

Many are first-generation college students. As a response to these promising, though academically and financially disadvantaged students, SUNY (including New Paltz) offers the Educational Opportunity Program (EOP).

The mission of the Educational Opportunity Program is twofold: first, the program seeks to recruit and admit students who otherwise would not have access to the University due to educational and financial disadvantages. Second, the program provides comprehensive services to support the success, retention, and graduation of its students.
These services, by definition, are to extend beyond that which is available to the rest of the student body.

Although each campus's EOP program is slightly different, all campuses participating in EOP offer financial aid for room, board, books and expenses. Other services may include (Chase, 2004):

1. diagnostic testing for prospective and admitted students to determine their academic needs
2. tutoring services for students who need additional help with their courses
3. personal, academic, and career counseling to help students adjust to college life
4. pre-freshman summer programs with instructional and other supportive services for students entering their first semester.

Statement of Problem

College Algebra is a required general education course. Many EOP students do not have the pre-requisite mathematics skills to be in College Algebra. They generally have to take Basic Algebra first. However, this course is no longer offered at SUNY (including New Paltz). This places many EOP students at a disadvantage.

In response to this need, the College Algebra Extended Program (CAEP) was developed and pilot tested during the fall of 2003. The study focused on the three primary components of CAEP, namely: classroom, workshops, and online pedagogies.

Since the early 1980s, after the study *A Nation at Risk* (U.S. Department of Education, 1983) and more recently the Glenn Commission report (U.S. Department of Education, 2000), achieving mathematics competency has been a major priority of the United States of America in being competitive with other developed nations. Many EOP
students are admitted to college because of affirmative action programs and often lack the pre-requisite mathematics skills needed for College Algebra. This study, in the fall of 2004, examined the feasibility of an extended mathematics program helping students learn college algebra.

**Purpose of Study**

The purpose of this study was to investigate the academic performance of Educational Opportunity Program students in a College Algebra Extended Program (CAEP) at SUNY New Paltz. In addition, this study examined how certain personal and pedagogical variables were related to the learning of algebraic concepts. EOP students’ success in this course may open doors to academic careers in Mathematics, Science, Technology, and Business-related programs.

**Research Questions**

1. What is the mathematics performance of EOP students in CAEP?
   a. How will students perform on pretest and posttest assessments?
   b. How well do students do on homework, workshop, quizzes, concept-model-application (CMA), midterm and final exam mathematics achievement tests?

2. To what extent do performance (homework, quizzes, midterm and final exams, CMA test, and pretest and posttest) in college algebra relate to certain demographic variables (race and gender)?

3. To what extent do certain personal variables (learning styles, Math Placement Levels [MPLs], and primary language) influence students’ performance (homework,
quizzes, midterm and final exams, CMA test, and pretest and posttest) in College Algebra?

4. Which pedagogical approaches (classroom instructions, workshops, online resources) do students find most helpful?

5. How is students' mastery of mathematics concepts (workshop index scores) related to their performance on problem-solving questions (word problems or quiz-type questions on midterm and final exams)?

6. Which achievement variables (homework, quizzes, workshop index, midterm exam, and CMA test) are related to students' college algebra performance (scores on the final exam)?

7. In what ways will the College Algebra Extended Program enrich students?

**Brief Program Description**

**Program Overview**

The College Algebra Extended Program was designed specifically to help students with poor math placement levels succeed in college mathematics. This modified course provided additional instructional support for EOP students who normally needed to take both remedial Basic Algebra and regular College Algebra to fulfill their minimum college mathematics requirement. It was important because Basic Algebra is no longer offered at SUNY New Paltz because of a recent change in SUNY’s college entrance requirements for mathematics competency. College Algebra Extended Program provided students with additional instructional support in both Basic Algebra and College Algebra and met for 6 hours each week instead of 4 hours for a typical College Algebra course. The computer-assisted extended College Algebra course consisted of at least 3 hours of
regular classroom instructions, at least 3 hours of classroom workshops, and 2 hours of online support per week. The same instructor was involved in all three educational supports.

At the beginning of the program or course, students took a pretest, which was similar to the final exam in content, and their individual learning styles assessed. Classes met for 2 days each week over a 14-week period for 3 hours each day. The first hour and a half was regular classroom instruction, and the last hour and a half was a workshop. Students were required to spend at least 2 additional hours online each week doing interactive homework and using various multimedia educational resources for both Basic and College Algebra. Throughout the semester (14-week period), students took surveys, quizzes, weekly homework and workshop assignments, a midterm exam, a concept-model-application (CMA) exam online near the end of the course, a posttest (the same pretest), the final exam, and a post-course interview. The computer-assisted software monitored and recorded each student’s online usages. Chapter 3 presents a comprehensive description of this program or CAEP curriculum.

Learning Outcomes

One of the program's (CAEP) main objectives was to design a curriculum to help EOP students achieve certain learning outcomes. These learning outcomes, established by the EOP department at New Paltz, were to help students:

1. Meet the minimum requirements for Basic Algebra proficiency by getting at least a D in College Algebra Extended

2. Meet the minimum requirements for General Education (GE-II) mathematics (C- in College Algebra Extended)
3. Build strong contextual knowledge of College Algebra (50% or above on Part 3 of College Algebra common final exam)

4. Develop and improve their knowledge of college mathematics (significant improvement from pretest to posttest).

**Conceptual Framework**

The underachievement of racial and language minorities, females, and students with low socioeconomic background in mathematics has been well-documented (Erickan, McCreith, & Lapointe, 2005; Oakes, 1990; Secada, 1992; Swarat, Drane, Smith, Light, & Pinto, 2004). Four main factors contribute to the low mathematics achievement of these minority groups: personal factors, demographic factors, institutional factors, and social/cultural factors (see Figure 1).

The demographic factors include those factors or variables that are recognized as background information about the learner which are often unchangeable because of physical or social characteristics. Variables such as gender and race or ethnicity are considered demographic variables (Byrnes, 2003; Gurian & Stevens, 2004). For example, cross-cultural research studies have shown that in some countries female students’ scores on standardized math tests are equal to or better than males’. This suggests that American females’ poor representation in fields requiring mathematics is a cultural phenomenon (Gray, 1981; Hanna, 1989; Rowley, 2004).

The personal factors include those factors or variables that the learner brings to the learning environment. They include such complex attributes as individual learning styles, instructional and assessment preferences, prior knowledge, attitude of self,
instructor or the instructional media, primary language, and physical or various learning disabilities. Prior knowledge influences how the instructor and students interact with the

![Figure 1. Factors that affect learning outcomes.](image)

learning material and the environment as both individuals and a group (Kalyuga & Sweller, 2004; Kujawa & Huske, 1995). To facilitate students learning new materials, instructors should link classroom activities and instruction to students’ prior knowledge (Beyer, 1991). At the Center for the Study and Teaching of Learning Styles in New York, researchers found that students when presented with new materials through their preferred learning channel (style) tend to remember significantly more than when they are taught through their least preferred learning channel (Dunn & Dunn, 1978, 1979; Keller & Reigeluth, 2004).
The institutional factors are those factors or variables that the learning environment imposes upon the learner in order to facilitate learning or learning outcomes. These variables are the instructor, instructional pedagogy, computer-assisted support, assessment tools, instructional materials, learning environment, and accommodations to certain learning disabilities. The literature is rich with studies of how these institutional variables affect learning outcomes (Berliner, 2005; Borman, 2003; Hrabowski, 2003; Vodounon, 1995). Cohen recommended using cooperative learning strategies to help underrepresented groups improve their educational performance (Cohen, 1986).

The social/cultural factors are those factors or variables that help shape the learner’s perspective on how his or her learning experience/environment is viewed or conceptualized and experienced. Some of these variables are economic posture (family income, for example), family values, community support, social learning, cultural norm and behaviors, exposure to educational technology (computers in the home, for example) and family structures (single-family home life, for example). There is often some overlap between some demographic variables and social/cultural variables; for example, race is both a demographic and cultural variable. One example of the social and cultural factors on mathematics education was Anyon’s comparative study of how the mathematics classrooms received very different types of instruction for five schools in different socio-economic neighborhoods in two nearby districts (Anyon, 1980, pp. 67-92). Another example is the influence that a person’s parental belief has on one’s math achievement as well as career choices (Bleeker & Jacobs, 2004).

For the variables (Figure 1) to interact effectively, in the context of the College Algebra Extended Program, the following assumptions were made:
1. Certain instructional approaches such as cooperative, collaborative, and social learning strategies will benefit this group (Byrnes, 2003; Dilig, 2003; Hazelbaker, 1998; Romberg, 2004; Swarat et al., 2004).

2. Computer-assisted educational design may provide opportunity for learning at the student’s own pace and was designed to target specific learning styles to optimize individual learning (Blackner, 2003; Campbell, 1996).

3. “It takes a community”: EOP’s social learning community is designed to provide support of tutors, peers, and faculty mentors in a community setting to help motivate interest in learning. Motivation is a key ingredient to mastery learning of any subject (Borman, 2003; Cokley, 2003; Reyes, Scribner, & Scribner, 1999).

4. Exposure to an abundant number of examples of fully worked out solutions to mathematics problems enhances learning (Carroll, 1994; Linn & Hsi, 2000).

5. Guided on-line learning resources (College Algebra On-line Resources) enhance mathematics learning (Moren & Duran, 2004), especially for all types of learners if cooperative learning is involved (Vodounon, 1995).

6. An educated learner can adequately assess the degree and effectiveness of learning and so with appropriate feedback an educational technologically adept instructor may customize instructional deliveries for effectiveness and individualized instruction (NCTM, 1997b; Pietsch, Walker, & Chapman, 2003; Stevens, Olivarez, Lan, & Tallent-Runnels, 2004).

This research examined the influence which certain demographic variables (gender and race), personal variables (learning styles, prior knowledge, and primary language), and some institutional variables (instructional pedagogy, computer-assisted
pedagogy, and assessment strategies) had on EOP students’ mathematics performance. These were the only variables studied since the purpose of this research was to examine the mathematics performance for some disadvantaged minorities and how such performance may be influenced by these selected demographics, personal and institutional variables.

One of the main objectives of this study was to help these students build strong contextual mathematics knowledge through sound pedagogical approaches appropriate to these learners with various learning needs. The building of students’ conceptual mathematics knowledge required developing strong associations between their mathematics concepts, learning appropriate models (formulas), and application or problem-solving skills (see Figure 2). Therefore, this research tried to measure the degree of association between these three elements of mathematics learning.

![Steps to Math Problem Solving](image)

Figure 2. Mathematics model: Concept-model-application.

**Significance of the Study**

This research was conducted because basic college-level mathematics skills are prerequisites to placement in academic programs in Mathematics, Science, Engineering,
and Business. Additionally, a strong foundation in college algebra may lead to job opportunities that offer better economic prosperity to many (Moncarz & Crosby, 2005).

Results from this study will help expand the knowledge of how best to improve the pedagogy and learning outcomes of minority and other groups of students who traditionally do poorly in college-level mathematics. The role and nature of instructional pedagogy, group study, and online or technology-assisted learning specific to minority students’ performance in mathematics at the college-level was examined. This study provided a better understanding on how to make extended algebra programs more effective for EOF and minority students by understanding how various factors may be optimized to improve performance in college algebra. Students’ success in College Algebra could open doors to many academic careers requiring fulfillment of the general education mathematics requirements.

Limitations

The research was conducted specifically to understand how best to help underprepared EOP students succeed in mathematics? Therefore, the number of students enrolled each semester varied based on the number repeating college algebra courses, recruitment successes, EOP students’ interest in academic programs requiring college algebra as a minimum requirement (traditionally EOP students avoid these programs because of the challenging math requirement), and funding concerns.

During any given semester, the population of EOP students taking college algebra is very small; for this research, 18 students originally enrolled. Only 12 completed the course. Therefore, the effective sample size for this study was limited to only 12 students.
This study did not have a control group. There was no similar group of students
with these characteristics and treatments prior to this program or since its termination in
the fall of 2005.

EOP students are considered a protected group because of their educational and
economic disadvantage; therefore, certain demographics data could not be reported
without strict scrutiny in compliance with appropriate federal laws and regulations.
Results collected on these students were de-identified prior to reporting (i.e., the removal
of any personal or specific information that may identify who the subject of the research
was). None of the eight categories of protected information of the No Child Left Behind
(NCLB) Act (2001) was collected for this study. These eight categories were a recent
amendment to the No Child Left Behind Act (Selwitz, 2003).

**Definitions of Terms**

**Affirmative Action:** The Webster's New College Dictionary defines Affirmative
Action as “a policy or program that seeks to redress past discrimination by increasing
opportunities for underrepresented groups, as in employment” (Webster, 1999, p. 19).

**De-identified:** The removal of any personal or specific information that may
identify who the subject of the research or study is.

**Diversity:** The National Council for Accreditation of Teacher Education
(NCATE) in its Standards for Professional Development Schools defines diversity as
“differences among groups of people and individuals based on race, ethnicity,
socioeconomic status, gender, language, exceptionalities, religion, sexual orientation, and
geographic region in which they live” (NCATE, 2001, p. 30).
Educational Opportunity Program (EOP): A program designed to assist educational and economically disadvantaged groups through financial and educational opportunity initiatives.

Underrepresented: Implies that certain colors, races, ethnicities are not proportionately represented in employment or education as their proportions in the populations or the communities in which they live.

Overview of Methodology

This research design used both quantitative and qualitative data to describe the mathematics performance and the experiences of a group of EOP students in a College Algebra Extended Program class. Basically, this study used the one group pretest-posttest design with no control group. Comparative and correlational approaches were also used. A post-course interview was also conducted.

Organization of the Study

This dissertation is organized into six chapters. Chapter 1 is an introduction, which presents the following: introduction, statement of problem, purpose of study, research questions, brief program description, conceptual framework, significance of study, limitations, definitions of terms, overview of methodology, and organization of the study. Chapter 2 is the literature review for this study, which covers the following: the need for mathematics education in the United States, learning theories/outcomes, factors affecting students' performance, mathematics performance, technology in mathematics education, minority performance in mathematics, and a summary. Chapter 3 presents the research methodology, which includes the following: introduction, research design,
population and sample, variables, instrumentation, procedure, human subject
consideration, analysis of data, and summary. Chapter 4 presents the description and
implementation of the College Algebra Extended Program. This chapter includes the
following: introduction, program development, course content and design, pedagogical
illustrations, instructor narrative, and summary. Chapter 5 shows the results of this study.
It includes the following: an overview, demographics analysis, research questions
findings, other results, and a summary of major findings. Chapter 6 presents the
conclusions of this study. This includes the following: an introduction, findings and
discussions, conclusions, and recommendations for practice and research.
CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature on the need for mathematics education in the United States, learning theories/outcomes, factors affecting students’ performance, mathematics performance, technology in mathematics education, minority mathematics education, and a summary of the literature presented in this chapter.

The Need for Mathematics Education in the United States

In American society, a good mathematics education is important not only for employment but for everyday problem-solving activities. The Glenn Commission report, Before It’s Too Late (U.S. Department of Education, 2000), stated that the economic and democratic foundations of our country are in serious jeopardy unless we produce students who understand and can use fundamental ideas from mathematics. An earlier report by the United States Department of Education, A Nation at Risk (U.S. Department of Education, 1983), made similar recommendations. Despite the importance of this, many minority groups are underrepresented in academic majors requiring higher-level math skills and a large percentage of Blacks and Latinos are placed in remedial college-level mathematics courses (Donovan & Gross, 2002; NCTM, 2000a, 2000b, 2000c). These Blacks and Latino students represent a higher rate of high-school dropouts than other groups; therefore, Fine (1991) along with the Glenn Commission report (USDOE, 2000)
suggested that an equitable education of this combined group of minority dropouts must focus not only on educational access, but also on educational outcomes. More than 50 years have passed since the U.S. Supreme Court’s *Brown v. Board of Education* decision, and minority students’ performance in mathematics and science subjects is still lower than that of their White counterparts (Barton, 2005; Gonzales et al., 2004; Swarat et al., 2004).

Mark Rank proposed that one way disadvantaged groups can escape the perpetual cycle of poverty is for them to obtain a quality education (Rank, 2004, pp. 207-210). Rank went on to show, by analysis of U.S. census data, how being a Black person with less than a college education is a recipe for experiencing poverty across one’s adult life cycle (pp. 97-101). Recent United States Department of Labor reports showed how workers with more education usually win when workers with different levels of education compete for jobs that require complicated math, science, writing, or other academic skills (Moncarz & Crosby, 2005). The report also showed that even though there are many jobs available for non-college graduates, one could increase his or her chances of getting jobs in these occupations (certain high-paying jobs not requiring a college degree) by studying algebra. The Office of Occupational Statistics and Employment Projections’ recent job outlook report showed that college-educated workers earn more money than workers who have less education, and the occupations that are expected to have the most openings for college graduates are in the business, computers and engineering, education, counseling, and healthcare fields (Lacey & Crosby, 2005). Most of these occupations require a strong math foundation. In his State of the Union Address, President George Bush reaffirmed
the nation’s commitment to train teachers to help students who struggle with math to have a better chance of getting high-wage jobs (Bush, 2006).

**Learning Theories/Outcomes**

Educators have long used the knowledge – that students learn in different ways – to instruct using a wide variety of approaches to help these diverse learners acquire academic subjects more effectively (Buchanan, 1992; Burke & Dunn, 2002; Henson, 2003). Learning theory for the first half of the 20th century viewed learning as a response to external stimulus. These theories were built upon the classical conditioning theories of Pavlov, Skinner, and Thorndike (Mayer, 1992; Rothstein, 1990). Learning was viewed as response acquisition by educators when designing instruction and explaining students’ responses or learning outcomes. About the mid-1990s, educational researchers shifted from learning in animals to human subjects that focused learning as knowledge acquisition (Mayer, 1992). More recent studies have shifted from the study of the learning of abstract information to subject-based learning in more meaningful settings. Researchers such as Vygotsky have forwarded the philosophical view of the learner as a constructor of knowledge. This is often called the constructivist framework (Fosnot, 1996, Kozulin, 2003). This view of the learner as the constructor of knowledge has moved educators to design instruction based on a learner-centered philosophical view (Blackner, 2003; Darden & Richardson-Jones, 2003; Henson, 2003; NCTM, 2000c; Woelfel, 2003).

There are numerous literary summaries on various learning styles theories and philosophies. Most recent theories are learner-centered (Bransford, Brown, & Cocking, 1999; Henson, 2003; Reed, 2000; Rose & Nicholl, 1997). The learning style theories and
assessment of such learning styles of interest to the field of mathematics and this study stemmed from Howard Gardner’s eight multiple intelligence models of learning styles (Gardner, 1983; Rose & Nicholl, 1997). Howard Gardner’s eight intelligences include the following: linguistic intelligence (word smart), logical-mathematical intelligence (number/reasoning smart), spatial intelligence (picture smart), bodily-kinesthetic intelligence (body smart), musical intelligence (music smart), interpersonal intelligence (people smart), intrapersonal intelligence (self-smart), and naturalist intelligence (nature smart). Professor Arem and others (Arem, 1993; Conrath & Henderson, 2001; Dunn, Dunn, & Price, 1979) have focused on three of the eight learning styles of Gardner (visual, auditory, and tactile-kinesthetic). They have created assessment instruments to measure these along with suggestions for learners of various types on how to use their preferred learning styles to optimize academic learning.

One danger in designing any curriculum using learning style theories is the temptation for the designer or educator to design based on his or her preferred teaching or learning style. Instructors with knowledge of their preferred learning and teaching styles tend to use a variety of instructional approaches to teach a wider audience of learners (Dunn & Dunn, 1979). Joyce presented an excellent overview of many models or exemplars for instructions at both the undergraduate and college levels for many academic subjects (Joyce & Weil, 1996).

Nancy Protheroe is the director of Special Research Projects at Educational Research Service (ERS), a nonprofit research organization founded by the national Association of Elementary School Principals and six other associations of school administrators. She identified nine instructionally related practices that may affect
students' learning of a wide variety of academic subjects from kindergarten through 12th grade (Protheroe, 2004). Protheroe's conclusions were based on analyses of textbooks, research and survey of educational researchers and related studies. Numerous researchers support Protheroe's suggestions for effective instructional practices rooted in learning theories. Some of these suggestions are (pp. 28 & 29):

1. **Graded homework**: Students learn more when they complete homework assignments which are graded, commented upon, and discussed with them by their teachers. The teacher's feedback reinforced what has been learned correctly and helped re-teach what has not. Research results from Maddox and Ing supported the theory that delayed feedback adversely affects learning, especially of information integration. Maddox and Ing's research was based on ANOVA results from 112 college students (Maddox & Ing, 2005). In a study of 253 sixth- and eighth-grade students, researchers found that students who received help from their parents or other family members returned more homework assignments than those who did not receive such interactions or supports (Voorhis, 2003). These students' returned homework was more accurate, and they performed better in school than those who did not receive support from a family member.

2. **Aligned time on task**: Students who are actively focused on educational goals do best in mastering subject matter. The teacher, by taking into account what is to be learned while identifying the most efficient way to present it, increases effective study time. In addition, researchers found that sharing with students the future benefits of what is being taught increases learning outcomes (Weber, 2004).
3. **Direct instruction:** This process emphasizes systematic sequencing of lessons, guided student practice, and feedback. Some researchers believe that mathematics must be learned sequentially because new topics are invariably dependent upon previous topics (constructivist learning theory). It is possible that not all teachers can provide this approach to mathematics instruction; some instructors with a non-constructivist approach to teaching and learning found it difficult changing the way they went about constructing their understanding of science (Lindgren & Bleicher, 2005).

4. **Advance organizers:** Showing students the relationships between current and past concepts increases the depth and breadth of their learning. When instructors show how current lesson is related to previous lessons, students can connect the two, which helps them better remember and understand. Beyer recommended that instructors should strive to link current topics with prior knowledge (Beyer, 1991).

5. **Teaching learning strategies:** Delegating some control of learning goals to students and allowing them to monitor their progress can result in learning gains. This may require the teaching of learning skills and strategies for some students (Bransford et al., 1999). Teaching students learning strategies may result in their seeking multiple or alternative learning resources other than their textbooks (Daniels & Zemelman, 2004).

6. **Tutoring:** Teaching one student or a small group with the same abilities and instructional needs can be effective. If well organized, peer tutoring also works and can promote effective learning both for those being tutored and those doing the tutoring (Rose & Nicholl, 1997). Other researchers have found that not only did peer tutoring help with college science courses, but also it increased students’ mathematics performance (Swarat, Drane, Smith, Light, & Pinto, 2004).
7. **Mastery learning**: Mastery learning, with its emphasis on sequential outcomes and monitoring progress, can help both slower and faster learners. It allows more time and remediation for students who need it, while enabling faster learners to skip material they already know. The acronym for MASTER in Mastery learning stands for: (a) Motivating your mind, (b) Acquiring the information, (c) Searching out the meaning, (d) Triggering the memory, (e) Exhibiting what you know, and (f) Reflecting on what and how you have learned (Rose & Nicholl, 1997, pp. 62-67).

8. **Cooperative learning**: When students work in small, self-instructing groups, they support and increase each other’s learning. When students work in groups of two to four, each group member can participate extensively and individual problems are more likely to become clear and can be remedied. Learning proceeds more effectively when exchanges between teachers and students are frequent. Many researchers have been successful in using cooperative learning techniques with minority students (Hrabowski, 2003; Montecel & Cortez, 2002; Swarat et al., 2004; Vodounon, 1995).

9. **Adaptive education**: Adaptive instruction is a comprehensive program that combines the above approaches (tutoring, mastery learning, cooperative, etc.) in order to tailor instruction to individual and group learning needs. Researcher Jere Brophy suggested that an optimal adaptive instructional program would involve a variety of instructional approaches and learning activities (Brophy, 2004).

**Factors Affecting Students’ Performance**

This section reviews some of the factors that affect students’ academic performance. Factors affecting academic performance are demographics, personal, institutional, and social and/or cultural factors.
Demographic factors include those factors or variables that are recognized as background information about the learner which are often unchangeable because of physical or social characteristics. Variables such as gender and race or ethnicity are considered demographic variables. The literature related to ethnicity and students’ performance in mathematics will be presented later in this chapter.

Early cross-cultural research studies have shown that in some countries female students’ scores on standardized math tests are equal to or better than male students’ scores. This suggests that American females’ poor representation in fields requiring mathematics is a cultural phenomenon (Gray, 1981; Hanna, 1989). An analysis of the findings of the Third International Mathematics and Science Study (TIMSS) by researchers from the University of British Columbia (Erickan et al., 2005) concluded that students’ home environmental related variables were a stronger predictor of math achievement for females than for males in the three countries examined (Canada, Norway, and the USA). The researchers concluded that even though the TIMSS results demonstrated that gender differences in mathematics achievement and participation levels displayed different patterns in different countries (45 countries studied by TIMSS), that in the three countries examined, these gender differences become more pronounced as students progress through school to more advanced mathematics courses (p. 6). The British Columbia University study analysis of the TIMSS results observed that, in all three countries, males showed higher participation rates in mathematics than did females. Personal and home environmental related variables accounted for a larger amount of variance in the mathematics achievement scores for Canadian males and female students. This study also showed that confidence in mathematics (a self-concept related variable)
was the strongest predictor of mathematics achievement for females and for males in all three countries, and students' self-expectation (in attending university) was more strongly associated with males' achievement than females' regardless of country (p. 10).

Analysis of research on gender and education revealed disconnection between teaching practice and the needs of male and female brains (Gurian & Stevens, 2004). Gurian and Stevens argued that the physiology of the male and female brains is different. These differences suit girls for learning that involves verbal and emotive functions and boys for physical-spatial functions. This, Gurian and Stevens believe, is why males tend to gravitate towards physics, industrial engineering, and architecture, even though some females excel in these areas (pp. 22-23). Gurian and Stevens emphasized that using verbal functioning – reading and written analysis – to teach such spatial-mechanical subjects as math, science, and computer science is one reason why we are bridging the gender gap for females in math achievement (p. 24). We are not as successful for male learning achievement level however, because we fail to account for the fact that males' language learning experience is richer and more expansive when they are actively learning or engaging in a task while learning (p. 25). Campbell and Skoog (2004) observed that involving female students in a mentoring program (rich in modeling, motivation, and confidence building) was a successful factor in their desires to pursue science and research academic careers or professional studies. One student noted that this mentoring undergraduate experience made a big difference in her career decision. She noted that the experience allowed her to “see what the whole research field is like” (p. 25).
In a *Time* magazine special report in the March science section, Amanda Ripley presented statistical data and charts to show that men outpaced women in scientific and engineering jobs (Ripley, 2005). Ripley went on to show that men scored higher on college entrance exams (SAT and AP) in mathematics and science than did women; however, women are now outpacing men in the number receiving Bachelor degrees in science and engineering since 2001 (Ripley, 2005).

**Personal**

Personal factors include those factors or variables that the student brings to the learning environment. They include such complex attributes as individual learning styles, instructional and assessment preferences, prior knowledge, attitude of self, instructor or the instructional media, primary language, and physical or various learning disabilities.

**Prior Knowledge**

Prior knowledge influences how the instructor and students interact with the learning material and environment as both individuals and as a group (Kalyuga & Sweller, 2004; Kujawa & Huske, 1995). To facilitate students learning new materials, instructors should link classroom activities and instruction to students’ prior knowledge (Beyer, 1991). Researchers in studying the effects of prior knowledge and aptitude on 353 college students’ performance in an introductory psychology course showed that prior knowledge was a good predictor of students’ achievement (Thompson & Zamboanga, 2004). Using pretest and background information on prior courses taken in comparison to exams given throughout the course, results showed that background (e.g.,
aptitude), prior knowledge (pretest), and course involvement (e.g., attendance and homework) were good predictors of performance (p. 783).

**Learning Styles**

At the Center for the Study and Teaching of Learning Styles in New York, researchers found that students remember significantly more when presented with new materials through their preferred learning channel (style) (Dunn & Dunn, 1978, 1979; Keller & Reigeluth, 2004). A more detailed presentation of learning theories and outcomes was developed in the previous section of this chapter.

**Primary Language**

There is very little research on how primary language relates to best practice for mathematics instruction, learning and performance; however, the need for this type of study has received national attention from the National Academy of Science and the National Council of Teachers of Mathematics (August & Hakutu, 1997; Mackay & Palmer, 1981, NCTM, 1999).

**Motivation**

Some students' motivation to succeed and expend effort to perform academically is linked to their perceived ability to perform the task required for success (Tollefson, 2000). In a study of 245 female college teacher candidates, researchers showed that students' motivation, performance, and persistence could be enhanced by pointing out the relevance of the study material to achieve future goals (Vansteenkiste et al., 2004). Using Multivariable Analysis of Variance (MANOVA) to compare students' intrinsic and extrinsic values (usefulness and what it was useful for) with assignment tasks, these
researchers were able to show that students' motivation levels were able to predict their performance when both the intrinsic and extrinsic values of each task were shared with them.

Institutional

Institutional factors are those factors or variables that the learning environment imposes upon the learner in order to facilitate learning or learning outcomes. Some of these variables are the instructor, instructional pedagogy, technology support, assessment tools, instructional materials, learning environment, and accommodations to certain learning disabilities. The literature is rich with studies of how these institutional variables affect learning outcomes (Borman, 2003; Cohen, 1986; Ediger, 2003; Hrabowski, 2003; Swarat et al., 2004; U.S. Department of Education, 2000; Vodounon, 1995).

Social/Cultural

Social/cultural factors are those factors or variables that help shape the learner's perspective on how the learning experience and environment are viewed or conceptualized and experienced. Some of these variables are economic posture (family income, for example), family values, community support, social learning, cultural norm and behaviors, exposure to educational technology (computers in the home, for example) and family structures (single-family home life, for example). There is often overlap between some demographic variables and social/cultural variables; for example, race is both a demographic and cultural variable. Culturally responsive teaching helps motivate learning through understanding and respect for the contributions that culturally diverse students bring to the learning environment (Dilig, 2003; Gay, 2000; Schifter, 1996). One example of the social and cultural factors on mathematics education is Anyon’s
comparative study on how the mathematics classrooms received very different types of instructions for five schools in different socioeconomic neighborhoods in two nearby districts (Anyon, 1980). Another example is the influence that a person’s parental belief about his or her mathematics potential may have on that person’s math achievement as well as career choices (Bleeker & Jacobs, 2004).

**Mathematics Performance**

This section presents an overview of the literature research on students’ mathematics performance at all levels of education with a focus on secondary and college education. Later section will focus on research specific to minority performance in mathematics.

Some of the factors that influence students’ performance in all academic subjects are summarized earlier in this chapter. Most noticeable, relevant to this study, are the roles a student’s gender, race, and economic background play in their performance in college-level mathematics:

1. Girls tend to do poorer in mathematics in the United States than do boys (Erickan et al., 2005; Gonzales, Guzman, Partelow, Pahlke, Jocelyn, & Williams, 2004; Gray, 1981; NCTM, 2000b). This gap, some researchers believe, is narrowing. However, girls tend to outperform boys overall academically across 35 industrial countries especially in reading and writing scores (Gurian & Stevens, 2004).

2. Minority students tend to do poorer in mathematics than their White counterparts do in college (Borman, 2003; Gonzales et al., 2004; Swarat et al., 2004).

3. Students who are socially or economically disadvantaged also tend to do poorer in mathematics than those who are not (Byrnes, 2003; Gonzales et al., 2004).
Research in mathematics performance suggested the use of the following strategies to enhance mathematics learning: (a) involve the use of visual learning props (Carlson, Chandler, & Sweller, 2003; Yancey, Thomson, & Yancey, 1989), (b) use interactive assessment tools for homework and other assignments (Voorhis, 2003), (c) provide active learning opportunities where mathematics problem-solving skills are modeled, using many different approaches (Carroll, 1994; Grillmeyer & Chance, 2001; Hrabowski, 2003; Nardi, 1991), (d) expand the role of reading in the classroom (Borasi & Siegel, 2000), and (e) reduce the effect of gender and other bias in learning attitudes and outcomes by understanding the roles gender and other learning attitudes play in instruction (Franke & Carey, 1997; Honigsfeld & Dunn, 2003; Ma, 1999; Orellana & Bowman, 2003; Verschaffel & De Corte, 1997).

Student-Centered Instruction

Research conducted with 29 prospective middle school teachers taking a college math class based on an inquiry-based approach to math instruction showed that the majority of students (20 out of 29) preferred a student-centered approach to instruction and learning to a teacher-centered approach (Stonewater, 2005). Stonewater suggested that these students preferred to learn math at a deeper level and sought understanding of concepts rather than just being able to solve basic math problems. Prior to taking the math class, the Stonewater research divided students into two groups:

*Group 1: Watch-Learn-Practice group.* These students described their best math class as one in which the teacher disseminated mathematical knowledge, seen primarily as procedures and examples. In this teacher-centered view, the teacher answered all questions, reviewed all homework, and assessed the students on problems similar to the
homework. These students viewed their role as practicing and mastering the given information, including working all of the homework problems and, as needed, asking the teachers questions for correction and during times of uncertainties.

*Group 2: Self as Initiator group.* These students’ view of a best math class saw the teacher’s role as facilitator of their learning rather than as giver of information. They saw their role as one in which they built an understanding of the mathematics, worked mathematical problems and found solutions, and discovered and explored mathematics ideas. These learning tasks were often carried out collaboratively with the teacher and other students.

**Instructional Strategies**

At the college level, a potpourri of teaching and learning strategies using computer-assisted learning and proven pedagogical approaches has contributed to success in higher mathematics achievements for some students taking remedial college-level math courses (Blackner, 2003; Borman, 2003; Miller, 1999). Research findings suggested that Black and Hispanic students require special instructional strategies for success in their mathematics education (NCTM, 1993, 1994a, 1994b, 1997a, 1997b, 1999, 2000a, 2000b, 2000c, 2002; Sadatmand, 1995; Swarat et al., 2004). African-American, Hispanic, and other minority students tend to learn best from instructions that incorporate an understanding of their cultural ways of learning (Buchanan, 1992; Bleeke & Jacobs, 2004; Hale, 1982; Honigsfeld & Dunn, 2003). Research showed that Black and Hispanic minority students tended to do well if instructions involve them as active learners, learning from peer instruction and social learning environments with members of their groups (Borman, 2003; Martin, 2000; NCTM, 1999, 2000a).

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In *Why the Professor Can't Teach*, Morris Kline, former Professor of Mathematics at New York University, stated that most American professors of mathematics are more focused on research unrelated to students' interest or the mathematics course being taught than the pedagogy required or needed for students' learning success or mastery of mathematics (Kline, 1977). Kline throughout his book illuminated the conflict that most mathematics professors constantly struggle with teaching proficiency or research publication requirements for tenure. This conflict arises owing to the higher value higher educational institutions place on research for the achievement of academic tenure. Kline stated that good teaching requires catering to students' psychological needs — "giving encouragement to some, putting pressure to work on others and imparting confidence to those who have been defeated by poor teaching in their prior studies" (p. 77).

Before It's Too Late, the Glenn Commission report (U.S. Department of Education, 2000), suggested that the solution to poor student performance in mathematics rests with the improvement of teaching (p. 5). Berliner (2005) pointed out that it is almost impossible to test for teacher quality in education. Berliner believed that successful teaching can be assessed by examining evidence of student learning, which is rarely evaluated, especially for beginning teachers. Berliner (2005) redefined his 1987 definition of "quality teaching" as consisting of two conceptually separate parts. Good teaching occurs when the standards of the field are upheld. Good is normative. It is what is expected of people in a position. In contrast, effective teaching is about reaching achievement goals. It is about students learning what they are supposed to in a particular class, grade, or subject. A high-quality teacher shows evidence of both good and effective teaching. (p. 207)
Delong and Winter (2002) provided an excellent research training manual or
guidebook to help college mathematics professors become better mathematics instructors.
In a one-semester study session, mathematics instructors may learn from the Delong and
Winter guidebook how to better prepare students for learning in their math classes. This
guidebook presented and discussed the following topics: (a) making in-class study-groups
work, (b) getting students to read the textbook, (c) assessing and evaluating students’
work (including homework), (d) teaching during office hour, (e) teaching with calculators
and computers, (f) motivating students, and (g) dealing with difficult students.

Social Learning Strategies

Institutional factors such as instructional approaches that use active or cooperative
learning strategies are known strategies that can improve students’ learning of
mathematics (Hazelbaker, 1998; Hernandez, 1999; Lan, 2003; Swarat et al., 2004).
Cohen recommended using cooperative learning strategies to help underrepresented
groups improve their academic performance (Cohen, 1986). The Glenn Commission
emphasized the need for better instructional pedagogy for the United States to help meet
its commitment to improve mathematics education (U.S. Department of Education,
2000).

Social factors such as creating learning support communities in the form of
additional help outside the classroom can enhance students’ learning (Borman, 2003;
Reyes et al., 1999; Swarat et al., 2004). Computer-assisted instruction can also enhance
students learning mathematics. Technology, when used to provide a wide range of
approaches to instruction (group interaction, visual and multiple media appealing to
different types of learners), does help some students learn mathematics (Blackner, 2003;
Cox, 1990; Moren & Duran, 2004). Many social and cultural factors affect student performance in mathematics. Two of these factors are parental attitude towards their children’s ability to succeed in math (Bleeker & Jacobs, 2004) and cultural ways of learning (Dilig, 2003; Gay, 2000; Grant & Sleeter, 1999; Gutierrez & Rogoff, 2003; Orellana & Bowman, 2003).

Student/Teacher Interaction

An overview of research on students’ performance in mathematics stressed the need to focus pedagogical approaches on understanding for mathematics instruction and assessment. From an instructional standpoint, teachers need to interact with students in the mathematics classroom to learn about students’ thinking and their understanding of the materials being taught (Franke & Kazemi, 2001). Some instructors have seen positive relationships between students’ performance on math tests and their ability to learn concepts when they focus on students’ understanding of mathematics concepts and procedures (Schwartz, 2004; Wood, 2001).

The Nature of Mathematics

In *The Glass Wall*, Frank Smith attempted to unravel why many students find mathematics difficult. He presented the notion that mathematics can be viewed as a universal language. Unlike our spoken language, it allows us to communicate across spoken languages. In a sense, Smith believed that because mathematics at its highest levels tries to communicate complex ideas and concepts numerically that are associated with the physical world, it does not describe this world the way we use language to talk about the physical world. He believed that there is also a world of mathematics and that a
glass wall exists between this world and the physical world preventing many from
understanding and communication successfully in mathematics (Smith, 2002). I present a
few examples to illustrate some of Smith’s contentions. One example is the concept of
infinity; we cannot in the physical world offer a concrete example that we can hold up to
show this concept. Another example is the concept of zero. It took humans centuries to
define this concept; zero could mean nothing, or a placeholder in such numbers as 205, or
we may struggle with the concept of division by or multiplication with zero. I present a
third example, used by Smith: it is the notion that a number such as the numeral 3 may be
used as a label, may be compared to other numbers in some ranking order, or may be
represented of some quantity (amount of or number of). One very useful point that I
gathered from Smith’s discourse is that mathematics relies mostly on understanding of
concepts and procedures or problem solving than on memorization. Therefore, Smith
proposed that students would tend to do better in mathematics if they strive for
understanding (pp. 112-135).

Teaching for Understanding

Romberg (2004) had studied the impact and progress of assessment based on
examining students’ understanding of mathematics through a variety of interactive
evaluation strategies. Teachers of middle school mathematics students focused on
mathematics learning in context, discovered with varying degrees of success that
classroom interaction while students were being taught was an important factor in
assessing for understanding. Romberg’s compilations of case histories and research
studies associated with mathematics learning assessment based on understanding
suggested that teachers needed to examine their classroom assessment practices and the
familiar conventions of testing, scoring, and grading that formally assessed students’ mastery of skills and procedures (pp. 223-235). For teachers to instruct based on students’ understanding, they needed to assess based on understanding rather than memorization.

There is some research in the limited area of student conceptualization of math topics at the college level (Bosche, 1998; Kwon, Allen, & Rasmussen, 2005; Montes, 2002; Orellana & Bowman, 2003; Sliger, 1992; Twyman, Ketterlin-Geller, McCoy, & Tindal, 2003). Students’ ability to conceptualize mathematics concepts influenced their understanding of mathematics. Kwon and associates (2005) showed that college students who were taught advanced mathematics courses in an environment that facilitated conceptual understanding gained a longer retention of mathematics knowledge. Twenty advanced-calculus students routinely taught to engage in explaining and justifying their thinking were compared with 15 similar students taught the same course but in a traditional mathematics class. The 20 students instructed in a non-traditional mathematics class based on conceptual understanding scored higher at the end of the semester and after 1 year of instruction than those traditionally instructed. Both groups of students scored about the same on procedural mathematics problems, but the 20 students instructed in the non-traditional class performed significantly better on conceptual problems than their traditional counterparts did (pp. 230-233).

The Constructivist Approach

For some academic subjects, the learning of new information requires knowledge of prior skills and information before one can learn topics that are more advanced. This is true especially for mathematics where new content knowledge is constructed upon prior
knowledge (Kalyuga & Sweller, 2004). Therefore, there is a need to provide support for
students weak in basic math or basic algebra skills to help them advance to higher-level
mathematics. Researchers believed that this can be accomplished through programs
designed to help these students learn how to learn mathematics and build prerequisite
knowledge before more advanced learning is introduced (Arem, 1993; Miller, 1999;
Sliger, 1992; Tobias, 1987).

Modeling Mathematics

What is the best way to teach math to high-school and college students?

Conventional classroom teaching includes explanation of the subject matter,
accompanied by a limited number of examples, after which students are assigned
unsolved problems to work out. Research in the mid-1990s has investigated the effect of
increasing the use of “worked out” examples of math problems in math instruction. The
results have shown that providing students with many such problems for assignments
increases their learning of mathematics (Carroll, 1994; Linn & Hsi, 2000).

An important research finding in mathematics education suggested that providing
students with worked out examples of math problems has been found to be more effective
than simply assigning the same problems for the students to work out on their own. In
one experiment (Carroll, 1994), 40 high-school students were instructed in how to solve
linear equations. In an “acquisition phase,” the students were divided into two groups
with deferring instructions. In the “conventional learning” group, students were assigned
44 unsolved problems to work out (in the classroom and at home homework). In the
“worked examples” group, students were provided with the same problems, but half of
the problems were accompanied by correct solutions. After completion of the assigned
problems, both groups were tested on 12 related problems, 10 of which were very similar to the linear equations presented in the acquisition phase, and two of which were word problems, used to test whether students could transfer and extend their knowledge to a new context. No worked out examples were available during the test. The test results revealed that students in the “worked examples” group outperformed students in the “conventional learning” group on both types of the test problems. A second experiment employed a similar methodology but focused on “low achieving” students (students with a history of failure in mathematics and students identified as learning disabled). Here, the data revealed that students in the “worked examples” group required less acquisition time, needed less direct instruction, made fewer errors, and made fewer types of errors than students in the “conventional learning” group.

Related research (Pass & Van Merrienboer, 1994) sheds light on the cognitive underpinnings of the effects described above. In this study, 60 college-age students were instructed in geometry concepts. As in the Carroll experiments, students were assigned un-worked problems to solve or worked out examples to solve. In this study, the researchers manipulated the nature of the problems presented to the students: within each group, some students received problems that were all similar to each other, while others received a more varied problem set. Furthermore, the researchers measured the “cognitive load” experienced by the students. This research revealed that while students in the worked examples group completed their work more quickly, they perceived the work as less demanding and displayed better transfer performance at test. The effect was most pronounced for the students given highly variable problems. The researchers suggest that the reduced cognitive load associated with the worked examples enabled
students to “take advantage” of the variability in problems by using the available cognitive resources to process the underlying similarity in the problems (i.e., the mathematical concepts being taught), and to integrate the current problem with existing knowledge (Linn & Hsi, 2000).

Self-Efficacy

Self-efficacy refers to an individual’s perceived capability to perform necessary tasks to achieve goals (Bandura, 1997). In a study of 416 high-school mathematics students, researchers concluded that self-efficacy was more significant in predicting future mathematics performance than self-concept (Pietsch et al., 2003). Self-concept refers to self-perception formed through experience with the environment and, in particular, through environmental reinforcements and the reflective appraisals of others (March & Hau, 2004; Pietsch et al., 2003). In general, recent studies have shown that self-efficacy significantly influenced college students’ performance in several academic tasks including exam concentration and note-taking (Choi, 2005). Choi’s research consisted of 230 college students of whom 38% were minority (34% Blacks), and he used the College Academic Self-Efficacy Scale to measure self-efficacy. The design of this research is such that both instructional and assessment strategies should help build self-efficacy and thus improve mathematics achievement (Choi, 2005; NCTM, 1993; Pietsch et al., 2003). Ways of building confidence and self-efficacy are: (a) to bridge the gap between prior math knowledge, skills, and current math content and (b) to use a variety of instructional techniques that help students learn in accordance with their optimal learning styles (Blackner, 2003; Borman, 2003; Hazelbaker, 1998; Montes, 2002).
Not all students learn mathematics, or any subject for that matter, the same way nor is it appropriate to present instruction only one way. Gardner proposed at least eight multiple ways in which we learn (Rose & Nicholl, 1997). More focused research on student learning mathematics has supported the multiple intelligence approach to learning and instruction. There are many approaches to optimize learning; one such approach involves the use of computer technology in mathematics education.

**Technology in Mathematics Education**

With advances in computer educational technology and the Internet as a means of providing educational opportunities, institutions of higher learning can deliver instructional diversity working in partnership with textbook publishers and educational technology manufacturers to offer unlimited capabilities for instruction, learning, and assessment deliveries in both the traditional and virtual classrooms (West & Graham, 2005). Bell and Bell (2003) compiled a comprehensive bibliography of articles between 1994 and 2002 that dealt with technology in science and mathematics education. Many recent innovations in computer-assisted instruction and learning employ various multimedia-rich Internet technologies. Some educators have advocated strategies to evaluate the effectiveness of Web-based instruction (WBI). In developing an evaluation of WBI for the US Navy training program, Reiser and his colleagues learned (from frequent feedback with their Navy clients) to pay close attention to content and delivery clarity of WBIs (Reiser et al., 2005). The use of computer-assisted instruction to help students with college mathematics has been studied extensively (Blackner, 2003; Bosche, 1998; Campbell, 1996; Cox, 1990; Hazelbaker, 1998; Rothman, 2000; Vodounon, 1995). When technology is used to deliver a number of interactive, visual, and multiple media
instructions that span the various learning styles of students, mathematics learning through computer-assisted learning can produce positive learning outcomes (Alexander, 1993; Blackner, 2003; Choi-Koh, 2003; Dyer, 1995). The use of computer-assisted learning has also received mixed reviews as to whether all learners can be helped by technology support (Lee, 2003).

Technology-assisted learning can help build students’ mathematics concepts (Bosche, 1998; Dyer, 1995). Interactive mathematics homework online can also build a community of learners who can provide support to struggling students learning mathematics (Hazelbaker, 1998; Vodounon, 1995; Voorhis, 2003). For educational disadvantaged students, computer-assisted mathematics instruction can provide remedial mathematics content that students often lack (Buchnnan, 1992).

West and Graham (2005) studied 35 cases of innovative teaching across 24 departments and 11 colleges in an attempt to understand the perceived impact of the use of computer technology on enhancing students’ learning. West and his fellow researcher found five ways that technology was used positively to influence learning. These five ways included: (a) helping students to visualize content, (b) promoting student/teacher and student/student interactions, (c) supporting meaningful student reflection, (d) providing opportunity for involving students in authentic, real-life learning activities, and (e) improving the quality and quantity of student’s practice.

West and Graham (2005) presented a model of the energy required for learning and teaching improvements to occur with and without technology-assisted learning (p. 26). In their model, West and Graham concluded that in learning and teaching, technology appeared to act as a catalyst to reduce the amount of energy required to
achieve some instructional goals. For example, in the West and Graham Model, computer
technology can provide students with interactive learning environments rich in problems
generation (creating many similar problems for students' responses) and response
assessment (direct and immediate feedback) that can often simulate real-life problem
solving situations (pp. 23-25). West and Graham's findings are consistent with
Protheroe's conclusions and recommendations for effective instructional strategies that
can influence the learning outcomes presented above (Protheroe, 2004).

Solomon (2005) supported the idea that computer technology in education, from a
post-modern philosophical sense, may help bridge the gaps between many cultural
boundaries and students' learning. Solomon presented technology as having the potential
to build upon social learning theories (from his earlier research) encompassing at least
four areas of instructional design theories and practices (p. 26). Solomon believed that
instructional design should be a dialogical and critical process that welcomes a blending
of theoretical orientations and approaches. Instructional messages should reflect multiple
representations of content and knowledge. Instructional strategies should be focused on
meaning making in sociocultural contexts (this should include dialogue, reflective
practice, and multiple delivery methods and tools). Learner characteristics should
emphasize anthropological variables, which may include distribution and relationship of
peoples, environmental and social relations, and culture.

Minority Performance in Mathematics

Minority students with potential to succeed in college-level mathematics courses
continue to score lower than do their White counterparts. The use of group or peer
workshops that stress problem solving through working out difficult math conceptual
problems seemed to improve minority student scores in college math courses (Byrnes, 2003; Cokley, 2003; Swarat et al., 2004).

The present climate in education supports diversity in education. Since Latinos and African-Americans continue to enroll in higher education, there is an urgent need for communities, educational administrators, and instructors to be more culturally responsive (Costa, McPhail, Smith, & Brisk, 2005; Gay, 2000; Grant & Sleeter, 1999; Irvine, 2003; NCTM, 1997b; Schoem, Frankel, Zuniga, & Lewis, 1993). Costa and others (2005) showed that as the number of English language learners (ELLs) in the United States increased, the need exists for teachers who are trained to teach bilingual students. Teachers must be trained to teach to all learners with varying language skills and cultural backgrounds.

Pedagogy

Educational research suggested that various instructional approaches, such as cooperative and active learning strategies that extend beyond the classroom and that involve various supportive communities, work best for minority students (Borman, 2003; Hrabowski, 2003; Montecel & Cortez, 2002; Vodounon, 1995).

Minority students who need the most positive teacher-student interaction during mathematics education are often at a disadvantage in the college mathematics classroom because of the lack of teacher consideration for their special needs (NCTM, 1994b, 1997a, 1999, 2000a). African-American students from low income families can succeed in mathematics education if appropriate pedagogy is introduced that augments the richness of their cultural background in language, views of the roles of the instructor, skill needs, and other factors (Delpit, 1995; Delpit & Dowdy, 2002; NCTM, 1997a,
2000a; Perry & Delpit, 1998). Some researchers agreed that since African-American students tend to learn in relational ways, for example, mathematics concepts should be taught using a variety of strategies so that students who learn this way may benefit from instruction. The National Council of Teachers of Mathematics supported the belief that most African-American students excel in cooperative learning environments (NCTM, 2000a, pp. 15-19).

Some research studies concluded that Latino mathematics students have a high sense of community and tend to learn well in groups; so active learning that involves group learning and real-life exemplars will foster success in the mathematics classroom for this group of students (Alas & Garcia, 2001; Calderon & Minaya-Rowe, 2003; Gonzalez, Huerta-Macias, & Tinajero, 1998; NCTM, 1999, 2000a; Reyes et al., 1999).

Social/Cultural Factors

Contemporary research findings dismissed early conclusions that cultural language differences or deficits – because of the influence of home and culture – are the cause of Latinos, mainly, and African-Americans doing disproportionately poorer in mathematics education. Researchers now believe that economic factors and inadequate educational preparation do play a role in the failure of these minorities to succeed in mathematics education (Ercikan et al., 2005; Fine, 1991; Hale, 1982; NCTM, 1999, 2000a). Barton (2005), found that such factors as hunger and malnutrition, too much television watching, parental unavailability or lack of participation in their students’ education influence students’ achievement. Barton also showed that Blacks and Hispanic students under age 18 are about three times more likely to be hungry than White students (p. 10). In an attempt to understand the causes of minority students’ poor academic
performance, Larry Rowley (2004) compared the analyses of racial inequality from the viewpoints of two authors, namely: *The Anatomy of Racial Inequality* by Glenn Loury and *The Source of the River: The Social Origins of Freshman at America's Selected Colleges and Universities* by Douglas Massey and others. Rowley (2004) presented Loury's claim that African-American students' low academic performances are not the result of any innate characteristics or shortcomings but the stigma of being racially marked as "Black". Massey, on the other hand, believed along with other scholars that neighborhoods and social life within neighborhoods have an impact on future levels of educational attainment. It was suggested by Rowley (2004) that African-Americans lived in the most socially isolated environment filled with a higher than normal social disorder and violence. Rowley, quoting Massey, argued that the main factor that predicted college academic outcomes was academic preparation such as high-school grade point average (Rowley, 2004).

In a review of the case studies of four African-American junior high school students and their parents, Martin (2000) shared the impact that their parents' early mathematics educational experiences had on these minority students and their parents. He showed how this socialization influenced their beliefs about themselves and their attitude towards the institutions of learning that have unsuccessfully educated them in mathematics (pp. 35-80). Research by Weber (2004) on the relationship between students' (209 college students) interest and teacher-student social interactions showed a significant correlation between the teacher's ability to impart meaningfulness and the feeling of competency among students and their interest or responses in the college classroom. Some of the implications of the results of Weber's research are that if teachers
want to stimulate students’ interest, they can do so by: (a) pointing out meaningfulness or connections to students’ real-life experiences, (b) designing activities or projects that facilitate active learning, and (c) designing their course so that students get periodic feedback on tests as opposed to just the midterm/final exam (p. 434). Many of the parents who participated in Weber’s (2004) study blamed their math teachers for their lack of success in mathematics in their early education. Most of the parents stated that their mathematics teachers did not make their math classes interesting. Some teachers spent more time correcting trivial writing mistakes than on math mistakes, gave preferential treatment to some students because of race, and did not stress the importance of math. The educational system, many believed, tended to steer minority students towards apprentice careers instead of academic careers requiring a strong math background (pp. 60-68).

Teacher Training

Various math pedagogical research studies suggested that compounding the challenge faced by students’ performance in mathematics not getting “good” teachers is the special needs of minority students in the mathematics classroom. There are calls for teacher education that addressed various learning needs associated with diversity of the American educational system at all levels of education. Some researchers pointed out the need for teachers to be sensitive to the special needs of English language learners. Citing a study showing that there were 9.6% of English Language Learners (ELLs) in public schools in 2000-2001 (a 32.1% increase from enrollment in 1997-1998), some researchers have called for a change in faculty education that sensitize aspiring teachers to the special language challenges to classroom learning that ELLs face (Costa et al.,
2005; NCTM, 1999). One such challenge is that these students must learn English while being taught mathematics.

Almost all research and experience with minority performance in mathematics and other academic subjects point to several similar themes and findings that are essential to their performance in any subjects. Teachers and educators must be culturally sensitive to the special needs of minority students who bring many strengths and weaknesses to the learning environment. This sensitivity must go beyond just attempting to improve their academic grades, to setting high standards of performance while providing a diversity of opportunities for learning and academic achievements for this group of learners (Hrabowski, 2003; Lee, 2003; Gutierrez & Rogoff, 2003). Rolon (2003) and others (Costa et al., 2005) suggested that providing Latino students with learning opportunities among themselves and with their family and communities while understanding their prior knowledge would provide a richer learning environment than one that does not consider this special strength. Hrabowski (2003) believed that the same is true for all minority groups.

Personal Factors

Research done to study the relationship between primary language and mathematics achievements underscored the need for instructors to understand the relationship between concept understanding and linguistic contributions to learning new concepts (Gonzalez et al., 1998; NCTM, 1999; Secada, 1992). In addition, research suggested that an understanding by the instructor of the special challenges facing groups such as those of Latino students may help develop more effective instructional methods that may result in these groups succeeding in educational endeavors (De Jong, 2002;

Norma Hernandez in an article entitled “The Mathematics-Bilingual-Education Connection: Two Lessons” suggested that in teaching mathematics concepts to bilingual students (Spanish-English) it may be necessary to introduce concepts first in Spanish and then in English for Latino students to better grasp the learning of mathematics (NCTM, 1999).

Motivation and Self-Efficacy

Research showed that intrinsic motivations and self-efficacy play a vital role in minority or ethnic groups succeeding in mathematics (Cokley, 2003; Stevens et al., 2004; Weber, 2004). Research on self-efficacy showed that strategies that help build self-efficacy do improve mathematics achievement for minorities (Choi, 2005; NCTM, 1993; Pietsch et al., 2003).

Conclusion

Due to a lack of understanding about the role and influence of culture on education (learning outcomes), the line between students with special educational needs (i.e., learning disabilities) and those who are at an educational disadvantage as a result of social economic factors is now blurred. It is no longer about Black and White, but a need to provide educational success to all cultural groups within America so that our nation can maintain its technological competitive edge (NCTM, 1994b, 2000c; Seller & Weis, 1997). American corporations are seeking employees outside the United States with skills and knowledge in mathematics and other technical areas when underdeveloped human resources are available at home in the untapped pool of minorities seeking educational equity in these areas.
Summary

The Glenn Commission report, *Before It's Too Late* (U.S. Department of Education, 2000), stated that the United States' economic and democratic foundations are in serious trouble unless we can produce students who understand and can use mathematics knowledge and skills effectively. Current job outlook showed that college graduates with good mathematics background have a better chance of securing the higher paying jobs in business, computers and engineering, and education than those without such qualifications (Lacey & Crosby, 2005; Moncarz & Crosby, 2005).

Numerous factors are related to students' academic performance. Demographic, personal, and social/cultural factors not only influence general academic performance but also students' mathematics performance (Gonzales et al., 2004; Gurian & Stevens, 2004; Kalyuga & Sweller, 2004; Ripley, 2005; Thompson & Zamboanga, 2004; Vansteenkiste et al., 2004).

A constructivist, student-centered learning educational philosophy seemed to be amenable to the improvement of students' academic performance (Blackner, 2003; Fosnot, 1996).

Computer-assisted instruction and learning have been successfully used to enhance mathematics education (Blackner, 2003; Choi-Koh, 2003). West and Graham (2005) showed five ways that technology might influence learning, one of which is its capability to provide multiple approaches and examples of real-life problem-solving situations and models.

Many minority students studying mathematics need extended support beyond the regular classroom-learning environment if they are to succeed (Hrabrowski, 2003; Montecel & Cortez, 2002). Some minority groups come to the mathematics classroom
with certain cultural strengths and many social issues; if understood by educators, these strengths and issues may be used to optimize their learning of any subject (Alas & Garcia, 2001; Calderon & Minaya-Rowe, 2003; Delpit & Dowdy, 2002). Self-efficacy plays an important role in understanding minority performance, especially among Black students (Choi, 2005; Pietsch et al., 2003).
CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

The purpose of this study was to investigate the academic performance of Educational Opportunity Program (EOP) students in a College Algebra Extended Program (CAEP) at SUNY New Paltz. In addition, this study examined how certain personal and pedagogical variables were related to the learning of algebraic concepts. The research focused on the three primary components of CAEP, namely, classroom, workshops, and online pedagogies.

This chapter is organized to describe the research methodology, which includes the following: introduction, research design, population and sample, variables, instrumentation, procedure, human subject considerations, data analysis, and summary.

Research Design

This research design used both quantitative and qualitative approaches to describe the mathematics performance and experiences of EOP students in a College Algebra Extended Program class. The basic design used the one group pretest-posttest method with no control group. The use of pretest and posttest design to study mathematics-learning performance for students taking college-level mathematics is well-documented (Alexander, 1993; Blackner, 2003; Bosche, 1998; Hernandez, 1999; Kwon et al., 2005;
Miller, 1999; Rothman, 2000; Sadatmand, 1995). The pretest and posttest exam were identical. These exams tested the students' comprehensive knowledge of college algebra at the beginning and ending of the semester. Students went through the program over a one-semester period, and their pretest and posttest scores were compared to see the degree of learning outcome achieved by this program. The design approach was selected for this study because a pilot study in the fall of 2003 indicated that extended algebra support made a difference for EOP students doing well in College Algebra.

There was no control group since there was no parallel study that adequately represented a control group that could provide an unbiased comparison to the EOP students who took the CAEP for this study. The additional instructional time, learning growth and progress study, and instructional and assessment resources were unique to this program. Not having a control group was one limitation of this design; however, since the population of EOP students requiring College Algebra (because of their majors) is limited, a research design that focused on the measurement of a curriculum's ability to meet certain specific outcomes was appropriate.

Another limitation was the small sample size of EOP students taking the College Algebra Extended course. Using both non-parametric quantitative and qualitative analyses allowed for a reasonable interpretation of the results given the small sample size of this study. Table 2 summarizes the sources and indicators used to measure each of the four learning outcomes for this study.

Quantitative data were collected in the forms of weekly assignments, mathematics achievement tests, and quantitative surveys. Comparative and correlational approaches
were also used to analyze quantitative data. Non-parametric approaches were used to analyze quantitative results because of the small sample size of this study.

Qualitative data were collected in the forms of the instructor’s (primary researcher’s) narrative in the form of observation logs of bi-weekly classroom and workshop sessions, an exit survey (Appendix O), and a post-course interview (Appendix P) that addressed the research questions posed in this study. Qualitative methods were used in combination with quantitative approaches to analyze the results. Interviews and survey responses allowed for a deeper understanding of quantitative results and certain attitudinal analyses.

Table 2

Learning Outcome Summary

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Indicators</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Meet basic algebra requirement</td>
<td>Grade of at least D in CAEP Homework, workshop, quizzes, midterm, and final (Appendices H, I and J)</td>
<td></td>
</tr>
<tr>
<td>2. Meet GE-II minimum math requirement</td>
<td>Course Grade (C- or better): 30% Final Exam, 20% Midterm Exam, 20% Quizzes, 15% Workshop 10% Homework, 5% Online Usage</td>
<td>Mathematics tests, and weekly assignments (Appendices H, I and J)</td>
</tr>
<tr>
<td>3. Build strong context knowledge in College Algebra</td>
<td>Grade on a Final Exam, Part 3 (at least 50% score)</td>
<td>Final exam (Appendix J)</td>
</tr>
<tr>
<td>4. Enhance students’ mathematics learning</td>
<td>Posttest Scores (compared to Pretest scores)</td>
<td>Posttest (Appendix A)</td>
</tr>
</tbody>
</table>
Population and Sample

The primary subjects for this research were Educational Opportunity Program students or students with low math placement levels taking the College Algebra Extended course at State University of New York at New Paltz. Typically, EOP students are mostly minority students (African-American, Asian, and Hispanic) who are considered educationally and economically disadvantaged. All of the educationally and economically disadvantaged students taking the College Algebra Extended course in the fall of 2004 were enrolled in this study. The sample size (entire population of EOP students who completed the CAEP in fall 2004) was 12.

Variables

The variables used in this study are:

1. Demographic variables:
   a. Gender
   b. Race

2. Personal variables:
   a. Math Placement Level (MPL)
   b. Primary Language (language spoken outside of classroom or at home, English and non-English)
   c. Learning Styles

3. Achievement variables:
   a. Pretest
   b. Posttest
   c. Homework
d. Workshop (Workshop percentage grade and Index Scores)
e. Quiz
f. Concept-model-application (CMA) test
g. Midterm Exam
h. Final Exam

4. Students’ Engagement variables:
   a. Classroom Pedagogy: In-class instructional and assessment approaches
   b. Workshop Pedagogy: Workshop activities
   c. Online Pedagogy: Online instructional and assessment deliveries.

Table 3 shows both the descriptions and the values of the achievement variables used in this study. Table 4 shows the descriptions and the values of the demographic, personal, and students’ engagement variables used in the study.

**Instrumentation**

Description of Instruments

I designed all the surveys, quizzes, pretest and posttest, midterm exam, and online Concept-model-application mathematics' achievement tests. I also composed the homework assessment using Thomson Learning Center's example algorithms under copyright agreement from Thomson Learning Center (for educational use only). The homework assessment instrument is owned solely by Thomson Learning Center who owns the copyright rights to the technology that both delivered and assessed the instrument.
Table 3
Achievement Variables Description and Value Matrix

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Mini-exam of 15 questions designed to assess students’ prior math knowledge (see Appendix A).</td>
<td>0 – 100% College Algebra Exam</td>
</tr>
<tr>
<td>Posttest</td>
<td>Same as Pretest but intended to assess students’ math knowledge gain during course (see Appendix A).</td>
<td>0 – 100% College Algebra Exam</td>
</tr>
<tr>
<td>Homework</td>
<td>10 Questions Online each week designed to cover course work topics and to help with building math skills (see Appendix I).</td>
<td>80% - 8 Multiple Choice Questions 20% - 2 Fill-in or Essay or Graphics Questions</td>
</tr>
<tr>
<td>Workshop</td>
<td>10 Quiz-type Questions created by students similar to midterm part 2 and final part 3</td>
<td>0 – 100%</td>
</tr>
<tr>
<td>Workshop Index</td>
<td>An assessment of weekly workshop questions (about 10) designed to measure students’ ability to add context to lecture problems (see chapter 3).</td>
<td>0 – 10 points</td>
</tr>
<tr>
<td>Quizzes</td>
<td>5 Quizzes with 10 questions similar to Part II of Midterm Exam that assess cumulative knowledge (see Appendix H, Part II).</td>
<td>0 – 100%</td>
</tr>
<tr>
<td>Concept-model-application (CMA) Test</td>
<td>Online Pre-Final Exam test designed to assess students’ mastery of key college algebra concepts, formulas and problem-solving skills (see Appendix B)</td>
<td>Concept-Model (1 – 10) Concept-Application (11-20) Model-Application (21-30) Concept-Application (31-40) Mixed-CMA (41-50) Application-Model (50-60)</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>25 Mid-semester basic and college algebra questions (see Appendix H).</td>
<td>40% - Part I (MC) 40% - Part II (Quiz) 20% - Part III (Word)</td>
</tr>
<tr>
<td>Final Exam</td>
<td>Common Post-course exam created and assessed by team of mathematics professors (see Appendix J).</td>
<td>10% - Questions 1 – 10 30% - Questions 11-25 50% - Questions 26-33 10% - Questions 34-35</td>
</tr>
</tbody>
</table>
### Table 4

**Demographics, Personal, and Students’ Engagement Variables Description Matrix**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>See Appendix D, Question 1</td>
<td>Male or Female</td>
</tr>
<tr>
<td>Race</td>
<td>Nationality (Appendix D, Question 2)</td>
<td>Blacks, Hispanic, Asian, and Whites</td>
</tr>
<tr>
<td>Math Placement Level</td>
<td>Measures students’ mathematics competency levels (Appendix K)</td>
<td>1 - Lacks Fundamental Math Skills</td>
</tr>
<tr>
<td>(MPL)</td>
<td></td>
<td>2 - Lacks Basic Math Skills</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - Ready for College Math</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - Met minimum GE II Math Requirement</td>
</tr>
<tr>
<td>Primary Language</td>
<td>Primary Language spoken outside of class (Appendix D, Question 3)</td>
<td>English or Non-English</td>
</tr>
<tr>
<td>Learning Styles</td>
<td>CAPSOL Styles of Learning (Appendix R)</td>
<td>Visual (V)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Auditory (A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bodily-Kinesthetic (K)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Individual Learner (I)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Group Learner (GR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oral Expressive (O)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Written Expressive (W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sequential (S)</td>
</tr>
<tr>
<td>Classroom Pedagogy</td>
<td>Classroom instructional and assessment approaches (Appendix G)</td>
<td>Instruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lectures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quizzes</td>
</tr>
<tr>
<td>Workshop Pedagogy</td>
<td>Classroom instructional and assessment approaches (Appendices G and M)</td>
<td>Instruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workshops</td>
</tr>
<tr>
<td>Online Pedagogy</td>
<td>Online instructional and assessment approaches (Appendices F and G)</td>
<td>Instruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Homework</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Online and Blackboard Resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assessment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Homework</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMA Test</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
The surveys and the Concept-model-application instruments composed on Blackboard are mine and may be distributed only by my permission. The Institutional Research Statistical Summary is available in part and distributed as public domain information, and the individual instructor report card from that instrument was used for educational use or educational research.

The final exam was owned by the Department of Mathematics at SUNY New Paltz and was used by permission for the purpose of this research. It was not the intent of this study to publish any part of the final exam as part of its documentation. Description of all the instruments used in this study is summarized in Table 5.

Validity and Reliability

The reliability of the CAPSOL Learning Styles Assessment was determined by test-retest. The mean coefficient for the CAPSOL questions was 0.74 (Conrath & Henderson, 2001).

The pretest-posttest, midterm, and final exams were designed to measure the learning outcomes (math performance) for college algebra based on predefined specification tables (see an example in chapter 4, Figure 7). The validity of the instruments used to assess algebra-learning outcomes for this course was determined based on specification tables and was reviewed by math colleagues at SUNY New Paltz. Table 6 lists the number of each mathematics achievement test given to students. The final exam was constructed by a committee of mathematics instructors who set the standard for mathematics achievements for all students taking college algebra at SUNY New Paltz. I did not see the final exam before it was given to students and did not
Table 5

**Instruments Description Table**

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest/Posttest (Appendix A)</td>
<td>13 Forced-Choice</td>
<td>Measured math knowledge/learning at beginning and end of course</td>
</tr>
<tr>
<td>CMA Test (Appendix B)</td>
<td>2 Problem Solving</td>
<td>Measured integration of math concepts, models, and applications</td>
</tr>
<tr>
<td>Math Learning Style Survey (Appendix C)</td>
<td>30 Matching</td>
<td>Assessed learning styles: Visual, Auditory, and Tactile/Kinesthetic</td>
</tr>
<tr>
<td>Introduction Survey (Appendix D)</td>
<td>12 Demographic Types: (Thurstone)</td>
<td>Gathered demographic information</td>
</tr>
<tr>
<td>Example of Progress Survey (Appendix E)</td>
<td>7 Likert Questions</td>
<td>Intermediate assessment of students’ progress</td>
</tr>
<tr>
<td>Online Survey (Appendix F)</td>
<td>1 Guttman</td>
<td>Assessed online pedagogy</td>
</tr>
<tr>
<td>Post Class Survey (Appendix G)</td>
<td>9 Likert</td>
<td>Assessed classroom, workshop and on-line pedagogy</td>
</tr>
<tr>
<td>Midterm Exam (Appendix H)</td>
<td>10 Multiple Choice</td>
<td>Assessed mid-semester’s knowledge of college algebra</td>
</tr>
<tr>
<td>Homework Example (Appendix I)</td>
<td>10 Forced-Choice</td>
<td>Assessed mid-semester’s knowledge of college algebra</td>
</tr>
<tr>
<td>Final Exam (Appendix J)</td>
<td>5 Problem Solving</td>
<td>Assessed mid-semester’s knowledge of college algebra</td>
</tr>
<tr>
<td>Math Placement Level (MPL) (Appendix K)</td>
<td>25 Multiple Choice</td>
<td>Determined students’ prior math knowledge (Description only)</td>
</tr>
<tr>
<td>Student Evaluation of Instruction (Appendix L)</td>
<td>2 Guttman</td>
<td>Assessed classroom pedagogy</td>
</tr>
<tr>
<td>Workshop Usage Survey (Appendix M)</td>
<td>7 Likert Questions</td>
<td>Assessed workshop pedagogy</td>
</tr>
<tr>
<td>Quiz Example (Appendix N)</td>
<td>5 Open Ended</td>
<td>Measured cumulative math learning</td>
</tr>
<tr>
<td>Exit Survey (Appendix O)</td>
<td>8 Force-Choice</td>
<td>Collected students’ response to the research questions of this study</td>
</tr>
<tr>
<td>Post Course Interview (Appendix P)</td>
<td>9 Open Ended</td>
<td>Post final exam interview questions</td>
</tr>
<tr>
<td>Self Analysis Example (Appendix Q)</td>
<td>10 Yes/No</td>
<td>Memory Aid/Assessment tool</td>
</tr>
<tr>
<td>CAPSOL Learning Style Assessment (Appendix R)</td>
<td>45 Likert (4-point)</td>
<td>Learning Styles Assessment: Visual, Auditory, Bodily-Kinesthetic, Individual, Group, Oral Expressive, Written Expressive, Sequential, and Global</td>
</tr>
</tbody>
</table>
participate in the grading of the final (the final exam was graded by a committee of examiners who were selected by the course coordinator).

The reliability analysis was performed after the data were collected and results from each instrument assessed for its internal reliability using a number of measurements. Cronbach’s alpha or KR-21 procedures were used to estimate the internal consistency reliability of survey and math achievement tests (e.g., surveys, pretest-posttest, and midterm and final exams) and the results are summarized in Table 7. The Learning Style Assessment was provided by The CAPSOL organization (Conrath & Henderson, 2001).

Table 6

*Math Performance Test Statistics*

<table>
<thead>
<tr>
<th>Math Test</th>
<th>Number of Tests</th>
<th>Number of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Posttest</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Homework</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Workshop</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Workshop Index</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Quiz</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>CMA Test</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>Midterm</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Final</td>
<td>1</td>
<td>35</td>
</tr>
</tbody>
</table>
Table 7

**Summary of Internal Consistency Reliability Measurements**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Description/Document Location</th>
<th>Number of Items</th>
<th>Reliability Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Appendix A</td>
<td>12</td>
<td>0.91</td>
</tr>
<tr>
<td>Posttest</td>
<td>Appendix A</td>
<td>12</td>
<td>0.96</td>
</tr>
<tr>
<td>Midterm</td>
<td>Appendix H</td>
<td>25</td>
<td>0.90</td>
</tr>
<tr>
<td>Final</td>
<td>Appendix J</td>
<td>35</td>
<td>0.86</td>
</tr>
<tr>
<td>Overall Usefulness of CAEP</td>
<td>Appendix G</td>
<td>9</td>
<td>0.78</td>
</tr>
<tr>
<td>Workshop Usefulness</td>
<td>Appendix G</td>
<td>3</td>
<td>0.84</td>
</tr>
<tr>
<td>Workshop Usage/Usefulness</td>
<td>Appendix M</td>
<td>7</td>
<td>0.81</td>
</tr>
<tr>
<td>Online Usefulness</td>
<td>Appendix G</td>
<td>3</td>
<td>0.67</td>
</tr>
<tr>
<td>Online Usage/Usefulness</td>
<td>Appendix F</td>
<td>7</td>
<td>0.90</td>
</tr>
<tr>
<td>Learning Style Assessment</td>
<td>Appendix R</td>
<td>45</td>
<td>0.74</td>
</tr>
</tbody>
</table>

The surveys questionnaires were designed to answer specific questions asked by the research questions for this study. They were conducted according to survey confidentiality guidelines. Surveys were also designed in accordance with Institutional Review Board (IRB) regulations and guidelines for conducting research with economically and educationally disadvantaged groups. Survey responses were validated by comparison with data from certain performance variables and online monitoring statistics collected during this research.

**Procedure**

The following procedure shows how the College Algebra Extended Program was developed, implemented, and studied for the purpose of this research:
During the spring of 2003, the EOP director, the College Algebra coordinator, the Math Lab director, the mathematics department chairman, the associate dean of the School of Science and Engineering, and I held several meetings to design the CAEP curriculum to meet the needs of EOP and other students with weak college entry-level math skills.

The online resources, the assessment instruments (mathematics achievement tests and surveys), were developed during the summer of 2003. I received training and IRB approval to conduct research with human subjects, especially research with protected groups.

Several CAEP classes were added to the list of available mathematics courses during the fall of 2003. One section of the course that I piloted included regular classroom sessions, workshops twice each week, and online resources. All other sections of the CAEP classes had only classroom and workshop sessions. The CAEP extended the regular College Algebra course to 6 hours of instructions each week (3 hours for classroom and 3 hours for workshop). The session I piloted was the only section where students had the same instructor for both classroom and workshop sessions. Eighteen EOP students were enrolled in my session of CAEP; all 18 students were Hispanics. The mathematics achievement tests and surveys were refined during this pilot study. The success of the pilot helped to provide justification for the research.

The CAEP continued during the spring of 2004 while I received IRB approval to conduct the study. My committee accepted my research topic and proposal during the spring of 2004 and the fall of 2004 respectively.
The research was conducted with 12 students completing (18 started the study) the CAEP study in the fall of 2004. Because of the small sample size, a post-course interview was added to enhance the qualitative procedures of the study. This interview was approved by IRB prior to being administered to students near the end of the fall 2004 semester. A detailed description of the CAEP that was implemented for this research is presented in chapter 4.

Because of the experience and performance of students in this program, the CAEP was terminated after the spring semester of 2005. Though some students passed College Algebra (C- grade in the course), it was my opinion and others that they needed a stronger and separate course for Basic Algebra prior to taking College Algebra classes. The CAEP was also terminated because of funding and resource availability issues with workshop sessions. EOP students with poor math skills can now take a special basic algebra class prior to enrolling in college algebra. The EOP department funds this course.

**Human Subject Considerations**

Care was taken to conduct this research in an ethical manner designed to protect the rights of all participants and those associated with this research. These assessments and procedures were part of students' educational learning and assessment resource for this course and would have been done even if students did not join the study; however, only data from students with signed consents were used in this study.

This research was conducted in compliance with federal laws for conducting research with human subjects especially EOP students who were considered a protected group because of their status as an educational and economically disadvantaged group. In addition, care was taken to obtain parental consent and participants' assents in the case of
minors involved as subjects. I was certified to conduct research with human subjects and only used instruments approved by the Institutional Review Board (IRB). Efforts were made to de-identify all information, thus removing any personal information except as aggregate or statistical summaries.

Analysis of Data

Because of the small sample size of this study, the quantitative data analyses were performed using mostly non-parametric statistics such as the Mann-Whitney test, Kruskal-Wallis ANOVA, and Spearman Rank Order Correlation. Descriptive and inductive statistics were also used to analyze the data. The descriptive statistics used were summary statistics and graphs that showed relative comparison between groups of data. Some basic statistics such as correlation and regression analyses were used to compare the strength of relationships between data set and variables. Inductive statistics such as t-test and non-parametric chi-square tests were used to make inferences. Analysis of Variance (ANOVA) type analyses using the levels of each variable (e.g., gender has two levels, male and female) were used to analyze variances between average scores or grades for each dependent variable.

All data collected for this study were presented using generalized, descriptive, or statistical analysis such as non-parametric ANOVA-type analyses. Statistical summaries such as basic statistics, descriptive statistical charts, statistical tests (t-test and some non-parametric tests), ANOVA, correlation and regression analyses, and various population comparison tests were used to analyze quantitative data. Data collected for qualitative research were categorized or coded to protect the identities of the students.
The interviews were analyzed after transcription using HyperResearch software, and the coding schemes were determined after the interview. Coding was structured to group responses into several thematic categories.

Research Question 1: To compare the results of the pretest and posttest to see if there are significant differences between these two test scores, t-test and various non-parametric rank tests were used. Descriptive or summary statistics provided some measures of the degree of differences of students’ scores on both pretest and posttest. Spearman Rank Order Correlation analysis gave some insight on the degree of the relationship between students’ individual scores on both exams if there was any. Summary statistics and various non-parametric tests were used to examine students’ progress on combinations of mathematics achievement tests.

Research Question 2: To measure the degree of the relationships between demographic variables and performance variables, several tests were used. Nonparametric rank analyses gave some indication as to whether any of the variables or combinations of variables (race and gender) predicted students’ performance. Mann-Whitney U Rank test, for example, measured the relationship between male and female performance on math tests. Kruskal-Wallis ANOVA measured whether there was any relationship between race and students’ performance on math tests. Descriptive statistics gave some measure or summary of the difference, if any, of test results by race and gender.

Research Question 3: To measure the degree of the relationships between personal variables (MPL, learning styles, and primary language) and achievement variables, several statistical tests were used. Descriptive statistics and non-parametric
ANOVA tests gave some indication of the degree or relative difference between levels of personal variables and achievement variables. Spearman Rank Order Correlation analysis showed the strength of the relationship between levels of personal variables and achievement variables.

Research Question 4: A combination of descriptive statistics helped to answer the question about students' perception of the usefulness of certain pedagogical approaches. A combination of average ranking of answers to survey questions relative to a set of approaches was analyzed and discussed using summary and descriptive statistics.

Summary statistics compared students' survey responses of their technology usage or helpfulness of various online resources. Comparative analysis was used to gather information on online resource usefulness from students' survey responses.

Research Question 5: Zero-order correlation analyses were used to assess whether students' mastery of math concepts (as reported by workshop-index scores) showed any relationships between their average scores on problem solving questions on exams. These analyses were appropriate since we were looking for correlation between these variables.

Research Question 6: Zero-order and correlation analyses were used to determine the relationship and degree of such between achievement variables and final exam scores in an attempt to see if performance on final exam was correlated with mathematics achievement scores. This question attempted to look for early indicators of students' performance on the final exam.

Research Question 7: Several themes from students' interview responses were used to summarize their experiences in the CAEP. These responses also highlighted the things students found beneficial to them. These results were compiled from post-course
interviews using the HyperResearch qualitative analyses software. Themes were selected based on students’ responses.

**Summary**

This research design used both quantitative and qualitative approaches to describe the mathematics performance and experiences of EOP students in a College Algebra Extended Program class. The basic design used the one group pretest-posttest method with no control group. A new mathematics curriculum (College Algebra Extended, see chapter 4 for a detailed description of this program), designed and implemented during the fall semester of 2004, provided both workshop and technology support inside and outside the regular classroom. The variables were demographic, personal, achievement, and students’ engagement variables gathered from surveys, mathematics achievement tests, and interviews.
CHAPTER FOUR

PROGRAM DESCRIPTION AND IMPLEMENTATION

Introduction

New Paltz has adopted the State University of New York’s higher college mathematics standard making College Algebra a required course for completion of one of its General Education minimum requirements. Therefore, Educational Opportunity Program (EOP) students normally admitted to college with low mathematics placement in Basic Algebra are now at a disadvantage since this remedial Basic Algebra math is no longer available to them. The EOP department at the State University at New Paltz contracted me to develop and implement appropriate instructional and learning resources to assist EOP students in succeeding in College Algebra. These learning resources were classroom, workshop, and online instructional instances or installations. EOP at New Paltz provides a supportive culture for learning inside and outside of the classroom (reading, writing, and basic mathematics courses) to facilitate social learning and community involvement (Chase, 2004).

This research examined how various computer technologies and other instructional strategies affected the performance and experience of EOP students in College Algebra. A new mathematics curriculum (College Algebra Extended), designed during the fall semester of 2003 (pilot) and the research conducted during the fall semester of 2004, provided both workshop and technology support inside and outside the
regular classroom. This course was developed to help find ways to optimize EOP students' learning outcomes in College Algebra courses. The research design used both qualitative and quantitative data to study the effect the College Algebra Extended Program (CAEP) had on students' performance and various learning outcomes.

**Organization of Chapter**

In this chapter, I describe the CAEP in detail while sharing some stories of students who went through the program. This reflective method of a teacher's narrative interrogating some puzzle or compelling question of teaching or learning through the creation of a narrative, by construction and telling stories and their meaning, is a common practice in research (Lyons & Laboskey, 2002; Schifter, 1996). Aliases are used to protect students' identities, and no direct reference to gender or race is made. This chapter describes the CAEP development, its content and design, illustrations of pedagogical applications, selected instructor's narratives, and a summary.

**Program Development**

**Program Overview**

This new program was originally called computer-assisted Extended College Algebra; I refer to it as the College Algebra Extended Program (CAEP, the name adopted after the pilot in the fall of 2003) in this document. The College Algebra Extended Program provided students with additional instructional support in both Basic and College Algebra and met for 6 hours each week instead of 4 hours as a typical College Algebra course. The version of the CAEP used for this study (computer-assisted) consisted of about 3 hours of regular classroom instructions, 3 hours of classroom
workshops, and 2 hours of online support each week. The same instructor was involved in all three educational supports.

At the beginning of the program or course, students took a pretest, which was similar to Part 3 of the final exam in content (quiz-type or word problem questions), and their individual learning styles were assessed. Classes met for 2 days each week over a 14-week period for 3 hours each day. The first hour and a half was regular classroom instruction and the last hour and a half was workshop. Students were required to spend at least 2 additional hours online each week doing interactive homework and using various multimedia educational resources for both Basic and College Algebra. Throughout the semester, students were given surveys, a pretest, five quizzes, weekly homework and workshop, a midterm exam, a concept-model-application exam (CMA given near the end of the course), a posttest (the same as the pretest), the final exam, and a post-course interview. The computer-assisted software monitored and recorded each student’s online usages.

Augusta: A Student’s Perspective

Augusta was a visual learner with poor math skills whom this program (CAEP) was designed to help. This student was tracked in high school away from math courses involving algebra and so lacked the prerequisites to do well in college mathematics. This student was able to meet the Basic Algebra requirement for the CAEP but did not meet the General Education (GE-II) requirement by getting at least a C- in the course. Augusta found it very difficult to keep up with the regular classroom lectures and often complained that the workshops were difficult even with the help from peers and tutors. Often the instruction had to include basic math concepts prior to introducing algebra.
concepts for Augusta to understand new topics in algebra; a topic on algebraic additions, for example, would have to be preceded by an introduction to fractions additions from basic math. This student, though a visual learner, stated during the interview that math concepts were best understood when first demonstrated on the board by the instructor and then practiced under supervision one-on-one with a tutor.

Augusta liked algebra concepts that were explained systematically; therefore, this student found complex numbers and the Synthetic Division algorithm the easiest concepts to learn. During the interview, Augusta was excited about retaking the course for Math Placement Level (MPL) improvement and stated that there was a lot of self-doubt about ability to do the level of math required going into the CAEP. When asked, What was learned in College Algebra? Augusta replied, “I learned that when I take it again, I would have prior knowledge.” Augusta who came into the program with a very low pretest score was able to receive passing grades on all math tests (posttest, quizzes, homework, midterm, and final).

Pilot Program

For one semester (fall 2003), this technology-assisted model for teaching College Algebra, developed during the summer of 2003, was assessed for completeness and usefulness with a group of 18 EOP students taking College Algebra. All the technology supports were developed and refined with students’ feedback and assessments. Most of the instruments were tested and adjusted for usefulness and user-friendliness. The interview was developed during the actual study in the fall of 2004.

Surveys were administered to students online, and students could complete them by viewing all questions and could skip any question. Students who took the surveys
were authenticated by the system prior to starting each survey only once. All survey results were reported as aggregate data. Because it was necessary to correlate or relate students with their individual responses on surveys and interviews, these instruments were administered directly to students during the fall of 2004 and coded when collected so that individual responses were de-identified.

The same College Algebra textbook was used throughout both the pilot and actual study (Gustafson & Frisk, 2004). The basic math part of the syllabus used the Musser (Musser, Burger, & Peterson, 2003) textbook. There were some lessons learned from the pilot that went into the design of the study for the fall of 2004 that helped improve the students’ overall performance in this course (higher scores on posttest and the final exam).

Some of the major differences in designing the fall 2004 curriculum were:

1. Both the workshops and classroom environments were changed from students having their own computer during instruction and group work, to no computers at all. The presence of computers was a detractor during lectures and group work; few students used their computers for non-course-related activities. Other research had showed similar disadvantage of computers in the classroom (Lowther, Ross, & Morrison, 2003).

2. The classroom lectures were recorded for playback later only during the fall 2004 study. At least two of the students commented on the positive benefits of having instructor’s lecture notes available. Some students confessed that they were poor note takers and having the teacher’s notes available was of great help.
One student said, "I love Blackboard, because what I missed in class I got to catch up on Blackboard." "I liked the recorded classroom lecture notes for my notes were crappy when I wrote them in class; but when I saw them online they made sense."

3. For the fall 2004 study, certain lectures were taught without the use of graphic devises (computer graphics or computer simulation: http://www.pindling.org/Math/College_Algebra/Resource/Expanded_Syllabus/Chapter5/Program/5_1_Syn_Div_animation.ppt). I learned that though students understood the lecture better when illustrated graphically, they could not solve problems when using pencil and paper activities without the aid of the computer. Almost all the students in the pilot failed the question on Synthetic Division in the final of 2003 compared to almost all scoring well on this same question in the fall of 2004; the difference is that they learned it the way they were tested on the final. This was also true when teaching students how to sketch the graphs of various functions or their transformations. Instead of using the computer graphics illustration to teach graphing techniques as was during the fall of 2003, students were taught to use pencil and graph papers to sketch or illustrate answers requiring graphics solutions (transformation, compositions, graphs of functions, and inequality of systems of equations). This result was different from recommendations to use graphing devises or calculators in the math classroom (Alexander, 1993; Campbell, 1996; Choi-Koh, 2003).

4. Instead of weekly workshop problems being assigned from the textbook as was the case during the pilot, students in the fall of 2004 were asked to construct their own questions based on examples online, from classroom lectures, or from the textbook. This was an attempt to help students construct their own contextual framework for each major
math concept (Burns, 2004; NCTM, 1997b; Protheroe, 2004; Smith, 2002; Twyman et al., 2003). I tried to limit the number of major concepts or topics to one each day and about three each week; this was a very painful experience for many students who struggle with learning math concepts, skills, and information simultaneously. Students who found this a positive experience stated how this helped them with mastering concepts and skills for this course.

Another student commented, “My professor gave me a workshop to write my own problems. I think I learned better that way. It is something that you create, you don’t forget. But something that somebody else creates you could easily forget that.”

5. The Pilot used a class web page (see Figure 3) that did not track individual student’s activities, as did the format used to present online instructional content through Blackboard (see Figure 4). This change was made to facilitate the monitoring of students’ online usage for research question 4. Figure 4 illustrates the main entry or access page to the course for students during the fall 2004 study.

Both the pilot and study of 2004 used the same online homework assessment instrument and the content of the class web page; however, the content was packaged using Blackboard (https://blackboard.newpaltz.edu/webapps/portal/frameset.jsp) shown in Figure 4.

Learning Outcomes

The following learning outcomes were set as measures for the success of the CAEP. The EOP department at SUNY, New Paltz, established these exit outcomes:

1. Help students meet the minimum requirements for basic algebra proficiency by getting at least a D in College Algebra Extended
Figure 3. Entry resource page for students in pilot study.

Figure 4. Blackboard resource menu page for fall 2004.

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2. Help as many students as possible to meet the minimum mathematics requirement for General Education, GE-II (at least a C- in College Algebra Extended)

3. Build strong contextual knowledge of college algebra for students (50% or above on Part 3 of college algebra common final exam)

4. Develop and improve students’ knowledge of college mathematics (show significant improvement from students’ scores on pretest to posttest).

Decimie: A Student’s Perspective

Decimie was helped more than the other students were by this program. This student scored the lowest on the pretest and came into the program with a very weak basic math and algebra background. At the end of the program, Decimie showed the greatest improvement between pretest and posttest, and on almost all math achievement tests scored the highest (homework, workshops, quizzes, midterm, and posttest). This student was a tactile-kinesthetic learner who worked and learned better in group settings. Decimie spent the most time on workshop and homework assignments and would not leave the workshop session until a particular concept was understood and the student was confident of working out problems without help.

This highly motivated student was able to help others with math problem solving during both workshops and study sessions. The more help this student provided to others, the more mastery of concepts was acquired. Decimie had a positive experience going through this program; here are some excerpts for the post-course interview with this student:

Researcher: “Describe your overall learning experience in this course.”
Decimie: “It was a great learning experience. It has been a long time since I had an experience learning like that. I honestly can say that it is the first time I have taken a course and actually understood all that I learned in the course.”

Researcher: “How do you learn math best?”

Decimie: “I think I learn math best by actually sitting down and doing the problems, practicing and doing the problem. The instructor’s one-on-one explanations with me helped.”

Researcher: “Describe your online experience.”

Decimie: “It was great! My favorite resource online was the narrated lectures. I have never seen anything like this. You could play it a million times over and you were not going to break the record.”

Researcher: “Elaborate a bit more on the difference between the online math by examples and the textbook.”

Decimie: “I think anyone could read and understand it, the math by examples. The book it was unclear; I think at times that it was a little vague. I think that they could make it simpler so that students taking college algebra as a first time course could understand it better . . . . The ‘Math by Examples’ was able to help me out a lot.”

Researcher: “What part did the online homework play in your learning this course?”

Decimie: The great thing about the homework was, after doing it once, you could go back a second, a third, and fourth time and you would get a different set of problems. If any professor was to assign me homework from a textbook, I had to do the same type
of problems, but the homework online, I was able to get a different set of problems. With the textbook you are limited to the same problems.”

Physical Layout

The physical layout of the classroom and workshop session were designed and the space was set up with the following rationale: The classroom and workshop were held in different rooms across from each other (for students to differentiate lecture from workshop activity sessions). Both rooms were “smart” classrooms with whiteboards. Smart rooms allow for the use of computer or internet delivery of instructions and models for activities. In the classroom, the lectures were taught from the front of the room (lectern), and students sat at their own desks and took notes. The workshop room had about eight tables with chairs that could be arranged for group and individual activities. The technology (computer-assisted learning) allowed the instructor to teach using resources online, and allowed students to participate in group or individualized activities. The online resources were used during workshops for students and for the instructor to check work or review content. Students who missed lectures or some workshops were able to catch up by reviewing recorded lectures online (study sessions or instructional broadcasts posted online). Figure 5 shows a model of how both instructor and students used technology in the course. The computer was not a successful tool for cooperative learning during the pilot study as some had found (Hazelbaker, 1998; Vodounon, 1995); however, the workshop sessions facilitated this role (Swarat et al., 2004). Many have used a similar computer-assisted model of instruction as illustrated in Figure 5 (Cox, 1990; Dyer, 1995; Miller, 1999).
A complete Basic Math learning resource was provided online to help students narrow the gap between their college algebra skills and their weaknesses in basic math and algebra skills. Complete narrated lectures, basic math topic summaries, examples of problems with complete solutions, tables, illustrations, and formula were provided on Blackboard for students to consult at any time during the course (see Figure 6). Providing exemplar of problem solving was one important strategy in the CAEP design (Carroll, 1994; Linn & Hsi, 2000).

Figure 5. Computer-assisted model used in CAEP.
Similar learning modules were available to students for Basic Algebra (chapter 0), word problems (http://www2.newpaltz.edu/~pindline/WP/), and each topic in College Algebra (Figure 7). This was done to provide these students with models or examples of the correct way or alternate ways for solving or understanding course math content (Carroll, 1994; Linn & Hsi, 2000; West & Graham, 2005).

All course content and assessments (homework, workshops, quizzes, and exams) were designed based on concepts and skills that were needed for mastery of each topic in the course. Course content, for example, outlined the skills or knowledge to be learned or mastered for each topic and then continued to demonstrate the applications of these skills by examples (see Figure 7).
Key Concept: Know the basic properties of a quadratic function and how to find its vertex and use these

Skills to Learn:

1. Know how to graph quadratic functions (2nd degree polynomials)
2. Know how to find the vertex of a quadratic function
3. Know how to solve quadratic problems dealing with areas
4. Know how to solve quadratic problems dealing with revenue

Graphing Quadratic Functions

Graph the function $y = x^2 + 2x - 1$

Example: for $x = 4$: $y = 4^2 + 2(4) - 1 = 23$

Figure 7. Course content example: Quadratic function.

Students were able to see the homework grades immediately after doing assignments online. The same day of an exam, they were able to see their grades on Blackboard. It was very important that students knew how well they were doing in the course and what were their areas of weaknesses, so that they could get assistance from tutors or the instructor during the workshop sessions. Figure 8 displays the grades on Blackboard. The “Grade Before*” shown in Figure 8 was the grade without the final exam score.
<table>
<thead>
<tr>
<th>Course Grade</th>
<th>Course Letter Grade</th>
<th>Final Exam Grade</th>
<th>Grade Before*</th>
<th>CMA Test</th>
<th>Quiz 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>89.48</td>
<td>A</td>
<td>77</td>
<td>66.30</td>
<td>57.8</td>
<td>75</td>
</tr>
<tr>
<td>63.37</td>
<td>D</td>
<td>58</td>
<td>45.97</td>
<td>25.5</td>
<td>40</td>
</tr>
<tr>
<td>81.56</td>
<td>B-</td>
<td>75</td>
<td>69.06</td>
<td>66.3</td>
<td>75</td>
</tr>
<tr>
<td>72.27</td>
<td>C</td>
<td>57.5</td>
<td>64.93</td>
<td>66.3</td>
<td>70</td>
</tr>
<tr>
<td>64.32</td>
<td>C</td>
<td>53</td>
<td>63.37</td>
<td>66.6</td>
<td>60</td>
</tr>
<tr>
<td>96.51</td>
<td>B+</td>
<td>80</td>
<td>62.62</td>
<td>51</td>
<td>92.51</td>
</tr>
<tr>
<td>64.51</td>
<td>C</td>
<td>57</td>
<td>47.41</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>63.24</td>
<td>D</td>
<td>54</td>
<td>47.04</td>
<td>15.3</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 8. Blackboard grades summary illustration.

Course Content and Design

Course Credits

The typical college algebra course at SUNY New Paltz awards three credits that are counted towards meeting the minimum college mathematics requirement. Extended College Algebra students were awarded a passing grade in Basic Algebra by getting at least a D grade in the course. Students with a grade of D were awarded three registered credits in Basic Algebra (registered credits do not count toward the computation of students’ GPA, but allow them to meet the minimum mathematics requirements for certain courses). Extended College Algebra students who got at least a C- course grade were awarded a passing grade in Basic Algebra and a passing (C- grade) or better grade.
in College Algebra and could take higher mathematics level courses that lead to academic careers in mathematics, science, engineering, and business. Getting at least a C- in the College Algebra Extended course granted a student three registered credits in Basic Algebra, three credits in College Algebra, and an upward change in their mathematics placement level to a four (MPL 4).

Course Content

The College Algebra textbook covers eight chapters of algebra (Gustafson & Frisk, 2004). The first chapter (labeled Chapter 0) consists of a comprehensive review of basic mathematics and basic algebra, and the next seven chapters cover college algebra. Typically, the final exam consists of about five questions on the first chapter and the rest of 35 questions from the remaining seven college algebra chapters. The basic mathematics, typically taught in a 14-week semester course, was covered in 2 hours of lecture.

The first chapter contains a basic mathematics overview (sets of numbers: natural number, whole numbers, integers, rational numbers, irrational numbers, real numbers, and inequalities) and a comprehensive overview of basic algebra (integer exponents, scientific notation, rational exponents, radicals, polynomials, factoring polynomials, and algebraic fractions). The content of the first chapter is covered in 3 weeks with periodic reviews throughout the semester when introducing related advanced topics.

The remaining chapters are comprehensive presentations of college algebra. These chapters consist of the following topics: equations and equalities, the rectangular coordinate systems and graphs of equations, general functions, exponential and logarithm functions, solving polynomial equations, linear systems of equations, and conic sections.
In total, there are about 38 key concepts that were taught during the semester for College Algebra Extended. Typically, each concept was covered in about 2 hours of regular classroom lecture.

Typical Instructional Session

A typical one and a half hour instructional session for the CAEP followed the following format: An assessment session, an instructional session, a mini-workshop session, and a review session. The assessment session took about 15 minutes to half an hour and consisted of testing prior knowledge on one to two concepts or major topics (except basic mathematics and/or basic algebra review). Here each topic was introduced as questions in the form of a real world problem to established context. Students were asked during the assessment session to solve problems before any instructions to help the instructor determined the prior knowledge of students and assessed students’ strengths and weaknesses on specific pre-requisite topics prior to classroom lecture (Sliger, 1992; Thompson & Zamboanga, 2004).

Next came the instructional session. A 1-hour lecture was conducted where any missing (required) prior knowledge observed from the assessment session was presented along with new topics. Each instructional session consisted of:

1. Presenting concepts in terms of context and relevance to real life problems or future mathematics topics or courses

2. Introducing all relevant formulas and mathematical models: These first two steps helped to establish meaning and relevance for students (Rose & Nicholl, 1997; Solomon, 2005; Weber, 2004)
3. Illustrating and discussing alternate ways of solving related problems (Daniels & Zemelman, 2004; Moren & Duran, 2004).

Students demonstrated learning of concepts during the mini-workshop session where each student was required to solve related problems under the instructor’s supervision. These mini-workshop sessions provided the active learning environment after each classroom lecture (Alas & Garcia, 2001; Delong & Winter, 2002; Martin, 2000; NCTM, 1997a; Swarat et al., 2004). Finally, students often were provided with a summary of the lecture and topics or concepts learned during a short review session. The review session consisted of students assisting the instructor in stating key concepts, formulas, and approaches to problem solving in summary form. This was a memory aide as well as a method to help students discover the truth that just a few concepts were presented during each lecture; therefore, optimizing their cognitive load (Bransford et al., 1999; Kalyuga & Sweller, 2004; Kwon et al., 2005).

Each lecture was recorded and made available to students for their review later on Blackboard. These electronic recordings of classroom lectures were intended not to replace students’ personal note taking, but to enhance them.

**Jules: A Student’s Perspective**

Jules was a tactile-kinesthetic learner who had the prior knowledge of high-school Algebra II (equivalent to College Algebra) before taking this course. This student scored lower than average on most math tests, especially tests that were standard exam settings (quizzes, pretest, posttest, midterm, and final exam). The student would show signs of anxiety during exams and often moaned and complained during tests conducted in class. Early in the course, Jules told me that taking regular exams or math tests was a very
difficult activity. During the interview, this student reemphasized the fact that math was a hated subject matter. Jules stated that the College Algebra curriculum was the same as in high school and complained about having problems with formulas and mixing up numbers when working with math. After the interview, I shared this with the EOP coordinator.

During classroom lectures, Jules would start working on problems while the instructor was doing the work on the board and did not pay attention during lectures. This student loved the workshop experience and started workshop type-activities before the classroom lectures were concluded.

*Researcher:* “Tell me about your workshop experience.”

*Jules:* “When I got to the workshop, I knew how to do a problem. So I did them fast and had to wait for everyone else.”

*Researcher:* “So why did you think you knew how to do the problems when you got to the workshop?”

*Jules:* “I had done it before in class [actually did them while the lecture was being conducted].”

This student stated during the interview that the notes taken in class were not reviewed for exams. Jules liked working in groups and recognized that group study was important to success in math. Even though Jules did well online, this experience was not considered a positive one. To Jules, the online homework lacked the opportunity for writing and working out problems on paper and so spent very little time doing the work online. Jules rarely accessed the learning resources on Blackboard. Though this student preferred working in groups, the study groups created outside of the workshop had
members who mostly preferred working alone. However, I think that many of Jules’s study members dislike the fact that this student was not a team player.

This student did not meet the GE-II requirement; however the student met the Basic Algebra requirement. After the interview, I talked to this student about scoring low on the final exam. Again, we talked about test anxiety and the concern that standard testing environments were a threatening experience for some students. Jules was allowed to retake an equivalent final exam under different testing conditions the day after the interview. The new testing conditions were: (a) an isolated testing room, (b) the student was allowed to use notes, and (c) unlimited time for exam. The student took less than 3 hours to complete an otherwise 2-hour exam and scored a grade of C+ to B- on the exam. Even though I did not change this student’s grade after this make-up exam, I saw a renewed confidence in Jules about math tests and exams, and I hope this will help alleviate any fear the student may have about math in the future.

Typical Workshop Session

The purpose of the workshop session was to help students build basic mathematics skills (computational, use of calculator, and methods of solving fundamental mathematics problems) and to provide an environment for group study through cooperative learning (Hrabowski, 2003; Swarat et al., 2004). Each topic had a predefined set of workshop questions with answers for students to review online (about 10 per topic: http://www.pindling.org/Math/College_Algebra/Workshop/index.html). The workshop sessions were divided into two parts. Part 1 helped students build basic college-level survival skills, such as how to study for exam, how to read mathematics textbooks, how to take notes, overcoming test anxiety, and many such topics. Part 2 helped students
master algebra topics by workings in groups. Learning in these groups facilitated social learning activities.

A typical workshop session spent 15 minutes on how to take mathematics notes or other math survival skills. The remaining time was devoted to cooperative learning sessions; here students working in groups solved predefined problems covering all the concepts presented in the first hour and a half of classroom lecture. Students were required to create 10 questions for the next class based on the topics covered for that week. These questions were required to be original questions created by students. These problem formulations were intended for students to build conceptual knowledge of topics discussed in class (Woelfel, 2003).

May: A Student’s Perspective

May was a tactile-kinesthetic learner who came into the program with all the necessary prerequisite background knowledge for College Algebra. May’s pretest score and other math test scores were above average. This student did exceptionally well on the final exam. May had an almost perfect attendance for classroom and workshop sessions (only missed one workshop session).

May liked the workshop experience; however, this student did not like working in groups as much. This student led most group math problem-solving activities and would always take time out to help other students even during group quiz at his or her own expense. May complained during the interview about a preference to work alone and stated that groups often were a learning distracter. This student was a hard worker who did all but one of the required workshop and homework assignments and was one of the top scorers in these take-home assignments. May was always an eager volunteer for
working out problems on the board during workshop sessions when others did not want
to do so. This student took advantage of extra help by participating in study sessions (by
the instructor twice each week, about 2 hours) and special group study with the instructor
just before the final exam in the students’ dorm study hall.

The computer as an instructor and assessor was a new experience for May. This
student stated during the interview that the computer was often a learning distracter and
time spent doing homework was often a tiresome task. However, May liked the recorded
classroom lectures online and sometimes used it to review notes. May welcomed
alternate ways of learning and stated that one of the best things about this program was
having an instructor who took the time to explain things both inside and outside of the
classroom and workshop sessions.

**Workshop Index Scores**

Students received two grades for their workshop assignment: the first grade was a
score out of 100% assessing that the problems created were valid problems solved and
answered correctly. The second score was a workshop index score out of 10 points. This
workshop index score assessed students’ ability to create problems in context to topics
covered in class and at the level of the course requirements. It also assessed students’
ability to use appropriate models or formulas to solve problems created properly. Only
the first score was used to calculate students’ grades; however, the workshop index score
was used as an additional input variable to help predict learning outcomes in the course.
Students had access to an online-extended college algebra resource that consisted of
between 10 and 20 fully worked out examples for each concept. Some of the problems
created by students during these take-home workshop assignments were foundations for
future quizzes and exams. For these take-home workshop questions (formulated by each student), students were asked to provide the following: (a) a problem statement, (b) formulas, (c) worked out solutions, (d) questions at level of the course, and (e) all answers stated clearly.

Typical Online Usage

Students were required to spend at least 2 hours outside of class time online to complete weekly homework assignments and to read and review many online learning resources for this course. These online resources are listed below. The homework was interactive, and each student was given 10 math problems covering the major concepts discussed each week. Students were allowed to retake the homework assignment as often as needed to score high (I took the best score). Each time a student took the homework, a new set of questions was presented similar to the previous and a student could continue to retake any one question (new problem each time) until they had mastered that concept. The online homework assessment tool monitored and kept a record of individual students' attempts and progress during successive retakes.

Students could preview lectures (audio-visual and animated prerecorded presentations of concepts) and review lectures (actual instructor's lecture during class) at any time. All the online learning resources (except the homework online) are listed below (see pp. 102-104) and are shown in Figure 4 as well. Students' use or preview of online learning resources was tracked and monitored by the computer-assisted software on Blackboard.
Juno: A Student’s Perspective

Juno was a very quiet visual learner who seldom spoke in class unless asked to do so by the instructor. Even when Juno responded to questions, the responses were very sparse and to the point. Often I sensed that this student was somewhere else. During the interview, Juno stated that math exercises are best tackled in a quiet place where they can be reflected upon. This student came into the program with no prior knowledge of basic algebra and received the second lowest score on the pretest. Juno tended to like working in groups with the same gender and nationality as the student’s. Juno would come alive during group discussions and the study session with the instructor and peers. During study session, Juno discovered that college algebra was learned best when given the opportunity to work out the problems on the blackboard in front of peers or the instructor. This student often had difficulties expressing algebra concepts in words but was able to express it in writing on the board during study sessions (consistent with scores on CAPSOL’s learning assessment).

Juno loved the online resources on Blackboard and used them more than any other student, save one. This student would look at solutions to exams the same night they were posted. This student also spent the most time, except one other student, doing homework assignments online and attempted homework assignment about twice before scoring, on average, a B-. When doing homework online Juno would go back and forth between the college algebra by examples and the homework assignments, looking for similar problems that were worked out. Juno sometimes found it challenging when there were no clearly worked out examples to homework assignments. Online learning and assessment were new experiences for Juno. Juno met the GE-II requirement by getting at least a C- in College Algebra; however, this student failed Calculus the first time taking
This student wanted to major in an academic career involving math, but because of failing Calculus, is reconsidering. Juno also enjoyed both the classroom and workshop sessions when there were opportunities to practice exercises under the instructor’s supervision.

Program Implementation

The computer-assisted College Algebra Extended Program was implemented in the following ways:

1. Students had the option to preview pre-recorded narrated lectures prior to each classroom lecture (a separate lecture for each topic or section of the course, about 32).

2. The classroom sessions were primary lecture sessions that presented new topics on algebra, building upon previous lectures (all College Algebra lectures were recorded for students’ review later – this was an optional resource for this program). The mathematics achievement tests were administered during the classroom sessions.

3. After a 10- to 15 minute break, students participated in a workshop session (1½ hours) in which they did the following activities: (a) worked in groups to solve algebra problems, (b) worked with instructor one-on-one, (c) learned how to solve a particular word problem, (d) viewed on-line resources, and (e) participated in a post-exam analysis.

4. Each week students were required to do an online homework assignment consisting of 10 problems from topics covered that week. Students were also required to spend at least 1 hour each week using the learning resources on Blackboard. A study guide was provided to students to help them select appropriate Blackboard learning resources.
Pedagogical Illustrations

Classroom Sessions

Classroom lectures started out with a 2- or 3-minute description of each new topic and its application to either the physical or social sciences, engineering, medicine, business, and any other related field. The textbook does a good job of introducing each chapter with a focused career description that requires a mathematics background; throughout the text it highlights many interesting facts and stories about mathematicians past and present. I sometimes introduced each new topic with a problem that illustrated the essence of that particular topic. I then gave students a few minutes to solve it. This allowed me to assess the background knowledge students have of a topic. I then introduced appropriate formulas and presented sub-topics following this instructional approach: I ask a question at the level of the course or final exam and show step-by-step how to solve it using formulas and strategies appropriate to that question. I then ask a similar question and, in a question-and-answer format, elicited students’ help to solve the problem. Often I wait for students to solve a problem and then I solve it on the board and have students verify or compare their solution steps to what was written on the board. I often find myself reviewing basic math or basic algebra during a presentation of college algebra topics, because during my question-and-answer instruction periods, students indicated that they forgot or did not remember learning these prerequisite fundamental math concepts.

I encouraged students to strive for understanding rather than memorizing problems and answers. This approach allowed me to cover from four to six problems with students’ interactions.
I often used the computer to illustrate many visual concepts in the forms of animations, graphing tools, and illustrations. Because I recorded the lecture notes on a virtual whiteboard (Electronic Whiteboard from Mimio-Virtual Ink), students could replay these lectures (motion videos without sounds, as illustrated in Figure 9).

Figure 9. Electronic whiteboard example lecture.

Figure 10 is an example of a result from the graphing tool I used called MathGv (http://www.MathGv.com) to illustrate graphing. I used this sparingly because I found that students learned graphing techniques better with paper and pencil graphing of solutions that requires a graphical output.
Figure 10. Computer-graphing output: Systems of inequalities.

I also applied computer animations to illustrate certain math concepts or image maps to help students grasp the essentials of a topic. An example of computer animation is my PowerPoint web-based illustration of Synthetic Division shown in Figure 11 and illustrated online (http://www.pindling.org/Math/College_Algebra/Resource/Expanded_Syllabus/Chapter5/Program/5_1_Syn_Div_animation.ppt).
Example 2: $3x^3 - 2x^2 - 6x - 4 \div (x + 3)$

**Synthetic Division Example**

\[
\begin{array}{c|ccccc}
\text{r} & x^3 & x^2 & x^1 & x^0 \\
\hline
P(x) & 3 & -2 & -6 & -4 \\
Row 2 & & & & -9 \\
Row 3 & -3 & 3 & & \\
Q(x) & x^2 & x^1 & x^0 & R(x) \\
\end{array}
\]

Figure 11. Animation of synthetic division.

An example of a visual map is found at http://www.pindling.org/Math/College_Algebra/Resource/Reference/Visual_map/Visual_Learning_Map.html (example of chapter 2 overview visual map). An example of a web-based visual sub-topic illustration can be found at http://www.pindling.org/Math/CA/By_Examples/1_5_Complex_number/I_cont/The_i_continum.html (example of solutions to complex numbers with i). Usually several hours after the classroom lecture, I recorded my observations of the day’s events with students in my instructor’s log. I also made written observations when students were taking tests. I found group interactions during exams where students were allowed to work together (2 occasions) helpful in determining which...
students understood concepts and had appropriate skills to do the math. Excellent math
students were ones who were "consultants," while weak students rarely tried to solve a
problem on their own. I also observed that some students ignored those students who
tended to rely solely on others to do exams or in-class assignments.

Workshop Sessions

The workshop sessions followed the classroom lecture sessions after a 15-minute
break. The Asian and White students were rarely late for these sessions. Workshop
periods were an opportunity for students to reinforce learning by demonstrating that they
understood the classroom lecture topics by working as individuals or in group on
predetermined problems covering topics presented in the classroom lecture. I provided
copies of in-class workshop assignments to students weekly that covered topics discussed
in class for that week. I also gave copies to students of reference materials that
summarized particular topics or areas that students typically found difficult to understand.

Students were organized in groups (racially mixed) based on strengths and
weaknesses demonstrated on overall performance on class math tests. There were always
within any one group students who were A or B students and those who were C or D
students. During the workshop sessions, the A and B students would shine in leadership
of fellow group members during problem solving. Students were teachers during
workshop sessions; they were the ones who wrote out solutions to problems on the board.
Oftentimes, I made up problems to guide them through various stages of mastery of
particular problems and I observed that their common weaknesses were basic math and
basic algebra-related issues (chapter 0 of textbook). I noticed that some students did not
like working with a group; the learning style assessment confirmed this observation as
well as the students’ sharing this preference with me. Many students confessed that they did better when working in-group and noted that some of the stronger students were not group learners. I encourage them to form a study group outside of class (three were formed). The groups formed outside of class were more racially uniform in contrast to the diverse group formations during the workshop; I believed that this diversity among groups helped mostly the weaker students and slightly the stronger students. Stronger students seem to become masters of topics when they provided help to weaker students; two students told me that this was the case. The workshop session was also an opportunity for students to use the instructor as a mentor, tutor, and resource to help them develop problem-solving skills.

We used this session as a forum to teach and demonstrate test-taking skills, self-assessment (students graded their own work), math study skills, learn more about online support/resources, and a period to go over exams and tests taken during the classroom sessions. Students were often asked to solve, on their own or in groups and in-class workshops, problem sets of 5 to 10 problems that were related to the topic presented during the classroom lecture (http://www.pindling.org/Math/College_Algebra/Workshop/index.html). In addition to this, each week students were asked to construct 10 problems covering the topics discussed that week, solve these problems, and then clearly show the answer(s). They received two scores for this effort; one was used to compute their final grade for the class and the other to give an indication of their level of mastery or understanding of the topic. A few students complained about doing this; however, they were told that they could use the wealth of examples online (see web link above) if they were unsure about the process of doing so. An additional resource for helping students
with topic problems for their weekly assignments was a model workshop with solutions and answers developed during the pilot in the fall of 2003 http://www.pindling.org/Math/College_Algebra/Workshop/index_take_home_ans.html).

Online Setup and Technology Overview

Most of the learning resources online were available to students on Blackboard (Appendix 0, Question 9). Students’ use of any resource on Blackboard were tracked (date and time of access by students). There was a duplicate setup on the instructor’s website (see Figure 3) for support to anyone associated with this research (http://www.pindling.org/Math/College_Algebra/Resource/index.html). All grades were posted on Blackboard within hours of exams as well as the solutions to problems on exams. Many students reviewed their grades and checked these solutions within 12 hours of posting. Figure 4 shows the table of contents to the resources on Blackboard.

College Algebra by Examples was the most popular online resource used by most students; all College Algebra by Examples topics are found online at http://www.pindling.org/Math/CA/By_Examples/index_College_Algebra_by_Examples.html. Some students even checked Algebra by Examples prior to lecture session on the topics that were discussed that day. This observation came from polling students during classroom sessions and their responses to post-course interview questions.

Figure 12 shows a typical resource menu on Blackboard available to students. Students used the online resources to learn Basic Math, Basic Algebra and College Algebra. An entire course on Basic Math was provided to students online even though
Figure 12. Blackboard resource menu.

this was a one-lecture topic for this course (Figure 12). While online, students were able to check their grades and check solutions and answer keys to tests and assignments. During workshop, students used computer animations and graphing tools to check answers to in-class workshop assignments for topics such as synthetics division and graphing inequalities.

I used the online resource to share notes with students, to share documents with students, to communicate with absent students and the class, and to post grades and provide study guides for some math tests.

The technology developed for this new curriculum provided from 30 minutes to 1 hour per week in-class technology usage (during the workshop sessions) and 2 hours of additional technology-assisted learning by students each week at their own time and pace.
The 2 hours additional technology usage outside of the classroom were monitored or tracked by computer technology for each student. The technological resources were developed for 35 topics covering both basic algebra (six sections) and college algebra (29 sections); one of the six basic algebra sections was an overview of basic mathematics.

All the online learning resources for this course were packaged and made available to students through Blackboard. These technological resources were:

1. Math by Examples: Topics with worked-out-problems often illustrated in two to four different ways.


3. In-Class Workshops: Group Social Learning and Cooperative Learning Modules designed to teach each topic by problem-solving modeling (copies were made and distributed to each student every week).

4. Take-home Workshops: Weekly Assignments similar to In-Class Workshops designed for individual mastery of math topics.

5. Weekly Math Homework set of 10 Questions: Online Assessment where students took homework as many times as needed within a 7-day period. Correct answers were shown after each attempt and new attempts were given with different test parameters. Scores for each attempt (set of 10 questions) were recorded and saved even though the best score was kept by the instructor for grading purposes. Student could review graded homework with correct answer at any time after completion (Thomson Textbook Learning Technology).
6. Weekly Virtual Classroom Lectures: Recorded Virtual Classroom Lectures created by the instructor. These were stored and made available (for asynchronous viewing) to students using streaming video Internet technology (Mimio Virtual Classroom Technology).

7. Concept-Model-Application Assessment Quizzes: These assessed students' mastery and integration of mathematics concepts with related formulas or models and associated applications or examples specific to college algebra and basic algebra (Blackboard Technology).

8. Computer-Assisted Math Function Graphing Program: An easy to use graphing tool suited for mathematics from basic algebra to advanced calculus (MathGV.com). Used mainly by the instructor to illustrate graphical solutions.

9. e-Reference Learning Resources: Online organization of topics and chapters illustrated in three ways: (a) Concepts-Model-Application, (b) Visual Learning Maps, and (c) Narrative Overview of Problem Solving Strategies.

10. Expanded Syllabus: This was a one-page summary of the essentials of each chapter with hyperlinks to more detailed renditions of chapter sections by example.

11. Interactive Computer Programs: These were designed to simulate problem-solving steps through a student’s interactions with certain systematic topics of college algebra such as Synthetic Division (Microsoft Web-Based Excel Programs). These could be used during workshops by both teacher and students to check answers to problems.

12. Online Worked-out-Solutions or Answers to All Quizzes, Assigned Workshops, Exams and Question-and-Answer sessions: These were posted immediately after each quiz or exam to provide students with correct answers/solutions to graded tests
and assignments within hours after taking or returning tests and assignments. The levels of detail for these postings were dependent upon instructor’s assessment after grading assignments evaluating students’ strengths and/or weaknesses.

13. Weekly Study Guides: An organized page with hyperlinks to weekly assignments and study or learning modules appropriate for each week.

14. Posted Grades: Within 2 to 24 hours after each in-class assessment, grades and answers were posted for students to see their individual performance and class statistics on quizzes and exams. A detailed summary of their grades in each area of assessment was given to their EOP advisor in a separate report card. Each student had password-protected access to Blackboard. This provided them with status on their grades and progress with feedback from instructor and hyperlinks to resources that may help that student.

Online Sessions

One student, who later dropped the class, had a personal computer with a different operating system other than Windows. This did not prevent the student from doing homework assignments; however, it did restrict the time spent online looking at learning resources. Some students had pop-up blockers on their computers that would cause problems with certain resources that would open in a new frame. Outside of the secure environment of Blackboard, I later turned some of these off. For some reason, two of the students routinely had difficulty accessing the homework online with their personal computers; however, all students were able to use all of the resources online from at least six different computer labs on campus including access in their dorms; students with computers at home reported no problem with access. This experience caused me to
provide both online assignments and equivalent paper and pencil assignments for all math
courses that I now teach. By providing both approaches to assignments, students will
have no excuse for not doing assignments due to computer problems.

A typical online session for students, based on what they told me during
interviews and workshop sessions, consisted of them doing the following: (a) previewing
learning resources, (b) reviewing recorded lectures, (c) checking algebra by examples for
help with workshop assignments, (d) doing homework online, (e) checking answers to
assignments and exams, and (f) checking grades.

When a student signed on to the homework online, they are shown assignments
that needed to be taken and appropriate due dates associated with each assignment
(Figure 13). The instructor and student could also see a list of assignments past due or
already taken (Figure 14). Students then took the assignment as many times as they could
before the due date. The computer and instructor kept the best grade for each assignment.
Each time students retook the assignment or any question in the set of homework
problems, the computer generated a similar problem with different values or factors. Both
the student and instructor could look at the student’s responses (each trial) and see both
the student’s response and the correct answer.

The homework online resource provided the instructor with appropriate
information on setting up and analyzing students’ responses to weekly assignments.
Figure 14 shows a screen I used to schedule assignments for homework based on each
section of each chapter of the textbook.
Assignments for Courtney Pindling

To view a syllabus for a course, click on the course name in the table below.

<table>
<thead>
<tr>
<th>Due Date</th>
<th>Assignment</th>
<th>Course</th>
<th>Comment</th>
<th>Take</th>
<th>Score</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 31, 2005 3:54 PM</td>
<td>4.3 Zeros of Polynomials</td>
<td>Precalculus 04</td>
<td>homework</td>
<td>not taken / 100.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar 31, 2005 3:54 PM</td>
<td>4.5 Rational Functions</td>
<td>Precalculus 04</td>
<td>homework</td>
<td>not taken / 100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 13. Students’ homework assignment menu.

<table>
<thead>
<tr>
<th>custom order</th>
<th>assignment name</th>
<th>possible score</th>
<th>attempts allowed</th>
<th>type</th>
<th>category</th>
<th>status</th>
<th>start date</th>
<th>due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>6.1 systems of linear equations</td>
<td>100.0</td>
<td>unlimited</td>
<td>homework</td>
<td>default</td>
<td>Taken</td>
<td>Nov 3, 2004 8:00 PM</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Basic Algebra: Field Theory - Polynomial</td>
<td>100.0</td>
<td>unlimited</td>
<td>homework</td>
<td>default</td>
<td>Taken</td>
<td>Sep 19, 2004 6:00 PM</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Basic Math: Intro Basic Algebra</td>
<td>100.0</td>
<td>unlimited</td>
<td>homework</td>
<td>default</td>
<td>Taken</td>
<td>Sep 9, 2004 6:00 PM</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Composition and Transformation</td>
<td>100.0</td>
<td>unlimited</td>
<td>homework</td>
<td>default</td>
<td>Taken</td>
<td>Dec 6, 2004 5:00 PM</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Homework 11: Into Function- 3</td>
<td>100.0</td>
<td>unlimited</td>
<td>homework</td>
<td>default</td>
<td>Taken</td>
<td>Nov 17, 2004 8:00 PM</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Homework 14: Circles and Parabolas</td>
<td>100.0</td>
<td>unlimited</td>
<td>homework</td>
<td>default</td>
<td>Taken</td>
<td>Nov 24, 2004 8:00 PM</td>
<td></td>
</tr>
</tbody>
</table>

Figure 14. Instructor’s homework assignment menu.
Figure 15 shows the screen the instructor would see when looking at student’s responses to questions on the homework; the instructor may write a personal response to each question. Many students did not read these responses unless I told them to do so.

Figure 15. Example of a student’s homework response.

Figure 16 shows an example of a student’s homework grade. The best trial score from three trials of the same homework was kept.

All resources that students accessed on Blackboard or homework online were tracked by the computer and available to me in both summary or detailed output graphs and reports. Figure 17 shows a summary of number of accesses by students from November 11th to 24th, 2004, on Blackboard to the College Algebra by Examples link.
<table>
<thead>
<tr>
<th>Score:</th>
<th>100.00 / 100.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted Score:</td>
<td>108.00</td>
</tr>
<tr>
<td>Grading Method:</td>
<td>electronic</td>
</tr>
<tr>
<td>Comment:</td>
<td>Instructor's Comment here</td>
</tr>
<tr>
<td>Times taken:</td>
<td>3</td>
</tr>
<tr>
<td>Time spent:</td>
<td>0:59:29</td>
</tr>
<tr>
<td>Date completed:</td>
<td>Date last Taken</td>
</tr>
</tbody>
</table>

**Figure 16.** An Example of a student's homework trial grades.

**Figure 17.** Tracking chart of students' access to an online resource.

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Figure 18 shows the same tracking data as Figure 17, but in a detailed report by student by date during November.

Instructor’s Narrative

I used all the results from the math tests prior to the final exam as a means to learn about students’ strengths and weaknesses on certain topics. A repeated theme throughout my evaluations was students’ tendency to separate ideas in basic math to similar ideas in basic algebra and college algebra. For example, students failed to associate the additions and subtractions of fractions with similar operations on algebraic expressions. Students often had difficulties with evaluating concepts of solving an equation to
simplifying an expression. For example, students would mix up these two problems: (a) Solve the equation of \(1/(x+2) + x/(x-3) = 2/x\), and (b) Simplify \(1/(x+2) + x/(x-3) - 2/x\). The major difference between these two problems is one returns a numerical solution or value for \(x\) and the other returns an algebraic expression. I found that the best way to help students resolve solutions to problems such as these was to give them combinations of these problems to solve in one sitting while pointing out the differences.

I discovered that some students did not like problems that took some effort to solve. I resisted the urge to only teach students how without explaining why. One reason why this group of students tended to do poorly in higher math is that they seem to resist learning any new approaches that required more effort than what they had learned. I also observed this behavior during the pilot study. There were certain techniques, for example, such as completing the squares for quadratic equations, that only worked for quadratic equations with \(a = 1\). When \(a\) is not equal to one there is an additional step that may require working with mixed fractions that some students do not like because it required more effort to solve than what they learned earlier.

Hispanic students tended to have more problems with using the online resource, especially the homework online than most other racial groups. This group of students seems to spend less time working and learning online than other groups, and they often complained to me about their negative online experiences. This unfriendly experience with learning online seems to be consistent with both male and female Hispanic students.

After the midterm exam, students who left the workshop earlier started staying well past the scheduled end time. I asked them why the change and they quoted me saying, "You either spend time in class with the instructor’s help or outside of class on
your own.” There is no shortcut to spending time working problems on one’s own. Students also discovered that it was important to learn and master the correct ways to solve problems that they tended to get wrong. We used as our class motto the words of President John F. Kennedy, “A mistake is not an error, unless you failed to correct it.” It was important therefore, for us during the workshops to go over questions on math tests that students got wrong. Oftentimes, students when talking to me about questions on exams arrived at the correct approach or answer without any input from me. I encouraged this activity during the quizzes.

Earlier during the course, I discovered that some students who were doing poorly wrote a lot on exams without clearly showing the answers. When these students were interviewed, I discovered that they did this because they did not know when they had arrived at an answer or were unsure about the answer or what the question was asking. I started including an answer box (before the midterm exam) to direct students to giving the answers. I emphasized that students must also clearly show answers on workshops or any take-home assignments.

Two test-taking strategies that I had found helpful to most students were:

1. Students were told to prepare a formula sheet before an exam with examples of problems with solutions. Students who used this technique agreed that it helped them do better on an exam.

2. Students were told to check their answers before submitting their exam.

Of all the topics that gave students the most challenge during this course, inequality was the most difficult because it required testing solutions before deciding on the possible correct answer(s). Writing answers in interval notation was a challenge for
inequalities even though students knew what the answers were. I discovered that the use of the number line was useful because it helped students to visualize the solutions to these problems. The number line is a basic math concept and its use was helpful since some students had difficulties with the ordering or ranking of negative numbers without it. For example, some students thought -4 was larger than -2 but on the number line it was clear that -2 was larger.

A very unusual phenomenon for me to observe was students not submitting major exams for fear of the instructor seeing their poor exam scores. During the pilot study, I had one student not submit the midterm exam because that student “knew that the grade was low and was ashamed of the result.” This was also repeated during the posttest in the fall of 2004. One student did not submit the exam and lied about doing so. It seems that some students would rather fail than be perceived as poor math students. During both the pilot and this research, individual students would say, “Don’t even grade this quiz, because I know I did poorly.”

Summary

The College Algebra Extended Program was piloted in the fall of 2003, and studied in the fall of 2004. During the fall 2003 semester, assessment instruments were refined and evaluated with 18 EOP students. This chapter presented a comprehensive description of the CAEP development, its course content and design, and implementation. A detailed description of the three major components of the CAEP was presented and illustrated; namely, classroom, workshop, and online learning environments. Many stories were presented throughout the chapter telling how students interacted with, and
how they experienced this program. Finally, an instructor’s narrative was presented that shared some observations made by me on students’ engagements with the CAEP.
CHAPTER FIVE

RESULTS

Introduction

This research investigated the academic performances and experiences of Educational Opportunity Program (EOP) students in a College Algebra Extended Program (CAEP) at SUNY New Paltz. In addition, this study examined how certain demographical, personal, and pedagogical variables were related to the learning of algebraic concepts. In this chapter, the demographic characteristics of the subjects are described; the results as they relate to the research questions are reported; and a summary of the major findings is presented.

Demographic Characteristics

There were 18 students officially enrolled in the College Algebra Extended Program study at SUNY, New Paltz, in the fall of 2004. Twelve completed the course (67% retention rate). Of the students initially enrolled in the course and study, about 33% were male and the rest female. Of the 12 students who completed the course, 2 were male (about 17%). The students who completed the course consisted of two Asians, four Blacks, four Hispanics, and two White students.

The primary language of 6 of the 12 students (50%) in the study was not English. Also 5 of the 12 students (42%) took either a Basic or a College Algebra course within 1
year of enrollment in the study. All the students with Math Placement Level (MPL) of 3 were students whose primary language was not English. Five of the six students who were tactile-kinesthetic learners had MPL above 2 (four had MPL of 3).

**Research Questions Findings**

**Question 1**

What was the mathematics performance of EOP students in CAEP?

a. How did students perform on pretest and posttest assessments?

b. How well did students do on homework, workshop, quizzes, CMA, midterm and final exam mathematics achievement tests?

**Pretest and Posttest Results**

Table 8 shows the summary statistics of students' scores on both pretest and posttest mathematics achievement tests. Of the 12 students who took the pretest, only 10 completed the posttest, so a sample size of 10 was used to compare pretest and posttest statistics. Students' mean score on pretest was 13.55% and their mean score on posttest was 49.79%. Therefore, students showed improvement between the pretest and posttest of 36.24%. Pairwise *t*-test showed that this was statistically significant at the *p* < 0.05 level (*t* = -4.73, *df* = 9 and *p* = 0.001). Spearman Rank Order Correlations, *r* = -0.07, showed that there was no correlation between pretest and posttest scores at the *p* < 0.05 level, suggesting that posttest results were independent of pretest student performance. That is, there was no pre-testing effect.
Table 8

*Pretest and Posttest Summary*

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size, N</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Mean (%)</td>
<td>13.55</td>
<td>49.79</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>11.12</td>
<td>21.80</td>
</tr>
<tr>
<td>Median</td>
<td>8.33</td>
<td>46.88</td>
</tr>
<tr>
<td>Minimum</td>
<td>4.20</td>
<td>16.70</td>
</tr>
<tr>
<td>Maximum</td>
<td>33.33</td>
<td>81.25</td>
</tr>
</tbody>
</table>

*Note.* $t=-4.73$, $df=9$, and $p = 0.001$.

**Achievement Test Results**

Table 9 summarizes students' mean scores for each quiz, homework, and workshop assignment. Table 10 shows the results of the Friedman ANOVA and Kendall Coefficient of Concordance. These analyses examined students' progress from one assignment to the next for quiz (five quizzes), workshop (12), and homework (11). These analyses showed that the relationship between students' progress from one assignment to the next, for these achievement tests, was not statistically significant at the $p<0.05$ level. Therefore, students' progress from pretest to posttest could not be explained by any progress on weekly assignments (homework and workshop) or periodic assessment (quiz).
<table>
<thead>
<tr>
<th>Assessment Tool</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz 1</td>
<td>11</td>
<td>62.73</td>
<td>21.68</td>
</tr>
<tr>
<td>Quiz 2</td>
<td>12</td>
<td>72.27</td>
<td>20.74</td>
</tr>
<tr>
<td>Quiz 3</td>
<td>12</td>
<td>74.58</td>
<td>15.88</td>
</tr>
<tr>
<td>Quiz 4</td>
<td>12</td>
<td>68.42</td>
<td>17.18</td>
</tr>
<tr>
<td>Quiz 5</td>
<td>11</td>
<td>60.23</td>
<td>18.99</td>
</tr>
<tr>
<td>Workshop 1</td>
<td>12</td>
<td>98.75</td>
<td>3.11</td>
</tr>
<tr>
<td>Workshop 2</td>
<td>11</td>
<td>75.91</td>
<td>21.66</td>
</tr>
<tr>
<td>Workshop 3</td>
<td>8</td>
<td>77.50</td>
<td>22.52</td>
</tr>
<tr>
<td>Workshop 4</td>
<td>6</td>
<td>86.67</td>
<td>18.35</td>
</tr>
<tr>
<td>Workshop 5</td>
<td>12</td>
<td>91.25</td>
<td>11.51</td>
</tr>
<tr>
<td>Workshop 6</td>
<td>10</td>
<td>83.00</td>
<td>20.17</td>
</tr>
<tr>
<td>Workshop 7</td>
<td>9</td>
<td>42.78</td>
<td>26.94</td>
</tr>
<tr>
<td>Workshop 8</td>
<td>9</td>
<td>92.22</td>
<td>7.12</td>
</tr>
<tr>
<td>Workshop 9</td>
<td>12</td>
<td>100.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Workshop 10</td>
<td>10</td>
<td>74.00</td>
<td>18.97</td>
</tr>
<tr>
<td>Workshop 11</td>
<td>11</td>
<td>57.73</td>
<td>32.66</td>
</tr>
<tr>
<td>Workshop 12</td>
<td>10</td>
<td>71.00</td>
<td>14.87</td>
</tr>
<tr>
<td>Homework 1</td>
<td>12</td>
<td>90.14</td>
<td>9.16</td>
</tr>
<tr>
<td>Homework 2</td>
<td>12</td>
<td>89.17</td>
<td>2.89</td>
</tr>
<tr>
<td>Homework 3</td>
<td>12</td>
<td>86.67</td>
<td>6.51</td>
</tr>
<tr>
<td>Homework 4</td>
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<td>Homework 5</td>
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<td>89.00</td>
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<td>6</td>
<td>88.33</td>
<td>9.83</td>
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<td>Homework 7</td>
<td>11</td>
<td>71.82</td>
<td>23.59</td>
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<td>Homework 8</td>
<td>8</td>
<td>91.25</td>
<td>9.91</td>
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<td>Homework 9</td>
<td>10</td>
<td>79.00</td>
<td>22.34</td>
</tr>
<tr>
<td>Homework 10</td>
<td>6</td>
<td>96.67</td>
<td>5.16</td>
</tr>
<tr>
<td>Homework 11</td>
<td>7</td>
<td>97.14</td>
<td>7.56</td>
</tr>
</tbody>
</table>
Table 10

Friedman ANOVA and Kendall Coefficient of Concordance for Quiz, Workshop, and Homework

<table>
<thead>
<tr>
<th>Study</th>
<th>df</th>
<th>Chi-square</th>
<th>Coefficient of Concordance</th>
<th>Average Rank</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz</td>
<td>4</td>
<td>7.49</td>
<td>0.19</td>
<td>0.10</td>
<td>0.11</td>
</tr>
<tr>
<td>Workshop</td>
<td>11</td>
<td>16.34</td>
<td>0.74</td>
<td>0.49</td>
<td>0.13</td>
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<tr>
<td>Homework</td>
<td>10</td>
<td>7.10</td>
<td>0.24</td>
<td>-0.15</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Table 11 shows the statistical summary of students’ means and standard deviations on all mathematics achievement tests. For example, the quiz mean was obtained from the average of 12 students whose average of five quizzes was computed separately. From Table 11, students’ mean scores remained the same between midterm and final exam at about 64%. Pairwise t-test comparing midterm and final exam scores was not statistically significant at the $p<0.05$ level ($t=-0.09$, $df=11$, and $p=0.93$). Results showed that, on average, EOP students taking College Algebra Extended can all achieve the passing grade of D in the course (>50% on the quiz, midterm, and final achievement tests).

Question 2

To what extent was performance (homework, quizzes, midterm and final exams, CMA test, and pretest and posttest) in College Algebra related to certain demographic variables (race and gender)?
Table 11

Summary Statistics of Math Achievement Tests

<table>
<thead>
<tr>
<th>Achievement Tests</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>10</td>
<td>13.55</td>
<td>11.12</td>
</tr>
<tr>
<td>Posttest</td>
<td>10</td>
<td>49.78</td>
<td>21.80</td>
</tr>
<tr>
<td>Quiz</td>
<td>12</td>
<td>65.60</td>
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</tr>
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<td>Homework</td>
<td>12</td>
<td>68.42</td>
<td>19.84</td>
</tr>
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<td>Workshop</td>
<td>12</td>
<td>66.56</td>
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<td>CMA</td>
<td>8</td>
<td>46.75</td>
<td>18.31</td>
</tr>
<tr>
<td>Midterm</td>
<td>12</td>
<td>64.00</td>
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</tr>
<tr>
<td>Final</td>
<td>12</td>
<td>64.25</td>
<td>12.42</td>
</tr>
</tbody>
</table>

Mathematics Achievement and Gender

Table 12 shows means and standard deviations for students’ scores on mathematics achievement tests by gender. In general, male students scored higher than did female students in almost all math tests except for pretest and CMA tests. Table 13 shows the Mann-Whitney U results for mathematics achievement tests by gender; the CMA test was omitted from this analysis because there was only one male student. The Mann-Whitney results showed that although male students’ mean scores on achievement tests were generally higher than female students’ scores, the differences were not statistically significant at the p<0.05 level.

Additionally, male students showed the most improvement from pretest to posttest mean scores by 59.38%, whereas female students showed a difference of 29.78%. Female students showed a slight improvement of 1% from midterm to final exam (mean scores), whereas male students’ mean scores from midterm to final dropped by 3.5%.
### Table 12

**Summary of Math Tests Results by Gender**

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Gender</th>
<th>Male</th>
<th>Female</th>
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</thead>
<tbody>
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<td></td>
<td></td>
<td>N</td>
<td>M</td>
</tr>
<tr>
<td>Pretest</td>
<td></td>
<td>2</td>
<td>6.25</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td>2</td>
<td>65.63</td>
</tr>
<tr>
<td>Quiz</td>
<td></td>
<td>2</td>
<td>76.85</td>
</tr>
<tr>
<td>Homework</td>
<td></td>
<td>2</td>
<td>77.88</td>
</tr>
<tr>
<td>Workshop</td>
<td></td>
<td>2</td>
<td>57.80</td>
</tr>
<tr>
<td>CMA</td>
<td></td>
<td>1</td>
<td>62.08</td>
</tr>
<tr>
<td>Midterm</td>
<td></td>
<td>2</td>
<td>70.50</td>
</tr>
<tr>
<td>Final</td>
<td></td>
<td>2</td>
<td>67.00</td>
</tr>
</tbody>
</table>

*Note.* Highest mean scores for each test in boldface.

### Table 13

**Nonparametric Mann-Whitney Math Tests Results by Gender**

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Rank Sum Female</th>
<th>Rank Sum Male</th>
<th>U</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>71.00</td>
<td>7.00</td>
<td>4.00</td>
<td>1.29</td>
<td>0.20</td>
</tr>
<tr>
<td>Posttest</td>
<td>39.00</td>
<td>16.00</td>
<td>3.00</td>
<td>-1.31</td>
<td>0.19</td>
</tr>
<tr>
<td>Quiz</td>
<td>60.00</td>
<td>18.00</td>
<td>5.00</td>
<td>-1.07</td>
<td>0.28</td>
</tr>
<tr>
<td>Homework</td>
<td>63.00</td>
<td>15.00</td>
<td>8.00</td>
<td>-0.43</td>
<td>0.67</td>
</tr>
<tr>
<td>Workshop</td>
<td>65.00</td>
<td>13.00</td>
<td>10.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Midterm</td>
<td>62.50</td>
<td>15.50</td>
<td>7.50</td>
<td>-0.54</td>
<td>0.59</td>
</tr>
<tr>
<td>Final</td>
<td>63.50</td>
<td>14.50</td>
<td>8.50</td>
<td>-0.32</td>
<td>0.75</td>
</tr>
</tbody>
</table>

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Mathematics Achievement and Race

Table 14 shows means and standard deviations for students’ scores on mathematics achievement tests by race. On average, Asian students consistently did better on most achievement tests than other racial groups in this study. Asians’ and Whites’ mean scores were higher on both take-home assignments (workshops and homework) than other groups.

Asian students showed the most improvement from pretest to posttest mean scores (a difference of 54.15%). Blacks showed an improvement of 52.03% from pretest to posttest, Whites showed an improvement of 35.42%, and Hispanics showed an improvement of 9.74%. Table 15 shows the Kruskal-Wallis ANOVA (by Ranks) analysis of students’ achievement tests by race. Kruskal-Wallis analysis showed that achievement on mathematics tests was not race dependent; therefore differences in achievement scores were not statistically significant at the $p<0.05$ level. It is interesting to note that there appear to be very little improvement for the mean scores from midterm and final exams for most racial groups. The mean differences for Asians, Blacks, Hispanics, and Whites were -0.5%, -3.0%, 0.0%, +6.0% respectively.
Table 14

Summary of Math Tests Results by Race

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Race</th>
<th>Asian</th>
<th>Blacks</th>
<th>Hispanics</th>
<th>Whites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$N$</td>
<td>$M$</td>
<td>$SD$</td>
<td>$N$</td>
</tr>
<tr>
<td>Pretest</td>
<td>Asian</td>
<td>2</td>
<td>20.85</td>
<td>5.87</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>12.51</td>
<td>11.17</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hispanics</td>
<td>4</td>
<td>16.67</td>
<td>13.16</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>7.31</td>
<td>4.40</td>
<td>2</td>
</tr>
<tr>
<td>Posttest</td>
<td>Asian</td>
<td>1</td>
<td>75.00</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>64.54</td>
<td>14.97</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Hispanics</td>
<td>3</td>
<td>26.41</td>
<td>13.40</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>42.73</td>
<td>1.45</td>
<td>2</td>
</tr>
<tr>
<td>Quiz</td>
<td>Asian</td>
<td>2</td>
<td>69.45</td>
<td>15.91</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>72.60</td>
<td>20.15</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hispanics</td>
<td>4</td>
<td>53.16</td>
<td>11.25</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>72.60</td>
<td>3.96</td>
<td>2</td>
</tr>
<tr>
<td>CMA</td>
<td>Asian</td>
<td>2</td>
<td>56.10</td>
<td>14.42</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>2</td>
<td>54.40</td>
<td>4.81</td>
<td>2</td>
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<tr>
<td></td>
<td>Hispanics</td>
<td>2</td>
<td>20.40</td>
<td>7.21</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>56.10</td>
<td>14.42</td>
<td>2</td>
</tr>
<tr>
<td>Homework</td>
<td>Asian</td>
<td>2</td>
<td>83.17</td>
<td>10.92</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>71.32</td>
<td>25.68</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hispanics</td>
<td>4</td>
<td>56.06</td>
<td>19.20</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>72.58</td>
<td>3.64</td>
<td>2</td>
</tr>
<tr>
<td>Workshop</td>
<td>Asian</td>
<td>2</td>
<td>67.29</td>
<td>15.61</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>67.19</td>
<td>24.11</td>
<td>4</td>
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<td></td>
<td>Hispanics</td>
<td>4</td>
<td>64.37</td>
<td>12.32</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>68.95</td>
<td>5.59</td>
<td>2</td>
</tr>
<tr>
<td>Midterm</td>
<td>Asian</td>
<td>2</td>
<td>69.00</td>
<td>5.66</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>68.00</td>
<td>17.22</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hispanics</td>
<td>4</td>
<td>58.50</td>
<td>16.92</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>62.00</td>
<td>14.14</td>
<td>2</td>
</tr>
<tr>
<td>Final</td>
<td>Asian</td>
<td>2</td>
<td>68.50</td>
<td>22.63</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Blacks</td>
<td>4</td>
<td>66.00</td>
<td>14.76</td>
<td>4</td>
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<tr>
<td></td>
<td>Hispanics</td>
<td>4</td>
<td>58.50</td>
<td>7.33</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Whites</td>
<td>2</td>
<td>68.00</td>
<td>12.73</td>
<td>2</td>
</tr>
</tbody>
</table>

Note. Highest mean scores for each test are in boldface.
Table 15

Nonparametric Kruskal-Wallis ANOVA Math Tests Results by Race

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Asians (N=2)</th>
<th>Blacks (N=4)</th>
<th>Hispanics (N=4)</th>
<th>Whites (N=2)</th>
<th>Chi-square</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>18.0</td>
<td>23.5</td>
<td>28.0</td>
<td>8.5</td>
<td>1.96</td>
<td>0.58</td>
</tr>
<tr>
<td>Posttest</td>
<td>9.0</td>
<td>31.0</td>
<td>6.5</td>
<td>8.5</td>
<td>7.57</td>
<td>0.06</td>
</tr>
<tr>
<td>Quiz</td>
<td>15.0</td>
<td>32.0</td>
<td>14.0</td>
<td>17.0</td>
<td>4.23</td>
<td>0.23</td>
</tr>
<tr>
<td>Homework</td>
<td>20.0</td>
<td>27.0</td>
<td>17.0</td>
<td>14.0</td>
<td>3.50</td>
<td>0.32</td>
</tr>
<tr>
<td>Workshop</td>
<td>13.0</td>
<td>28.0</td>
<td>23.5</td>
<td>13.5</td>
<td>0.21</td>
<td>0.98</td>
</tr>
<tr>
<td>CMA</td>
<td>11.0</td>
<td>11.0</td>
<td>3.0</td>
<td>11.0</td>
<td>4.10</td>
<td>0.25</td>
</tr>
<tr>
<td>Midterm</td>
<td>16.0</td>
<td>30.5</td>
<td>20</td>
<td>11.5</td>
<td>1.52</td>
<td>0.68</td>
</tr>
<tr>
<td>Final</td>
<td>14.0</td>
<td>26.5</td>
<td>21.0</td>
<td>26.5</td>
<td>1.00</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Question 3

To what extent did certain personal variables (learning styles, Math Placement Levels [MPLs], and primary language) influence students' performance (homework, quizzes, midterm and final exams, CMA test, and pretest and posttest) in College Algebra?

Mathematics Achievement and Math Placement Levels

Table 16 shows means and standard deviations for students' scores on mathematics achievement tests by MPL. On average, students whose MPL were 3 received higher scores on all achievement tests (except pretest and CMA test) than those students with lower MPLs.
Table 16

Summary of Math Tests Results by MPL

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Pretest</td>
<td>6</td>
<td>15.64</td>
<td>10.69</td>
</tr>
<tr>
<td>Posttest</td>
<td>5</td>
<td>58.34</td>
<td>25.98</td>
</tr>
<tr>
<td>Quiz</td>
<td>6</td>
<td>67.26</td>
<td>21.49</td>
</tr>
<tr>
<td>Homework</td>
<td>6</td>
<td>75.98</td>
<td>14.55</td>
</tr>
<tr>
<td>Workshop</td>
<td>6</td>
<td>76.94</td>
<td>9.08</td>
</tr>
<tr>
<td>CMA</td>
<td>5</td>
<td>39.10</td>
<td>17.95</td>
</tr>
<tr>
<td>Midterm</td>
<td>6</td>
<td>67.83</td>
<td>18.54</td>
</tr>
<tr>
<td>Final</td>
<td>6</td>
<td>70.42</td>
<td>12.32</td>
</tr>
</tbody>
</table>

Note. Highest mean scores for tests are in boldface.

Table 17 shows Kruskal-Wallis ANOVA results of students' mean achievement test scores by MPL. Only the workshop achievement test was statistically significant by MPL at the $p<0.05$ level. For workshop, it looks like MPL 3 students ($M=76.94$, $SD=9.08$) performed significantly better than MPL 1 ($M=51.88$, $SD=6.19$) and 2 students ($M=58.33$, $SD=15.37$). Even though not all achievement tests were statistically significant by MPL, students with MPL of 3 showed the most improvement from pretest to posttest (an increase of 42.7%).

Students with MPL of 2 improved by 40.06% from pretest to posttest, and students with MPL of 1 showed a decrease in mean scores from pretest to posttest of 8.32%. It is interesting to note that students' mean scores for all achievement tests,
except the pretest, were progressively higher with each successive increase in MPL (see Table 16).

Table 17

Nonparametric Kruskal-Wallis ANOVA Math Tests Results by MPL

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Sum of Rank by MPL</th>
<th>Chi-square</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pretest</td>
<td>40.5</td>
<td>17.5</td>
<td>20.0</td>
</tr>
<tr>
<td>Posttest</td>
<td>32.5</td>
<td>21.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Quiz</td>
<td>40.0</td>
<td>26.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Homework</td>
<td>47.0</td>
<td>19.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Workshop</td>
<td>54.5</td>
<td>18.5</td>
<td>5.0</td>
</tr>
<tr>
<td>CMA</td>
<td>17.5</td>
<td>11.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Midterm</td>
<td>45.0</td>
<td>20.0</td>
<td>13.0</td>
</tr>
<tr>
<td>Final</td>
<td>50.5</td>
<td>22.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Note. Boldfaced items are significant at p < 0.05.

Mathematics Achievement and Learning Styles

Table 18 shows means and standard deviations for students' scores on mathematics achievement tests by Learning Styles. In general, Tactile-Kinesthetic learners performed better on most math tests except the pretest, workshop and final exam than other types of learners. As stated in the demographic section of this chapter, most Tactile-Kinesthetic learners had MPL of 2 and above (four of six had MPL of 3). Table 19 shows the Kruskal-Wallis ANOVA of students learning style assessment relative to...
their performance on achievement tests. Only homework was statistically significant at the $p<0.05$ level when relating students' achievements to their learning styles. From Table 18, it appears that Tactile-Kinesthetic students ($M=82.50, SD=10.96$) performed significantly better on homework than did Auditory students ($M=65.65, SD=8.42$) who, in turn, did better than Visual students ($M=43.03, SD=14.88$). It is interesting to note that Tactile-Kinesthetic learners showed the most improvement from pretest to posttest with an average improvement of 43.8%. Auditory and Visual learners showed improvements from pretest to posttest of 29.88% and 24.26% respectively. There was very little improvement between midterm and final exams for Auditory and Tactile-Kinesthetic learners—improvements of 2.67% and 1.16% respectively. Visual learners showed a decrease in mean scores from midterm to final of 4%.

Table 18

*Summary of Math Tests Results by Learning Style*

<table>
<thead>
<tr>
<th>Learning Style (LS)</th>
<th>Auditory</th>
<th>Visual</th>
<th>Tactile-Kinesthetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Tests</td>
<td>$N$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Pretest</td>
<td>3</td>
<td>11.82</td>
<td>8.40</td>
</tr>
<tr>
<td>Posttest</td>
<td>2</td>
<td>41.70</td>
<td>0.00</td>
</tr>
<tr>
<td>Quiz</td>
<td>3</td>
<td>58.55</td>
<td>15.66</td>
</tr>
<tr>
<td>Homework</td>
<td>3</td>
<td>65.65</td>
<td>8.42</td>
</tr>
<tr>
<td>Workshop</td>
<td>3</td>
<td>73.33</td>
<td>0.72</td>
</tr>
<tr>
<td>CMA</td>
<td>2</td>
<td>45.90</td>
<td>28.85</td>
</tr>
<tr>
<td>Midterm</td>
<td>3</td>
<td>65.33</td>
<td>18.90</td>
</tr>
<tr>
<td>Final</td>
<td>3</td>
<td>68.00</td>
<td>9.54</td>
</tr>
</tbody>
</table>

*Note.* Highest mean scores for each test are in boldface.
Seven of nine (78%) students who took the Post Survey (Appendix G) agreed or strongly agreed that knowing their preferred learning styles helped them learn college algebra. The other two students were not sure, and one of the two had difficulty assessing his or her preferred learning style.

Table 19

*Nonparametric Kruskal-Wallis ANOVA Math Tests Results by Learning Style*

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Auditory (N=3)</th>
<th>Visual (N=3)</th>
<th>Tactile (N=6)</th>
<th>Chi-square</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>17.5</td>
<td>21.0</td>
<td>39.5</td>
<td>0.17</td>
<td>0.92</td>
</tr>
<tr>
<td>Posttest</td>
<td>7.0</td>
<td>34.0</td>
<td>14.0</td>
<td>2.03</td>
<td>0.34</td>
</tr>
<tr>
<td>Quiz</td>
<td>15.0</td>
<td>16.0</td>
<td>47.0</td>
<td>1.65</td>
<td>0.44</td>
</tr>
<tr>
<td>Homework</td>
<td>17.0</td>
<td>6.0</td>
<td>55.0</td>
<td>8.12</td>
<td><strong>0.02</strong></td>
</tr>
<tr>
<td>Workshop</td>
<td>24.0</td>
<td>7.0</td>
<td>47.0</td>
<td>5.36</td>
<td>0.07</td>
</tr>
<tr>
<td>Midterm</td>
<td>20.0</td>
<td>14.5</td>
<td>43.5</td>
<td>0.91</td>
<td>0.63</td>
</tr>
<tr>
<td>Final</td>
<td>23.5</td>
<td>9.0</td>
<td>45.5</td>
<td>3.79</td>
<td>0.15</td>
</tr>
</tbody>
</table>

*Note.* Boldfaced items are significant at $p < 0.05$.

**Mathematics Achievement and Primary Language**

Table 20 shows means and standard deviations for students' scores on mathematics achievement tests by primary language (English or Non-English).

Table 21 shows the Mann-Whitney ANOVA results for primary language and students' achievement tests relationships. Mann-Whitney results showed that only workshop was statistically significant when compared to primary language at $p < 0.05$.
Table 20

**Summary of Math Tests Results by Primary Language**

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Primary Language</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>English</td>
<td>Non-English</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>N</td>
</tr>
<tr>
<td>Pretest</td>
<td>6</td>
<td>13.20</td>
<td>10.75</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Posttest</td>
<td>5</td>
<td>41.23</td>
<td>14.56</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Quiz</td>
<td>6</td>
<td>63.93</td>
<td>9.65</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Home-work</td>
<td>6</td>
<td>60.86</td>
<td>22.75</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Workshop</td>
<td>6</td>
<td>56.18</td>
<td>12.67</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>CMA</td>
<td>3</td>
<td>59.50</td>
<td>11.78</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Midterm</td>
<td>6</td>
<td>60.17</td>
<td>8.11</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Final</td>
<td>6</td>
<td>58.08</td>
<td>9.82</td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

*Note.* Highest mean scores for each test are in boldface.

Table 21

**Nonparametric Mann-Whitney ANOVA Math Tests Results by Primary Language**

<table>
<thead>
<tr>
<th>Math Tests</th>
<th>Rank Sum</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-English</td>
<td>English</td>
<td>U</td>
<td>Z</td>
<td>p</td>
</tr>
<tr>
<td>Pretest</td>
<td>40.50</td>
<td>37.50</td>
<td>16.50</td>
<td>0.24</td>
<td>0.81</td>
</tr>
<tr>
<td>Posttest</td>
<td>32.50</td>
<td>22.50</td>
<td>7.50</td>
<td>1.04</td>
<td>0.30</td>
</tr>
<tr>
<td>Quiz</td>
<td>40.00</td>
<td>38.00</td>
<td>17.00</td>
<td>0.16</td>
<td>0.87</td>
</tr>
<tr>
<td>Homework</td>
<td>47.00</td>
<td>31.00</td>
<td>10.00</td>
<td>1.28</td>
<td>0.20</td>
</tr>
<tr>
<td>Workshop</td>
<td>54.50</td>
<td>23.50</td>
<td>2.50</td>
<td>2.48</td>
<td>0.01</td>
</tr>
<tr>
<td>CMA</td>
<td>17.50</td>
<td>18.50</td>
<td>2.50</td>
<td>-1.49</td>
<td>0.14</td>
</tr>
<tr>
<td>Midterm</td>
<td>45.00</td>
<td>33.00</td>
<td>12.00</td>
<td>0.96</td>
<td>0.34</td>
</tr>
<tr>
<td>Final</td>
<td>50.50</td>
<td>27.50</td>
<td>6.50</td>
<td>1.84</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Note.* Boldfaced items are significant at $p < 0.05$. 

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level. From Table 20, it appears that students whose primary language was not English ($M=76.94, SD=9.08$) performed significantly better than students whose primary language was English ($M=56.18, SD=12.67$).

From the demographics characteristics section of this chapter, students whose primary language was not English (mostly tactile-kinesthetic) started the course with a high MPL of 3. Therefore, it was expected that these students would perform better on achievement tests than those students' whose primary language was English. Non-English primary language students showed the most improvements from pretest to posttest (an increase of 47.65%). English primary language students showed an increase of only 28.03%. While Non-English primary language students showed an average improvement of 2.59% between the midterm and the final exam, English primary language students showed a decrease of 2.09%.

Question 4

Which pedagogical approaches (classroom instructions, workshops, online resources) did students find most helpful?

Table 22 and Figure 19 show the average ranking of students' pedagogical preferences. Table 22 also shows the percentage of students who agreed or strongly agreed that these pedagogies were their preferred learning resources (Appendix G, Question 7). The mean rank was calculated as follows: each rank selection of 1 received 4 points, 2 received 3 points, 3 received 2 points, and 1 received 1 point. Classroom pedagogy received an average rank of 3.50, and workshop pedagogy received an average ranking of 3.38 out of 4. Homework received the lowest average rank of 1.14.
Table 22

**Statistical Summary of Students’ Ranking of Pedagogical Preferences**

<table>
<thead>
<tr>
<th>Pedagogy</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Percentage Agreeing/Strongly Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>8</td>
<td>3.50</td>
<td>0.76</td>
<td>100.00</td>
</tr>
<tr>
<td>Workshop</td>
<td>8</td>
<td>3.38</td>
<td>0.52</td>
<td>87.50</td>
</tr>
<tr>
<td>Online</td>
<td>7</td>
<td>2.00</td>
<td>0.58</td>
<td>12.50</td>
</tr>
<tr>
<td>Homework</td>
<td>7</td>
<td>1.14</td>
<td>0.38</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Note. Percentages are based on Appendix G, Question 7.*

Figure 19. Average ranking of students’ pedagogical preferences.
Classroom instruction was selected as students’ most preferred learning resource. From Post Survey responses, 62.5% of students (five of eight strongly agreed) preferred classroom instruction to other forms of pedagogy. Two of eight, 25.0% of students, selected the workshop session as their most preferred learning resource.

All students (100%) selected either classroom instruction or workshop session as their first most preferred pedagogical approach to learning mathematics—the most effective or useful pedagogy to students learning college algebra. During the interview, one student mentioned that the online resource was the major reason for success in the class even though this student’s pretest score was one of the lowest.

Table 23 shows students’ average ranking of various components of the CAEP and the percentage agreeing or strongly agreeing to their helpfulness (Appendix G, Questions 1, 3, 5, 9-14). Means were computed using reversal items: (a) response of 1 (strongly agree) received a score of 5, (b) 2 (agree) received a score of 4, (c) 3 (neutral) received a score of 3, (d) 4 (disagree) received a score of 2, and (e) 5 (strongly disagree) received a score of 1. The most helpful component of the CAEP was the “Classroom Sessions” ($M=4.56$, $SD=0.53$), the next helpful was the “Workshop Activities” ($M=4.33$, $SD=0.50$), and the least helpful was the “CMA Test” ($M=3.38$, $SD=0.74$). At least 89% of students agreed or strongly agreed that the CAEP and its three components (classroom, workshop, and online resources) were helpful.
Table 23

Post Survey: CAEP Response Summary

<table>
<thead>
<tr>
<th>Survey Questions/Statements</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Percentage Agreeing/Strongly Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. The classroom sessions were helpful.</td>
<td>9</td>
<td>4.56</td>
<td>0.53</td>
<td>100.00</td>
</tr>
<tr>
<td>3. The workshop activities were helpful.</td>
<td>9</td>
<td>4.33</td>
<td>0.50</td>
<td>100.00</td>
</tr>
<tr>
<td>14. The CAEP helped learning math.</td>
<td>9</td>
<td>4.22</td>
<td>0.97</td>
<td>88.89</td>
</tr>
<tr>
<td>11. The workshop assignments helped learning.</td>
<td>9</td>
<td>4.00</td>
<td>0.87</td>
<td>66.67</td>
</tr>
<tr>
<td>13. Knowing my learning style helped.</td>
<td>9</td>
<td>3.89</td>
<td>0.60</td>
<td>77.78</td>
</tr>
<tr>
<td>1. The online resources were helpful.</td>
<td>9</td>
<td>3.78</td>
<td>1.09</td>
<td>88.89</td>
</tr>
<tr>
<td>10. The Algebra by Examples was helpful.</td>
<td>9</td>
<td>3.78</td>
<td>1.20</td>
<td>77.78</td>
</tr>
<tr>
<td>12. The workshop assignments improved performance in math.</td>
<td>9</td>
<td>3.78</td>
<td>0.83</td>
<td>55.56</td>
</tr>
<tr>
<td>9. The CMA exam was helpful.</td>
<td>8</td>
<td>3.38</td>
<td>0.74</td>
<td>50.00</td>
</tr>
</tbody>
</table>

Note. See Appendix G.

Classroom Pedagogy

Table 24 and Figure 20 (Appendix G, Question 6) show the mean ranking of five classroom activities useful or helpful to students. Table 24 also shows the percentage of students selecting these resources as their first or second most helpful classroom activity. Students’ first choice was given a value of 5, second choice a value of 4, third choice a value of 3, etc. Students ranked “Classroom Lectures” \( (M=3.86, SD=1.68) \), followed by the “Post-Final Review” \( (M=3.14, SD=1.21) \), as the most helpful classroom activities, and quiz activity \( (M=2.14, SD=0.90) \) as the least helpful. About 71% of students (five of seven) selected the classroom lecture as the most effective or helpful classroom activity.
Table 24

*Statistical Summary of Students’ Ranking of Useful Classroom Activities*

<table>
<thead>
<tr>
<th>Classroom Pedagogy</th>
<th>$N$</th>
<th>$M$</th>
<th>$SD$</th>
<th>Percentage First or Second Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom Lectures</td>
<td>7</td>
<td>3.86</td>
<td>1.68</td>
<td>71.42</td>
</tr>
<tr>
<td>Post-Final Review</td>
<td>7</td>
<td>3.14</td>
<td>1.21</td>
<td>57.15</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>7</td>
<td>3.14</td>
<td>1.68</td>
<td>42.86</td>
</tr>
<tr>
<td>Posttest</td>
<td>6</td>
<td>2.33</td>
<td>1.63</td>
<td>17.56</td>
</tr>
<tr>
<td>Quizzes</td>
<td>7</td>
<td>2.14</td>
<td>0.90</td>
<td>4.08</td>
</tr>
</tbody>
</table>

*Note.* See Appendix G, Question 6.

![Figure 20. Students’ average ranking of useful classroom activities.](image)
Workshop Pedagogy

All students agreed or strongly agreed (three of nine strongly agreed) that workshop pedagogy helped them learn college algebra (Appendix G, Question 3, Table 23). Table 25 shows students’ average ranking of seven workshop engagement activities on a 5-point Likert scale and the percentage agreeing or strongly agreeing to the helpfulness of these activities (Appendix M, Questions 1-7). Means were computed using reversal items: (a) response of 1 (strongly agree) received a score of 5, (b) 2 (agree) received a score of 4, (c) 3 (neutral) received a score of 3, (d) 4 (disagree) received a score of 2, and (e) 5 (strongly disagree) received a score of 1. The two most useful opinions about the workshop from students were: (a) doing the workshop helped them learn algebra ($M=4.11$, $SD=0.93$) and (b) working in study groups during the workshop was very helpful ($M=4.11$, $SD=0.93$).

From the Workshop Usage Survey (Appendix M), 55.6% (five of nine) agreed or strongly agreed that the workshop sessions made a difference in the learning of algebra (Appendix M, Question 1), and eight of nine students agreed or strongly agreed (88.9%) that doing the weekly workshop assignments helped them learn college algebra (question 2). About 67% (six of nine) agreed or strongly agreed that working in study groups helped them learn college algebra (question 4). Sixty-two and a half percent (five of eight) of students mentioned working in groups (Appendix M, free-form Question 10) when asked, “What were the best things about the workshop sessions?” Sixty-two and a half percent of students (five of eight) stated that they would not change the format or anything about the workshop when asked, “What were the worst things about the workshop sessions and how would you improve it?”
Table 25

Workshop Usefulness Survey Summary

<table>
<thead>
<tr>
<th>Survey Questions/Statements</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Percentage Agreeing/Strongly Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Doing the weekly workshop assignments helped me learn algebra.</td>
<td>9</td>
<td>4.11</td>
<td>0.93</td>
<td>88.89</td>
</tr>
<tr>
<td>4. Working in study groups during the workshop was very helpful in my learning algebra.</td>
<td>9</td>
<td>4.11</td>
<td>0.93</td>
<td>66.67</td>
</tr>
<tr>
<td>6. The workshop sessions immediately after the classroom lectures were helpful in my learning algebra.</td>
<td>9</td>
<td>3.78</td>
<td>0.97</td>
<td>66.67</td>
</tr>
<tr>
<td>1. The workshop sessions made a difference in me learning algebra.</td>
<td>9</td>
<td>3.78</td>
<td>1.30</td>
<td>55.56</td>
</tr>
<tr>
<td>5. The word problem sessions of the workshops were very helpful in my learning algebra.</td>
<td>9</td>
<td>3.67</td>
<td>0.87</td>
<td>66.67</td>
</tr>
<tr>
<td>3. I preferred doing the workshop rather than homework assignments online.</td>
<td>9</td>
<td>3.44</td>
<td>1.51</td>
<td>55.56</td>
</tr>
<tr>
<td>7. The workshop sessions were more useful than working with math tutors or math lab help.</td>
<td>9</td>
<td>3.11</td>
<td>1.36</td>
<td>33.33</td>
</tr>
</tbody>
</table>

Note. See Appendix M, Questions 1-7.

Five out of eight students stated that working in groups was the best activity about the workshop sessions (Appendix M, Question 10). Sixty percent of students said they would not change anything about the workshop section (Appendix M, Question 11).

Online Pedagogy

For the online pedagogy, 88.9% of students (seven of eight, Table 23) agreed or strongly agreed (one of nine strongly agreed) and 12.5% (one of eight) strongly disagreed. The student who strongly disagreed received an average grade of C in the course.
Table 26 shows students’ average ranking of seven online engagement activities
and the percentage agreeing or strongly agreeing to the helpfulness of these activities
(Appendix F, Questions 1-7). Means were computed using reversal items of a 1-to-5
Likert scale: (a) response of 1 (strongly agree) received a score of 5, (b) 2 (agree)
received a score of 4, (c) 3 (neutral) received a score of 3, (d) 4 (disagree) received a
score of 2, and (e) 5 (strongly disagree) received a score of 1. The most useful online
resource for students was the posting of the solutions and answers to quizzes and exams
immediately after they were taken (Question 7: \( M=4.44, SD=0.88 \)) followed by “Algebra
by Example” (Question 5: \( M=3.67, SD=1.22 \)). Doing the homework online received the
lowest ranking of online activities (Question 2: \( M=3.22, SD=1.56 \)). Results showed that
at least one-half (56%, five of nine) of the students found the online resources useful.

During the interview, a student (who got an A grade in the course) stated that the
online resource was the major reason for success in the course. Sixty-three percent (five
of eight) of students believed that the online resources made a difference in the learning
of college algebra (Appendix F, Question 1). All students agreed or strongly agreed that
the homework online helped them learn algebra (Appendix F, Question 2). Only 55.6%
of students preferred doing the homework online to doing it on paper the traditional way
(Appendix F, Question 3).

Table 27 and Figure 21 (Appendix G, Question 2) show the mean ranking of five
online resources (useful or helpful) by students. Table 27 also shows the percentage of
students selecting these resources as their first or second most helpful online resources.
Students’ first choice was given a value of 5, second choice a value of 4, third choice a
value of 3, etc. Results from students’ responses to this question were consistent with
Table 26

*Online Usage Survey Summary*

<table>
<thead>
<tr>
<th>Survey Questions/Statements</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Percentage Agreeing/Strongly Agreeing</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. The posting of the solutions and answers to quizzes and exams immediately after tests were very helpful in my learning algebra.</td>
<td>9</td>
<td>4.44</td>
<td>0.88</td>
<td>77.78</td>
</tr>
<tr>
<td>5. The Algebra by Example was very helpful in my learning algebra.</td>
<td>9</td>
<td>3.67</td>
<td>1.22</td>
<td>66.67</td>
</tr>
<tr>
<td>4. The online-narrated lectures were very helpful in my learning algebra.</td>
<td>8</td>
<td>3.63</td>
<td>1.41</td>
<td>44.44</td>
</tr>
<tr>
<td>6. The recorded classroom lectures were helpful in my learning algebra.</td>
<td>9</td>
<td>3.56</td>
<td>1.42</td>
<td>55.56</td>
</tr>
<tr>
<td>1. The online resource made a difference in me learning algebra.</td>
<td>9</td>
<td>3.44</td>
<td>1.33</td>
<td>55.56</td>
</tr>
<tr>
<td>3. I preferred doing the homework on-line to doing it on paper and handing it to instructor for grading.</td>
<td>9</td>
<td>3.33</td>
<td>1.66</td>
<td>55.56</td>
</tr>
<tr>
<td>2. Doing the homework online helped me learn algebra.</td>
<td>9</td>
<td>3.22</td>
<td>1.56</td>
<td>55.56</td>
</tr>
</tbody>
</table>

*Note.* See Appendix F, Questions 1-7.
Table 27

Statistical Summary of Students’ Ranking of Preferred Online Resources

<table>
<thead>
<tr>
<th>Online Pedagogy</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Percentage First or Second Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math by Examples</td>
<td>9</td>
<td>4.22</td>
<td>1.56</td>
<td>77.78</td>
</tr>
<tr>
<td>Posted Solutions</td>
<td>9</td>
<td>3.33</td>
<td>0.86</td>
<td>55.56</td>
</tr>
<tr>
<td>Narrated Lectures</td>
<td>9</td>
<td>2.88</td>
<td>1.46</td>
<td>22.22</td>
</tr>
<tr>
<td>Recorded Lectures</td>
<td>8</td>
<td>2.63</td>
<td>1.19</td>
<td>33.33</td>
</tr>
<tr>
<td>Homework Online</td>
<td>7</td>
<td>2.38</td>
<td>1.30</td>
<td>11.11</td>
</tr>
</tbody>
</table>

*Note. See Appendix G, Questions 2.*

Figure 21. Students’ average ranking of preferred online resources.
results from the previous section (see Table 26). Students ranked “Algebra by Examples” \( (M = 4.22, SD=1.56) \), followed by “Posted Solutions” \( (M=3.33, SD=0.86) \) as their most preferred online resources, and “Homework Online” \( (M=2.38, SD=1.30) \) as their least preferred online resource. About 78\% of students (seven of nine) selected “Algebra by Example” as their first or second most effective or helpful online learning resource.

**Question 5**
How was students’ mastery of mathematical concepts (workshop index scores) related to their performance on problem-solving questions (word problems and quiz-type questions on the midterm and final exams)?

The workshop index was computed for almost all topics covered from 10 of all the 12 workshop assignments in the College Algebra syllabus. This workshop index score assessed students’ ability to create problems in context to topics covered in the class and at the level of the course requirements. It also assessed students’ ability to use appropriate models or formulas to solve problems created properly (see chapter 4 for more detail). The “Midterm Part 2” was quiz-type (free-form questions), “Midterm Part 3” was word problems, “Final Part 3” was both quiz-type and word problems, and “Final Part 3” was students’ scores on only two possible word problems on the final exam.

Table 28 shows the statistical summary of the average workshop-index scores and various math achievement questions (quiz-type or word problem questions only) on both the midterm and final exams for 11 students. Table 28 also shows the possible values for each group of questions. Students’ average scores on word-problem questions on the final exams were worse than expected (they were expected to get at least one of two word problems correct—only 3 out of 11 did). However, students’ mastery of math concepts
was about average for the final exams (7 of 12 students scored 50% and above on Part 3 of the final exam, 58%). One of the 12 data points was classified as an outlier and so not used for any quantitative results computed in this section (a student with poor exam-taking skills but excellent external-classroom-assessment skills). It is interesting to note that students’ mean scores were above average (>50% of maximum possible points) for “Midterm Parts 2”, “Midterm Part 3”, and “Final Part 3”. No student got both word problems on the final correct; their average score was 2.27% out of a maximum score of 10%.

Table 28

Statistical Summary of Workshop Index Scores and Other Math Measures

<table>
<thead>
<tr>
<th>Test/Question Types</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Possible Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Workshop Index</td>
<td>11</td>
<td>5.68</td>
<td>1.65</td>
<td>0-10</td>
</tr>
<tr>
<td>Midterm Part 2 (Quiz-type)</td>
<td>11</td>
<td>24.45</td>
<td>6.65</td>
<td>0-40</td>
</tr>
<tr>
<td>Midterm Part 3 (Word Problems)</td>
<td>11</td>
<td>14.64</td>
<td>5.66</td>
<td>0-20</td>
</tr>
<tr>
<td>Final Part 3 (Quiz-type)</td>
<td>11</td>
<td>33.27</td>
<td>6.63</td>
<td>0-60</td>
</tr>
<tr>
<td>Final Word Problem</td>
<td>11</td>
<td>2.27</td>
<td>2.28</td>
<td>0-10</td>
</tr>
</tbody>
</table>

Table 29 shows the Pearson’s correlation matrix for workshop index scores relative to their mean scores on certain types of questions (quiz-type and word problem questions) on both the midterm and final exams. Correlation results showed that the
workshop index score was significantly correlated ($r=0.87, p<0.05$) with students' scores on part 3 of the final exam. None of the other achievement tests (quiz-type or word problem) was significantly correlated with the workshop index score.

Table 29

*Pearson's Correlation Matrix (Workshop Index, Midterm, and Final Exams)*

<table>
<thead>
<tr>
<th>Test/Question Types</th>
<th>Average Workshop Index</th>
<th>Midterm Part 2</th>
<th>Midterm Part 3</th>
<th>Final Part 3</th>
<th>Final Word Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave WS Index</td>
<td>1.00</td>
<td>0.48</td>
<td>0.50</td>
<td>0.87</td>
<td>0.50</td>
</tr>
<tr>
<td>Midterm Part 2</td>
<td>1.00</td>
<td>0.08</td>
<td>0.44</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Midterm Part 3</td>
<td>1.00</td>
<td>0.50</td>
<td>0.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Part 3</td>
<td>1.00</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Word Problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Note.* Boldfaced items are significant at $p < 0.05$.

Question 6

Which achievement variables (homework, quizzes, workshop index, midterm exam, and CMA test) were related to students' College Algebra performance (scores on the final exam)?

Table 11 showed the basic statistics of students' mathematics achievement tests. Table 30 shows the Pearson’s correlation Matrix for students’ mean scores on mathematics achievement tests. Correlation analysis showed that students’ scores on...
workshop, quizzes, and midterm exam were significantly correlated with performance on the final exam. Pretest ($r=0.29$), CMA test ($r=0.40$), and homework ($r=0.55$) scores were not significantly correlated to students’ performance on the final; this is consistent with many students’ statement that the homework online helped them the least of all the online resources (see Table 27 and Figure 21).

Table 30

*Pearson’s Correlation Matrix: Math Assessment Instruments*

<table>
<thead>
<tr>
<th></th>
<th>Math Tests</th>
<th>Pretest</th>
<th>Quiz</th>
<th>HW</th>
<th>Workshop</th>
<th>CMA</th>
<th>Midterm</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1.00</td>
<td>0.36</td>
<td>-0.15</td>
<td>0.08</td>
<td>0.28</td>
<td>0.44</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Quiz</td>
<td>1.00</td>
<td>0.48</td>
<td>0.47</td>
<td>0.65</td>
<td>0.73</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework</td>
<td>1.00</td>
<td>0.61</td>
<td>0.63</td>
<td>0.45</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td>1.00</td>
<td>0.13</td>
<td>0.56</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMA</td>
<td>1.00</td>
<td></td>
<td>0.73</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midterm</td>
<td>1.00</td>
<td></td>
<td></td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Boldfaced items are significant at $p < 0.05$.

There were not enough data (due to the small sample size of 12) to establish a regression model for the variables that best predict students’ performance on the final exam. Using zero-order correlation analysis (see Table 30), quiz, workshop, and midterm mean scores, considered individually, appear to be good predictors of their performance.

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on the final exam. The mean quiz score has the largest correlation ($r=0.78$) with students’ performance on the final exam. The pretest, homework, and CMA mean scores had the poorest correlation with students’ performance on the final exam.

**Question 7**

In what ways did the College Algebra Extended Program enrich students?

Of the nine students who took the Post-Survey (appendix G, question 14), 89% agreed or strongly agreed that the College Algebra Extended course made a difference in their learning of mathematics compared to other math classes they have taken. One of the nine disagreed that this course helped the learning of mathematics compared to other math classes taken. This student did not say why the CAEP did not make a difference in the learning of mathematics.

After the final exam, I conducted a post-course interview of all the students to ask them in what ways the CAEP enriched their learning of college algebra. The interview questions are showed in Appendix P, and the coding scheme for the interview is found in Table 36 of Appendix S.

Here are some themes from students’ responses to the post-course interview questions that showed how they experienced the CAEP and how this program benefited them.

*Self-Efficacy:* Students came into this program with a high degree of self-doubt in their abilities to do the mathematics required to succeed. Students with the highest overall achievement in this course (A and B students) had a higher self-efficacy about their mathematics skills and potentials than those whose overall achievements were the lowest.
(grade of D). High achievers were able to overcome self-doubt because of this program, more so than low achievers.

One high achiever stated, “I didn’t think I could do math at all; but once I started doing the workshop and the classroom activities on a regular basis, then I started saying to myself, ‘I could do this!’ Another high achiever stated, “I was sure [of myself] taking the final. I knew how to do every single question and that surprised me. I know everything; I am not a master of it, but if I see a problem, I can use the formula to solve it. I learned a lot!”

One low achiever stated, “I felt that the workshop was going to help me pass this course—but when I got to the test—when I got my first test and I saw that I failed, I guessed that affected me for the rest of the course and I was discouraged and I did not try that hard because I knew I was going to fail. I guess that was what discouraged me when I failed the test. Once I failed it I just wanted to stop trying.” Another low achiever stated, “I doubt myself a lot when I do the work. I would be doing it right and then I do something else. I was nervous.”

In some instances, improvement in students’ self-efficacy increased their motivation to do well in the course. One such student who was highly motivated by the CAEP stated, “Prior to this class, I was not able to understand word problems at all. Now I am able to understand it.” “It definitely made a difference in me, because now I could, I feel confident, now I actually love math. Before, I hated math.” “I hated math because I had a hard time doing it. Ask any student, I/they would do something if it was easy to do. Something that they cannot do, they would not like it.”
Prior Knowledge: Students were able to use online or other learning resources to build the prior knowledge or requisite knowledge needed to understand new topics. These students read ahead, using online study guides and advanced announcements of upcoming topics to prepare for classes. Some students recognized that the CAEP course was a prerequisite to retaking the course or more advanced topics in mathematics. During the classroom lectures, I stressed the relevance of each topic to future mathematics courses.

A high achiever stated, “The instructor after class would tell us next week what we were going to cover so I went home and read the lectures before I got to class.” One student stated, “I was placed into this class because I had difficulties with high school math; I was upset at first because I had the math that I needed to take calculus. But now, fortunately for me, it was helpful because I now have the knowledge and techniques needed to go on to other math courses.” Another student said, “At the beginning of the class, the instructor didn’t just move on straight to college algebra; but started with some of the basic stuff [build the foundations for new materials] and then moved on to college algebra and I think that’s how math course should be taught. If it is taught to me that way, I think that I could learn and move on to other types of math.”

Learning Styles: Students’ knowledge of their preferred learning styles and learning how to study mathematics to optimize learning was beneficial to many students.

One student who discovered for the first time the concept of using learning style to optimize learning stated, “I think every teacher should do the learning assessment test so students may know their learning styles.” Another learner stated, “I actually found out that I am tactile-kinesthetic learner. As I worked out the problems, I saw the problems
and I could keep doing it over; this made the difference.” Another tactile-kinesthetic learner stated, “I learn math best if I am showed something once and I get to work on it by myself.”

Active Learning: Students welcomed and strived in an active learning environment. The CAEP provided many opportunities during classroom and especially throughout workshop sessions for instruction and learning involving students’ participation.

Commenting on the workshop, one student stated, “Basically I learned more in my workshop because I create my own work and then I solve it.” Another student stated, “The lecture was where I focused and learned how to do my problems and solve it and then in the workshop I understood it better and learned to be creative.”

Social Learning: Students found learning activities that facilitated social or cooperative learning very useful. The workshop sessions provided many such opportunities.

One student stated, “I preferred working in groups. I learn from my group mates. They learned from me. I would rather work in groups than work by myself.” Another student stated, “I like the workshop experience as we got something from each other. I know of the different ways you could do one problem.” “I do it one way and another student does it another way. I learned how you could do one problem different ways so I learned from others.”

Teacher-Student Interactions: Students welcomed and benefited from a learning environment that facilitated a high degree of teacher-student interactions.
A student’s comment about teacher-student interaction said, “The teacher [for this program] should be willing to help not only in the classroom but outside of the classroom as well and create other activities that may help the student learn better.” Commenting on the best type of instructor for this course, one student stated, “Instructors should be approachable, because you do not want to be afraid of your teacher, especially if you are already intimidated by the topic itself. Why have teachers who are going to intimidate you even more?”

**Technology Support:** Students had mixed feelings about the role of the computer as both an instructor and an assessor. For most students, using the computer to learn mathematics was a first-time experience.

Commenting on the learning resources on Blackboard, some students stated, “The good thing about the computer learning was [recorded lectures] we could go back and then see it again and it refreshed our memory.” “I love the Blackboard [resource online] because what I missed in class I got to catch up on Blackboard.” Although many students found the learning resources on Blackboard useful, the homework online [computer as an assessor] was not as helpful. One student stated, “The resources on Blackboard I found helpful but the homework itself, the online homework, I didn’t find that helpful.” Some students had negative experiences with the computer as a learning tool. One student, comparing the online and classroom experiences, stated, “I really did not have online experience. I find it difficult for me. I needed someone to explain it to me.” “I think in the classroom everything was clear.”
Other Results

Course Evaluation

Table 31 shows the summary of students' evaluation of instruction for the College Algebra Extended course. Of the 11 students who took the survey, all stated that it was a required course and 5 said that it was a part of their major field of study.

The mean response for the effectiveness of the CAEP was 1.5. That is, students agreed or strongly agreed that the course was a success in educating them ("Contributed toward making me a more, educated informed person," "Achieved the stated objectives of the course outline," and "Overall, was an effective teacher").

Online Assignments

Doing weekly online homework assignments was mandatory for students. Below is a summary of the average number of trials for students per homework assignments and the average time spent online doing the assignments. These averages are then compared to students' overall performance and various other input and demographic variables to determine if there is any relationships between homework online (students' behavior) and these variables or factors.

Table 32 shows students' homework online behavior (Mean Trail and Mean Time) compared to their mean homework scores by various demographic (Gender, and Race) and other variables (MPL, Learning Styles, and Grade Levels). Students with MPL of 2 and above spent more time online doing homework assignments, got higher homework grades, as well as redid assignments more often than students with a low MPL (1). Male students tended to spend more time doing homework assignments, got better online homework grades, and redid assignments more often than did female students.
### Table 31

**Summary of Student Evaluation of Instruction**

<table>
<thead>
<tr>
<th>Question Numbers/Statements</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Stimulated students' interest in the subject matter</td>
<td>1.80</td>
<td>0.79</td>
</tr>
<tr>
<td>18. Gave exams that were appropriately related to the course material</td>
<td>1.73</td>
<td>0.65</td>
</tr>
<tr>
<td>4. Made the objectives of the course clear</td>
<td>1.64</td>
<td>0.67</td>
</tr>
<tr>
<td>16. Adjusted his/her teaching to reflect the students' level of comprehension</td>
<td>1.60</td>
<td>0.70</td>
</tr>
<tr>
<td>8. Made effective use of examples and/or illustrations</td>
<td>1.55</td>
<td>0.69</td>
</tr>
<tr>
<td>3. Contributed toward making me a more, educated informed person</td>
<td>1.50</td>
<td>0.53</td>
</tr>
<tr>
<td>5. Achieved the stated objectives of the course outline</td>
<td>1.50</td>
<td>0.53</td>
</tr>
<tr>
<td>22. Overall, was an effective teacher</td>
<td>1.45</td>
<td>0.69</td>
</tr>
<tr>
<td>12. Treated students with fairness and concern</td>
<td>1.36</td>
<td>0.50</td>
</tr>
<tr>
<td>13. Was actively helpful and concerned with students' progress</td>
<td>1.36</td>
<td>0.50</td>
</tr>
<tr>
<td>20. Gave helpful, instructive feedback (beyond grade) on graded materials</td>
<td>1.36</td>
<td>0.67</td>
</tr>
<tr>
<td>6. Clearly informed students how they would be evaluated</td>
<td>1.30</td>
<td>0.48</td>
</tr>
<tr>
<td>21. Showed enthusiasm for both teaching and for the subject matter</td>
<td>1.30</td>
<td>0.48</td>
</tr>
<tr>
<td>9. Was confident and competent with the subject matter</td>
<td>1.27</td>
<td>0.47</td>
</tr>
<tr>
<td>17. Gave assignments that were appropriately related to the course</td>
<td>1.27</td>
<td>0.47</td>
</tr>
<tr>
<td>7. Was well prepared for class</td>
<td>1.18</td>
<td>0.40</td>
</tr>
<tr>
<td>10. Raised challenging and interesting questions/problems</td>
<td>1.18</td>
<td>0.40</td>
</tr>
<tr>
<td>19. Returned students' work/exams within a reasonable timeframe</td>
<td>1.18</td>
<td>0.40</td>
</tr>
<tr>
<td>14. Was easy to approach for help outside of class</td>
<td>1.14</td>
<td>0.38</td>
</tr>
<tr>
<td>15. Was available for meeting with students during office hours</td>
<td>1.14</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*Note.* The means and standard deviations are based on a 4-point Likert scale (0-to-4 rating scale), where 1 = strongly agree, 2 = agree, 3 = disagree, 4 = strongly disagree, and 0 = not applicable. $N = 11$. 

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Table 32

*Homework Online Behavior Versus Math Performance Plus*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Levels</th>
<th>Mean Trials</th>
<th>Mean Time</th>
<th>Homework Mean</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPL</td>
<td>3</td>
<td>1.30</td>
<td>46.01</td>
<td>75.98</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td><strong>1.60</strong></td>
<td><strong>53.08</strong></td>
<td>61.36</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1*</td>
<td>0.87</td>
<td>30.95</td>
<td>51.88</td>
<td>2</td>
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<tr>
<td>Gender</td>
<td>M</td>
<td><strong>1.75</strong></td>
<td><strong>97.67</strong></td>
<td><strong>77.88</strong></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>F*</td>
<td>1.25</td>
<td>35.50</td>
<td>66.53</td>
<td>10</td>
</tr>
<tr>
<td>Race</td>
<td>A</td>
<td>1.46</td>
<td>55.20</td>
<td><strong>83.17</strong></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.62</td>
<td>71.12</td>
<td>71.32</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>H*</td>
<td>0.81</td>
<td>18.52</td>
<td>56.06</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td><strong>1.67</strong></td>
<td><strong>40.66</strong></td>
<td><strong>72.58</strong></td>
<td>2</td>
</tr>
<tr>
<td>Learning Styles</td>
<td>A</td>
<td>1.19</td>
<td>37.23</td>
<td>65.65</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td><strong>1.56</strong></td>
<td><strong>53.38</strong></td>
<td><strong>82.50</strong></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>1.14</td>
<td>44.83</td>
<td>43.03</td>
<td>3</td>
</tr>
<tr>
<td>Grades</td>
<td>A</td>
<td><strong>1.75</strong></td>
<td><strong>107.58</strong></td>
<td><strong>97.27</strong></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.58</td>
<td>49.47</td>
<td>79.44</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1.20</td>
<td>40.81</td>
<td>62.18</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>D*</td>
<td>1.16</td>
<td>30.08</td>
<td>58.18</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note.* Highest mean scores for each level or variable are in boldface and the levels with the lowest overall mean scores are marked with an asterisk. Mean Trial is the average number of weekly attempts, Mean Time is the average time (minutes) spent online each week, and Mean Homework is the average homework score.

Asian students got the highest homework grades, Black students spent more time online, and Whites redid assignments more often. Hispanic students spent the least amount of time doing homework assignments; often they did not do assignments online and got the lowest grades on homework. Tactile-Kinesthetic students spent more time doing homework, redid assignments more often and got the highest grades on homework.
assignments. The student who got a grade of A in the course spent more time doing homework, redid assignments more often, and got the highest grades on homework assignments. However, students with a D average in the course spent the least amount of time doing homework, redid assignments less often than other grade levels, and got the lowest grades on homework assignments. Only gender was statistically significant for Mean Time (no significant finding for Mean Trial) spent on homework at the $p=0.05$ level (Mann-Whitney analysis) and Table 19 showed that learning style was significant for Mean Homework.

Workshop Assignments

After seeing the results from this summary, I calculated a similar summary comparing workshop averages and workshop index scores to various levels of demographic and other variables. The results are summarized in Table 33. Table 33 shows students' average workshop scores and various demographic and other variables. Similar to homework assignments, students with an MPL of 2 and above did better on written workshop assignments (not computer based) than students with lower MPL (MPL of 3 did the best on workshop assignments). In contrast to results for homework assignments online, female students did better on written assignments than did their male counterparts. Whites scored highest on workshop grades, and Asians scored higher on workshop index scores than any other groups. Visual learners tend to do poorer than other learner types on workshop assignments. Students with higher grade levels tended to do better on workshop assignments than those with lower grade levels (students with grades of A doing the best and students with grades of C doing the worst). Table 17 showed that Average Workshop was significant for MPL and Kruskal-Wallis analysis.
showed that Average Workshop Index Score was significant for MPL (chi-square=6.72, 
$p=0.03$), grades (chi-square=9.33, $p=0.03$), and learning style (chi-square=6.27, $p=0.04$).

Table 33

Workshop Scores Versus Math Performance Plus

<table>
<thead>
<tr>
<th>Variables</th>
<th>Levels</th>
<th>Average Workshop</th>
<th>Average Workshop Index Score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPL</td>
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<td>76.94</td>
<td>6.80</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2</td>
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<td>4</td>
</tr>
<tr>
<td></td>
<td>1*</td>
<td>51.88</td>
<td>4.38</td>
<td>2</td>
</tr>
<tr>
<td>Gender</td>
<td>M*</td>
<td>45.17</td>
<td>5.53</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>57.80</td>
<td>5.79</td>
<td>10</td>
</tr>
<tr>
<td>Race</td>
<td>A</td>
<td>67.29</td>
<td>6.22</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>67.19</td>
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<td>4</td>
</tr>
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<td></td>
<td>H</td>
<td>64.37</td>
<td>5.25</td>
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<td></td>
<td>W</td>
<td>68.95</td>
<td>5.72</td>
<td>2</td>
</tr>
<tr>
<td>Learning Styles</td>
<td>A</td>
<td>73.33</td>
<td>6.14</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>72.64</td>
<td>6.52</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>V*</td>
<td>47.64</td>
<td>3.93</td>
<td>3</td>
</tr>
<tr>
<td>Grades</td>
<td>A</td>
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<td>8.02</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B</td>
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<td></td>
<td>D</td>
<td>65.13</td>
<td>5.63</td>
<td>3</td>
</tr>
</tbody>
</table>

Note. Highest mean scores for each level or variables are in boldface, and the levels with the lowest overall mean scores are marked with an asterisk.
Learning Outcomes Results

The results of the CAEP measured by students’ learning outcomes were:

1. All 12 students who completed the course met the minimum requirements for basic algebra proficiency by getting at least a D in College Algebra Extended. All 12 who completed the course received grades of 50% or better on the final exam.

2. Seventy-five percent or 9 of 12 students who completed the course met the minimum requirements for GE-II mathematics (C- in College Algebra or College Algebra Extended).

3. Seven of 12 students (58%) scored average or above (30% and above out of a possible score of 60%) on Part 3 of the College Algebra final exam.

4. All but 1 of 10 students (90%) who took both the pretest and posttest showed significant improvement from pretest to posttest with an average improvement of 36%. A summary of the results of the pretest and posttest is shown in Table 8.

Summary of Major Findings

Twelve EOP students completed the course; there were two male students; and there were two Asian, four Black, four Hispanic, and two White students. This section summarizes the major findings of this study for the seven research questions asked.

Research Question 1: Comparison of students’ pretest and posttest scores showed that the students made significant improvements in students’ performance in College Algebra of about 36%. There was no significant difference between midterm and final exams and no pre-testing effects.

Research Question 2: There was no significant difference between students’ means scores on achievement tests by either gender or race. This result was in contrast to
the literature which showed that both gender and race are related to performance in mathematics (Erickan et al., 2005; Gonzales et al., 2004; Swarat et al., 2004). The lack of significance of this and other results is probably due to the small sample size used.

Research Question 3: For workshop, it appeared that students with higher MPL performed significantly better than did those with a lower level. For homework, Tactile-Kinesthetic learners seemed to perform significantly better than other types of learners. Students with non-English primary languages performed better than did those whose primary language was English (these were also the student with high MPL). None of the other differences were statistically significant at the $p = 0.05$ level.

Research Question 4: The classroom pedagogy was ranked number one as students’ preferred way of being taught or their preferred pedagogical resource. About 88% of students agreed or strongly agreed that the workshop was their preferred pedagogy compared to only about 13% who preferred online pedagogy.

Research Question 5: Students’ performance on workshop (workshop index scores which measured math concept mastery) was only significantly correlated to their performance on Part 3 of the final exam (quiz-type or word problem questions).

Research Question 6: The quiz, workshop and midterm exam, considered individually, were significantly correlated to students’ performance on the final exam. During interviews, students’ responses showed that the workshop and quiz were key contributors to their performance on the final exam because they were similar to questions on the final.

Research Question 7: Themes from interviews were that self-efficacy played a key role in students’ achievement in mathematics; prior knowledge could be acquired...
from many learning opportunities of the CAEP; students benefited and learned from active and social learning environments; teacher-student interactions were welcomed by students; and technology as an educator and assessor was both a help and a hindrance.
CHAPTER SIX

CONCLUSIONS

Introduction

The research investigated the academic performance and experiences of Educational Opportunity Program (EOP) students in a College Algebra Extended Program (CAEP) at SUNY New Paltz. In addition, this study examined how certain demographical, personal, and pedagogical variables were related to the learning of algebraic concepts. In this chapter, the research methodology is summarized; the findings are presented and discussed; conclusions from the results are made; and implications for practice and research are presented.

Research Questions

This research examined the answers to the following research questions:

1. What was the mathematics performance of EOP students in CAEP?
   a. How did students perform on pretest and posttest assessments?
   b. How well did students do on homework, workshop, quizzes, CMA, midterm, and final exam mathematics achievement tests?

2. To what extent did performance (homework, quizzes, midterm and final exams, CMA test, and pretest and posttest) in College Algebra relate to certain demographic variables (race and gender)?

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3. To what extent did certain input variables (learning styles, Math Placement Levels [MPLs], and primary language) influence students’ performance (homework, quizzes, midterm and final exams, CMA test, and pretest and posttest) in College Algebra?

4. Which pedagogical approaches (classroom instructions, workshops, online resources) did students find most helpful?

5. How was students’ mastery of mathematics concepts (workshop index scores) related to their performance on problem-solving questions (word problems or quiz-type questions on midterm and final exams)?

6. Which achievement variables (homework, quizzes, workshop index, midterm exam, and CMA test) were related to students’ college algebra performance (scores on the final exam)?

7. In what ways did the College Algebra Extended Program enrich students?

Learning Outcomes

This research measured four learning outcomes for the College Algebra Extended Program. The EOP department of SUNY at New Paltz established these program outcomes. They were:

1. Help students meet the minimum requirements for Basic Algebra proficiency by getting at least a D in College Algebra Extended.

2. Help students meet the minimum General Education, GE-II, mathematics requirement (a grade of C- or above in the College Algebra Extended course). The General Education (GE-II) mathematics requirement is the minimum needed for undergraduate degree graduation.
3. Help students build strong contextual knowledge of College Algebra (help students get 50% or above on Part 3 of College Algebra common final exam).

4. Help develop and improve students’ knowledge of college mathematics (show significant improvement from pretest to posttest).

Summary of the Methodology

The research methodology used both quantitative and qualitative data to examine and describe students’ mathematics performance and experiences as they interacted with various components of the College Algebra Extended Program. A number of mathematics learning-outcome tests along with several surveys and nine semi-structured, taped recorded, face-to-face interviews were used to provide both quantitative and qualitative data for the study. Additional quantitative data were collected online that measured students’ utilization of various online learning and assessment resources (Blackboard and online homework). Reliability estimates for the instruments used to measure mathematics performance and experiences in this study ranged from 0.67 to 0.96. The research was designed to measure four major learning outcomes and to answer the seven research questions stated earlier in this chapter.

Twelve of 18 EOP students who enrolled in College Algebra Extended Program at SUNY, New Paltz, in the fall of 2004 completed the course. The group who completed the course consisted of two Asians, four Blacks, four Hispanics, and two White students. Two males and 10 females completed the course.
Findings and Discussions

This section presents a summary of the results of the four major learning outcomes for the program. It also summarizes and discusses the major findings from analyses of the seven research questions. The four learning outcomes were met.

Learning Outcome 1: All 12 students who completed the course met the minimum requirements for basic algebra proficiency by getting at least a D in College Algebra Extended. All 12 who completed the course received grades of 50% or better on the final exam.

Learning Outcome 2: Seventy-five percent or 9 of 12 students who completed the course met the minimum General Education (GE-II) requirement for mathematics by getting at least a C- in College Algebra. These students are able to move on to advance math courses and pursue academic careers in Mathematics, Science, Business, and Engineering.

Learning Outcome 3: Seven of 12 students (58%) scored average or above (30% and above out of a possible score of 60%) on Part 3 of the College Algebra final exam. Since Part 3 of the final exam was quiz-type or word problem questions, this result showed that at least 50% of students had mastered the major concepts of the course.

Learning Outcome 4: All but 1 of 10 students (90%) who took both the pretest and posttest showed significant improvement from pretest to posttest with an average improvement of 36%. A summary of the results of pretest and posttest scores was shown in Table 8.

Although the four major CAEP learning outcomes were met for most students, I am convinced that one semester is not enough time to cover the large number of math topics and concepts these students were required to learn and master in this course. Only
three of six students who have taken the CAEP with me (both pilot study in the fall of 2003 and the study in the fall of 2004) were able to get a grade of C- or better in a higher-level math course (Precalculus, also taken with me). The three students who received a grade of C- or better in Precalculus had received grades of B or A in the CAEP course. Since one course builds upon the other, it is important that students have a firm grasp of fundamental math topics before they can successfully attempt to do more advanced math topics (Kalyuga & Sweller, 2004; Thompson & Zamboanga, 2004).

**Research Question 1:** Comparison of students’ pretest and posttest scores showed that the course significantly influenced students’ performance in College Algebra. Students mean score on pretest was 13.55% and their mean score on posttest was 49.79%, an improvement of 36.24%. Survey and interview analyses supported the result that students performed well because of the additional learning resources available through this extended program.

**Research Question 2:** Though not statistically significant, male students’ average math scores were generally higher than female students’ average math scores (4% higher on final exam). One reason for the lack of statistical significance for this and other results is the small sample size limitation of this study. Males performing higher on math tests than females is consistent with prior research conclusions (Erickan et al., 2005; Gonzales et al., 2004; Gray, 1981; NCTM, 2000b); however, female students can perform the same or better when it comes to math concepts acquisitions (chapter 5, Table 12, average workshop scores). As more female college students in the United States continue to enroll in mathematics and science subjects, new data indicate that the average math scores for female students will be at least equal to that of their male counterparts (Ripley, 2005).
The results of this study showed that Asian students consistently did better on all math tests than all other racial groups and Hispanic students consistently performed the lowest on math tests of all the groups. Again, none of these results were statistically significant at the \( p = 0.05 \) level. This study showed that Asian students' success in this course is possibly due to their performance on weekly assignments. High performers also had a higher level of prior knowledge of basic math and basic algebra concepts and skills coming into this course. The Hispanic students doing more poorly overall than any other groups was mainly because of their lack of prior knowledge of basic math and algebra skills. Most Hispanic students in this study had a strong dislike for the computer as an educator; these students tended to prefer a socially rich learning environment with human educators, not computer-assisted instruction (De Jong, 2002; Gutierrez & Rogoff, 2003; Hrabowski, 2003; Lee, 2003; Orellana & Bowman, 2003).

The students who were most successful in the CAEP were those who were more intrinsically motivated and who developed a higher sense of self-efficacy while taking this course and the students who did poorly had a low sense of self-efficacy. This result is consistent with the findings of others (Bandura, 1997; Choi, 2005; Stevens et al., 2004).

Research Question 3: Most students agreed that knowing their preferred learning style and integrating it into how they learn math helped their performance (78% for students taking the Post Survey, Appendix G). Tactile-Kinesthetic learners did better on all math tests except the final exam, workshop, and pretest; their success may be attributed to doing both homework and workshop assignments (activities requiring doing individual work outside of the classroom) and scoring high on these assignments. Tables 32 and 33 showed that, on average, Tactile-Kinesthetic learners spent more time doing
homework, attempted homework more often, and had a better grasp of the concepts of this course (higher workshop index score). For homework, differences in learning style were significant at the $p<0.05$ level.

The findings of this research on the relationships between learning styles and learning outcomes are consistent with known theories and results, which showed that students who approach the learning environment in a manner compatible to their preferred learning styles optimize their math learning experience (Arem, 1993; Dunn, et al., 1979). All students in this study preferred an active learning environment that facilitates social or group interactions (Bleeker & Jacobs, 2004; Swarat et al., 2004).

Students with higher course entry levels (Math Placement Levels [MPLs]) performed better than those with lower levels (students with MPL of 3 did 10% better than students did with MPL of 2 on final exam). Students whose primary language was not English scored higher on average than those whose primary language was English (12% higher than non-English primary language students on final exam). All non-English primary language students had a high MPL of 3. For workshop, differences in MPL were significant at the $p<0.05$ level. None of the other differences were significant at the $p<0.05$ level. It is possible that students’ work or study habits and math background played a key role in non-English primary language students doing well in the course.

Students with higher Math Placement Levels performed significantly better than those with lower levels did and students whose primary language was not English performed better than those whose primary language was English because of their higher MPLs. The higher MPL students doing better was mainly indicative of their higher prior
knowledge of pre-requisite math concepts coming into the course (Kalyuga & Sweller, 2004).

Research Question 4: More students preferred classroom instruction to other forms of instruction (62.5% on Post Survey, Appendix G). Though students ranked the workshop session second, in terms of their preferred pedagogical approach to learning, they stated that the workshop was a key element in their mastery and acquisition of math concepts and skills. It is possible that the cooperative benefits of group study and the fact that I allowed supervised practice sessions made workshop a useful approach to learning for most students. For most students, both the workshop and math help online were new experiences for them.

Students’ most preferred classroom activity was the classroom lecture followed by the review before the final (Post-Final Review) and their least preferred activity was taking quizzes. Eighty-nine percent of students agreed or strongly agreed that doing the weekly workshop assignments helped them learn college algebra. Students felt that the most helpful online resource for them was the “Algebra by Examples,” and the least helpful was doing the homework online.

Most students preferred classroom and workshop sessions that facilitated active or cooperative instruction and learning. Research showed that minority students do benefit from active learning environments that elicit their participation (Bleeker & Jacobs, 2004; Borman, 2003; Swarat et al., 2004). The computer-assisted pedagogy provided both many models or examples of math problems with solutions and an interactive mathematics assessment environment for learning (Hazelbaker, 1998; Voorhis, 2003). I propose (because of comments from students in this study) that future online homework
be designed to present a level of difficulty that would eliminate guessing but continue to provide immediate and appropriate feedback to students doing assignments online.

*Research Question 5:* Students’ performance on workshop (workshop index scores that measured the degree of math concepts learned) was a good predictor of their performance on the final exam (Pearson’s Correlation Coefficient was 0.87). Many students found the work necessary to achieve math concept mastery a difficult task, but those who did the work performed better overall in the course, especially on the final exam, than those who did not. Some students’ inability to perform well on workshop assignments was probably due to their poor math background (lack of basic algebra and basic math skills) coming into the class. Not enough students took the Concept-model-application (CMA) test to make any valid statistical comparison between students’ math concepts mastery and their math performance. However, of the eight students who took the CMA test those who received a grade above 45% passed the course. I hope that students with a better conceptual understanding of the course will retain their college algebra knowledge longer—as shown by the research of others (Kwon et al., 2005).

Students who had a better understanding of the math concepts (demonstrated by their workshop index scores) did better in the course than those who did not.

*April:* “I liked the workshop; it was basically working together and learning together. We could ask you [the instructor] questions that we did not ask in the class.”

*May:* “I think it was a good opportunity for me to learn more and to see where my strength and weakness were. When you do not practice you’ll just forget everything but I never forgot anything ever since I started doing my workshop.”
Sephan: “I like the workshop experience as we got something from each other. I know of the different ways you could do one problem. I do it one way and another student did it another way. I learned how you could do one problem different ways so I learned from others.”

Research Question 6: The quiz, workshop and midterm achievement tests were good predictors of students’ performance on the final exam. Zero-order correlation analyses of these variables showed them all to be significant predictors of students’ performance outcomes at the $p < 0.05$ level. This result may be due to these learning resources providing students with enough exemplars through problem solution modeling to help them increase their performance in math (Carroll, 1994; Linn & Hsi, 2000).

During interviews, students’ responses showed that they believed that the workshop and quiz were major contributors to their performance on the final exam. Both these instruments contained problems that were similar to questions on the final exam. One student specifically mentioned the posttest as a major contributor for doing well on the final exam.

Research Question 7: Students had many rich experiences with learning mathematics through the College Algebra Extended Program. Many found the classroom activities useful when active learning was encouraged. They enjoyed the workshop sessions because of the opportunities to reinforce through practice what was taught earlier during classroom sessions. Students had many positive experiences in this program. Students’ interview comments on all components of the CAEP (classroom, workshops, and online resources and assessments) showed many themes. Self-efficacy played a key role in students’ achievement in mathematics, prior knowledge could be acquired from
many learning opportunities of the CAEP, students benefited and learned from active and
social learning environments, teacher-student interactions were welcomed by students,
and technology as an educator and assessor was both a help and a hindrance.

Because of the sample size of this study, many statistical tests comparing groups
were not significant at the $p < 0.05$ level even though they appear to be large differences.
Many large differences were often consistent when comparing group means and relative
ranks with students' survey and interview responses.

Conclusions

The following are the conclusions of this study:

1. An extended mathematics program can help EOP students achieve the
minimum learning requirements for a college algebra course.

2. For workshop, it appeared that students with higher MPLs performed
significantly better than did students with lower MPLs. For homework, Tactile-
Kinesthetic learners seemed to perform significantly better than other types of learners.

3. These students welcome and tend to learn best in pedagogical environments
that facilitate cooperative and active learning.

4. Students' mastery of mathematics concepts (how well they integrate math
concepts, formulas, and problem-solving skills) is a good indicator of their performance
in college algebra.

5. Students' performance on quiz, workshop, and midterm achievement tests is a
good indicator of their performance on the final exam.

6. An online learning resource that is rich in examples and that provides timely
feedback to students on their performances on math achievement tests can be very helpful
to these students. Most EOP students in this study had little or no online learning experiences, and so training sessions should be established to educate them on learning online (Azevedo & Cromley, 2004).

**Recommendations for Practice and Research**

**Recommendations for Practitioners**

The following recommendations are based on the findings and conclusions of this research. This section highlights recommendations for instructors, curriculum designers, and directors of Educational Opportunity Program for college students who plan to provide an optimal and effective learning experience for these students taking college-level mathematics.

1. Although the College Algebra Extended Program met the main objective of allowing students to pass the course, they needed more time to absorb the materials over a longer period. Maybe the course should be taught over a two-semester period instead of one. First-semester emphasis should be placed on basic math and algebra topics. Students are unable to do well in higher-level math because strong math foundations in basic math and algebra concepts are missing. A Basic Algebra course must always be available to these students at the college level.

2. Students preferred traditional classroom lectures to workshop pedagogy and other newer forms of instruction or learning environments. Students’ responses showed that they benefited the most from either workshop or study sessions where they were allowed to practice doing mathematics problems on their own or in groups under the supervision of a knowledgeable mathematics instructor or tutor. Active instructional and learning activities facilitated learning for these students. Practicing doing assignments is
still the key to doing well in mathematics, so students must continue to be given
homework with an appropriate level of feedback from the instructor.

3. These students, especially low math performance students, come to college-
level math course with high stress and math anxiety levels; therefore, educators should
consider alternate methods of assessment and instruction to help alleviate students’ stress
levels. I recommend assessments that reward individual and team work outside of the
typical standardized math exam settings.

4. The computer as a learning resource is still new to these students, and training
is needed to help them be more acclimated to computer-assisted instruction and
assessment. When using the computer as an assessor of math learning, the computer
application must provide enough feedback to students doing math assignments online
while providing the right balance between learning challenges and time required for
content mastery. Very few minority students possess appropriate expertise using
computer-assisted learning, therefore care must be taken to use technology that is
computer and software independent. For example, java technology at present is more
computer software and hardware dependent than some packaged multimedia deliveries
such as Real-player applications.

Recommendations for Researchers

The following recommendations for further research are based on the findings and
conclusions of this research. This section highlights recommendations for research
concerning Educational Opportunity Program or minority students taking college-level
mathematics.
1. Since students who successfully passed College Algebra through the extended course plan are often rushed to learn a large amount of new math concepts, new studies should examine the extent to which a two-semester course plan improves students’ performance in higher level math courses such as Precalculus. Currently the best graduates from a CAEP received just a passing grade in the next higher-level math courses.

2. Additional study is needed to explore the impact of an extended math program on students’ performance by comparing the results of parallel treatments of students with and without extended support (support such as workshop and online learning resources).

3. New research should also examine and explore how minority or EOP college math students’ actual learning practices are consistent with their preferred learning styles and whether this has any impact on their performance. This research showed that visual learners may approach their math learning experience as would auditory or tactile-kinesthetic learners and the latter as would visual learners.

4. New studies should examine alternate evaluation or assessment schemes that assess math learning skills and knowledge without too much emphasis on assessments based purely on memory recollection of math content. Students, for example, might be allowed to use condensed notes or formula sheets during exams and their performance compared to other similar students who do not.

5. New research should also examine the role that math anxiety plays during exams and math classes on minority students’ performance. Many students in this study felt that mathematics is a very stressful subject, so research should be conducted to find ways to alleviate anxiety in the instructional and testing environments.
Answer all 15 questions. Each question is worth the same point; some
questions are easier than other - built-in curve - You have 45 minutes to do this quiz.

DO NOT use a red ink pen or red lead pencil to take this quiz (Exams are graded with a
red ink pen).

Answers all questions on this answer booklet and show all work (solutions, right triangle,
graphs, formula used etc.)

Circle or underline each answer

You may use the back of each sheet as workspace but show all work in answer section

Answers alone without showing work are worth only 50% of question points.

A copy of this exam will be return to you (the original will be kept by
instructor)

Grade: ________

Question 1 (1 point) Factor the polynomial $6x^4 + 11x^2 - 10$

Question 2 (1 point) Evaluate and write in $a + bi$, complex number form.
$(5 - 7i)(1 + 3i)$
Question 3. (1 point) Solve the inequality and graph the solution on a number line.
\[ |2x - 5| > 3 \]

Question 4. (1 point) Find the distance between point P and Q if the coordinates of P is (1, -1) and Q is (-3, 4)

or Find the slope of the line between points P and Q.

Question 5. (1 point) Find the x- and y-intercepts of the graph
\[ y = x^2 - 16x \]

Question 6. (1 point) Find the domain and range of the function \( f(x) = \sqrt{x + 5} \)

Question 7. (1 point). Find all vertical and horizontal asymptotes of the rational function
\[ y = \frac{x - 1}{x^2 - 9} \]. Topic Not Covered

Question 8. (1 point) Write the expression as the logarithm of a single quantity. Topic Not Covered
\[ 3 \log a - 3 \log b \]

Question 9. (1 point) Divide \( 2x^3 - 3x^2 - 4x - 1 \) by \( (x - 2) \)

Question 10. (1 point) Solve for x and y in these two equations simultaneously:
\[ x + 5y = 7 \text{ and } 3x + y = -7 \]

Question 11. (1 point) What is the perimeter of a rectangular swimming pool if its area is 2,400 square feet and its length is 50% larger than its width?

Question 12. (1 point) Find the equation of a parabola with vertex (4, -6) that passes through point (3, -8) and (3, -4). Topic Not Covered

Question 13. (1 point) Write the equation of a circle with center at (5, 7) and radius of 8.

Question 14. (1 point) Graph the function, \( y = |x + 2| \)

Question 15. (1 point). If it takes 12 men to complete a job in 1 hour, how many men will do the job in \( \frac{1}{2} \) hour?
APPENDIX B

CONCEPT-MODEL-APPLICATION TEST

Concept - Model

Match the following Concepts (topics or problem statements) in college algebra with the correct Model (formula or equation).

**Note:** Questions are in the left column and answer choices in the right.

<table>
<thead>
<tr>
<th>Concept (topics or problem statements)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Absolute Value of Complex Numbers</td>
<td>$\sqrt{a^2 + b^2}$</td>
</tr>
<tr>
<td>2. Complex Conjugates Multiplication</td>
<td>$a^2 + b^2$</td>
</tr>
<tr>
<td>3. Completing the Square</td>
<td>$(x^2 + bx + \left(\frac{b}{2}\right)^2) + c = \left(\frac{b}{2}\right)^2$</td>
</tr>
<tr>
<td>4. Finding Root(s) of a Quadratic Equation</td>
<td>$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</td>
</tr>
<tr>
<td>5. Equation of a Circle with center $(h, k)$</td>
<td>$(x - h)^2 + (y - k)^2 = r^2$</td>
</tr>
<tr>
<td>6. Equation of a Parabola with Vertex $(h, k)$ and opening either Left or Right</td>
<td>$(y - k)^2 = 4p(x - h)$</td>
</tr>
<tr>
<td>7. Equation of a Parabola with Vertex $(h, k)$ and opening either Up or Down</td>
<td>$(x - h)^2 = 4p(y - k)$</td>
</tr>
<tr>
<td>8. Difference of two Squares</td>
<td>$(a + b)(a - b)$</td>
</tr>
<tr>
<td>9. Difference of two Cubes</td>
<td>$(a - b)(a^2 + ab + b^2)$</td>
</tr>
<tr>
<td>10. Sum of two Cubes</td>
<td>$(a + b)(a^2 - ab + b^2)$</td>
</tr>
<tr>
<td></td>
<td>$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</td>
</tr>
<tr>
<td></td>
<td>$(x - h)^2 = r^2 + (y - k)^2$</td>
</tr>
<tr>
<td></td>
<td>$(a + b)(a + b)$</td>
</tr>
<tr>
<td></td>
<td>$(y - k)^2 = 4p(x - h)^2$</td>
</tr>
<tr>
<td></td>
<td>$(x^2 + bx + \left(\frac{b}{2}\right)^2) + c + \left(\frac{b}{2}\right)^2 = 0$</td>
</tr>
</tbody>
</table>
Concept - Application

Match the following Concepts (topics or Problem statements) in college algebra with the correct Application (Answer or Solution step).

| 11. Absolute Value of an Equality | (3x + 2) = ±4 |
| 12. Absolute Value of an Inequality | (3x + 2) ≥ 4 and (3x + 2) ≤ -4 |
| 13. Distance between Points P(-7, -3) and Q(-1, -2) in Rectangular Coordinate System | √((-1 + 7)^2 + (-2 + 3)^2) |
| 14. Midpoint between Points P(-7, -3) and Q(-1, -2) in Rectangular Coordinate System | (-7 - 1, -3 - 2) / 2 |
| 15. Slope of line with these points: P(-7, -3) and Q(-1, -2) | -1 + 7 / -2 + 3 = 6 |
| 16. Perpendicular line to y = 4x - 5 | y = -0.25x + 10 |
| 17. Parallel line to y = 4x - 5 | y = 4x + 10 |
| 18. Remainder, R for P(x) = 3x^3 - 5x^2 + 3x - 10 divided by (x - 1) | R = -9 |
| 19. A factor of P(x) = x^3 - x^2 + 2x - 8 | (x - 2) |
| 20. Find a root of P(x) = x^3 + x^2 + x - 3 | x = 1 |

R = 0

-2 + 3 / -1 + 7 = 1 / 6

x = -1

(-7 + 1, -3 + 2) / 2

(3x + 2) ≥ 4 and (3x + 2) ≥ -4

√((-1 - 7)^2 + (-2 - 3)^2)
### Model - Application

Match the following Models (formulas or equations) in college algebra with the correct Application (Answer or Solution step).

<p>| | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>21.</strong> Use substitution method to solve systems of linear equations: (1) $3x + y = 1$ and (2) $-x + 2y = 9$</td>
<td></td>
<td>(-1, 4)</td>
</tr>
<tr>
<td><strong>22.</strong> Use addition method to solve systems of linear equations: (1) $5x - 3y = 12$ and (2) $2x - 3y = 3$</td>
<td></td>
<td>(3, 1)</td>
</tr>
<tr>
<td><strong>23.</strong> Use midpoint formula to find the midpoint between points: $P(3, -6)$ and $Q(-1, -6)$</td>
<td></td>
<td>(1, -6)</td>
</tr>
<tr>
<td><strong>24.</strong> Use slope formula to find the slope of line with points: $P(8, 3)$ and $Q(10, 3)$</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>25.</strong> A point that is a solution to the system of Inequalities (1) $3x + 2y \geq 6$ and (2) $x + 3y \leq 2$</td>
<td></td>
<td>(3, -1)</td>
</tr>
<tr>
<td><strong>26.</strong> A point that is a solution to the system of Inequalities (1) $3x - 2y \leq 6$, (2) $x + 2y = 10$, (3) $x \geq 0$ and (4) $y \geq 0$</td>
<td></td>
<td>(1, 3)</td>
</tr>
<tr>
<td><strong>27.</strong> The point $(0, 0)$ on the graph $f(x) = x^2$ when translated $g(x) = f(x - 1) - 3$ becomes</td>
<td></td>
<td>(1, -3)</td>
</tr>
<tr>
<td><strong>28.</strong> The point $(0, 0)$ for the graph $f(x) =</td>
<td>x</td>
<td>- 2$ when translated $g(x) = -f(x) + 2$ becomes</td>
</tr>
<tr>
<td><strong>29.</strong> Given the function $f(x)$ then the transformation $g(x) = -f(x + 2) - 1$ results in a shift to left by 2, flip across x-axis and shift down by 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>30.</strong> A graph of the piecewise function, $f(x) =</td>
<td>x</td>
<td>$ for $x &lt; 0$ and $f(x) = \sqrt{x}$ for $x &gt; 0$ contains the point</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Concept - Application</th>
</tr>
</thead>
</table>

Match the following Concepts (topics or Problem statements) in college algebra with the correct Application (Answer or Solution step).

| 31. The domain of a rational function could be | $(-\infty, -3) \cup (-3, 3) \cup (3, \infty)$ |
| 32. The domain of a square root function of degree 1 under the radical could be | $x \geq -3$ |
| 33. Test to determine if a graph is a function | Vertical line test |
| 34. Test to determine if a graph is a one-to-one function | Horizontal line test |
| 35. The vertex for a quadratic can be determined easily from the following solution | $y = 3(x - 1)^2 + 6$ |
| 36. The x-coordinate of the vertex for a parabola can be easily determined from the following solution | $y = 3x^2 + 4x - 10$ |
| 37. The roots for a quadratic equation can be determined easily from the following solution | $y = 3(x - 1)(x + 2)$ |
| 38. Which of the following is an odd function? | $y = x^3 - 4x$ |
| 39. Which of the following is an even function? | $y = x^4 = 5x^2 + 4$ |
| 40. The Vertical Asymptote of a rational function could be | $x = -3$ and $x = 2$ |

See if its symmetrical about either the y-axis or the origin.
Mixed (Concept - Model - Applications)

Match the following Concepts or Models or Applications for college algebra with the correct Concepts of Model of Application.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>41. (MA) Determine $f \circ g(x)$ if $f(x) = 3x$ and $g(x) = x + 1$</td>
<td>$3x + 3$</td>
<td></td>
</tr>
<tr>
<td>42. (MA) Determine $g \circ g(x)$ if $f(x) = 3x$ and $g(x) = x + 1$</td>
<td>$x + 2$</td>
<td></td>
</tr>
<tr>
<td>43. (CA) The Inverse function of the function $f(x) = x + 2$ is $f'(x) =$</td>
<td>$x - 2$</td>
<td></td>
</tr>
<tr>
<td>44. (CA) The Inverse function of the rational function $f(x) = (x + 1) / (x - 1)$ is $f'$</td>
<td>$(x + 1) / (x - 1)$</td>
<td></td>
</tr>
<tr>
<td>45. (CM) A graph of a function $f(x)$ is symmetrical about the y-axis if</td>
<td>$f(x) = f(-x)$</td>
<td></td>
</tr>
<tr>
<td>46. (CM) A graph of a function $f(x)$ is symmetrical about the origin if</td>
<td>$f(-x) = -f(x)$</td>
<td></td>
</tr>
<tr>
<td>47. (CA) The horizontal Asymptote of the rational functions $f(x) = (x + 1) / 2(x - 1)$ is</td>
<td>$1/2$</td>
<td></td>
</tr>
<tr>
<td>48. (CM) The coordinates $(h, k)$ of the Vertex of a parabola $f(x)$ is given by the formulas</td>
<td>$(-b / 2a, f(-b / 2a))$</td>
<td></td>
</tr>
<tr>
<td>49. (CA) $w$ is directly proportional to $z$. If $w = 6$ when $z = 3$, find the constant of proportionality, $k$</td>
<td>$2$</td>
<td></td>
</tr>
<tr>
<td>50. (CA) The radius of the Circle</td>
<td>$3$</td>
<td></td>
</tr>
</tbody>
</table>

$y = 3(x - 1)(x + 2)(x + 3)$

$x : (-\infty, \infty)$
Application - Model

Match the following Application (Graphs) in college algebra with the correct Model (Formula).

<table>
<thead>
<tr>
<th>Question 51. (Graph 1)</th>
<th>Question 55 (Graph 5)</th>
<th>Question 59. (Graph 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph 1" /></td>
<td><img src="image2.png" alt="Graph 5" /></td>
<td><img src="image3.png" alt="Graph 9" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 52. (Graph 2)</th>
<th>Question 56. (Graph 6)</th>
<th>Question 60. (Graph 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4.png" alt="Graph 2" /></td>
<td><img src="image5.png" alt="Graph 6" /></td>
<td><img src="image6.png" alt="Graph 10" /></td>
</tr>
</tbody>
</table>

\[3x^2 + 3y^2 - 12x - 6y = 12\]
<table>
<thead>
<tr>
<th>Question 53 (Graph 3)</th>
<th>Question 57. (Graph 7)</th>
<th>Matching Formulas:</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graph 3" /></td>
<td><img src="image2" alt="Graph 7" /></td>
<td>51. $(y - 1)^2 = -2(x - 3)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52. $y = 4x + 1$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53. $x^2 + y^2 - 9 = 0$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>54. $y = \ln(x - 2)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55. $y =</td>
</tr>
<tr>
<td></td>
<td></td>
<td>56. $y = (x - 1)^3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>57. $y = \frac{x^2 - 1}{x^2 - 4}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58. $y = 2e^x$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>59. $y = \sqrt{x + 1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60. $y = -2(x - 3)^2 + 2$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 54. (Graph 4)</th>
<th>Question 58. (Graph 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Graph 4" /></td>
<td><img src="image4" alt="Graph 8" /></td>
</tr>
</tbody>
</table>
APPENDIX C

MATHEMATICS LEARNING STYLE QUESTIONNAIRE

Assessing Your Perceptual Learning Channels (Arem, 1993)

Carefully read the sentences in each of the following three sections and note if the items apply to you. Give yourself 3 points if the item usually applies, 2 points if it sometimes applies, and 1 point if it rarely applies.

Are You a Visual Learner?

<table>
<thead>
<tr>
<th></th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I am more likely to remember math if I write it down.</td>
</tr>
<tr>
<td>2</td>
<td>I prefer to study math in a quiet place.</td>
</tr>
<tr>
<td>3</td>
<td>It is hard for me to understand math when someone explains it without writing it down.</td>
</tr>
<tr>
<td>4</td>
<td>It helps when I can picture working a problem out in my mind.</td>
</tr>
<tr>
<td>5</td>
<td>I enjoy writing down as much as I can in math.</td>
</tr>
<tr>
<td>6</td>
<td>I need to write down all the solutions and formulas in order to remember them.</td>
</tr>
<tr>
<td>7</td>
<td>When taking a math test, I can often see in my mind the page in my notes or in the text where the explanations for answers are located.</td>
</tr>
<tr>
<td>8</td>
<td>I get easily distracted or have difficulty understanding in math class when there is talking or noise.</td>
</tr>
<tr>
<td>9</td>
<td>Looking at my math teacher when he or she is lecturing helps me to stay focused.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>If I am asked to a math problem, I have to see it in my mind's eye to understand what is being asked of me.</td>
</tr>
</tbody>
</table>

**TOTAL SCORE**

**Are You a Kinesthetic/Tactile Learner?**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>I learn best in math when I just get in and do something with my hands.</td>
<td>Points</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>I learn and study math better when I can pace the floor, shift positions a lot, or rock.</td>
<td></td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>I learn math best when I can manipulate it, touch it, or use hands-on examples.</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>I usually cannot verbally explain how I solved a math problem.</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>I cannot just be shown how to do a problem; I must do it myself so I can learn.</td>
<td></td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>I have always liked using my fingers and anything these I could manipulate to figure out my math.</td>
<td></td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>I need to take many breaks and move around when I study math.</td>
<td></td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>I prefer to use my intuition to solve math problems, to feel or sense what is right.</td>
<td></td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>I enjoy figuring out math games and math puzzles when I learn math.</td>
<td></td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>I learn math best if I can practice it in real-life experiences.</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL SCORE**

**Are you an Auditory Learner?**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong></td>
<td>I learn best from a lecture and worst from the Blackboard or the textbook.</td>
<td>Points</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>I hate taking notes; I prefer just to listen to</td>
<td></td>
</tr>
</tbody>
</table>
My dominant perceptual learning channel is: 

(enter the category with the highest total score)

My secondary perceptual learning channel is: 

(enter the category with the second highest total score)

My tertiary perceptual learning channel is: 

(enter the category with the third highest total score)
APPENDIX D

INTRODUCTION SURVEY

Name: College Algebra Survey - Information Request - 64152 (64093)

Description: Please fill out this survey so that your instructor may provide appropriate learning resource for this class to meet your needs

Instructions: Select appropriate response and enter comments where applicable

Question 1. What is your gender? (check one)
   1. Female
   1. Male

Question 2. What is your ethnicity? (check one)
   1. Asian
   2. Black
   3. Hispanic
   4. White
   5. Other ____________________

Question 3. What is your primary language? This is the primary language spoken outside of class or at home or when you were a child. (check one)
   1. English
   2. Spanish
   3. Other ____________________

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Question 4. Do you own a personal computer with internet access?

1. Yes
2. No

Question 5. Select the math course(s) you have taken within the past 1 year:

(check all that apply)

1. Basic Algebra
2. College Algebra
3. Precalculus
4. Others ______________________

Question 6. Where do you have access to the Internet? (check all that apply)

1. At Home
2. At School
3. At Work
4. Local Library
5. Others ______________________

Question 7. List your preferred learning style (check one)

1. Visual
2. Auditory
3. Tactile Kinesthetic
4. Other ______________________

Question 8. Do you know that you can get help with math from the Math Lab in Hum 305 (from 10am to 8 pm) or get a free personal math tutor at the learning center?

1. Yes
2. No

Question 7. Which Language are you fluent in? List all that apply. (check all that apply)

1. English
2. Spanish
3. Others

Question 8. Are you an EOP student?

1. Yes
2. No

Question 9. List all the computer technologies / applications you have access to: (check all that apply)

1. Internet Explorer
2. Netscape
3. Microsoft Office (Word, Excel and PowerPoint)
4. Adobe Reader
5. Netmeeting
6. Real Player or equivalent
7. Computer CD player
8. MP3 Player / Software
9. Web Cam / Camera

Question 10. What operating system do you use the most? (check all that apply)

1. Windows
2. Unix
3. Linux
4. Other _____________________

Question 11. Is your computer multimedia ready to? (check all that apply)

1. Play audio
2. Show video
3. Play movies
4. Dialup Modem
5. High Speed Connection (DSL or SUNY LAN)

Question 12. When are you available to meet with instructor? (check all that apply)

1. Mondays & Wednesdays in FOB - E12 between 5 – 7 pm
2. 1 hour after each workshop session
3. Virtually each week day from 12:00 noon to 1:00 pm
4. Virtually each week day from 8:00 pm to 9:00 pm
5. Virtually on Sundays from 12:00 noon to 2:00 pm
6. Interact with Instructor anytime through Blackboard Q&A Sessions

If you have any additional comments, please take survey online and add comments.

DONOT Write here. (You have 1 week to do so).
APPENDIX E

EXAMPLE OF PROGRESS SURVEY

Name: College Algebra Survey – Progress Report 1 - 64152 (64093)

Description: Please fill out this survey so that your instructor may obtain your feedback on your progress in this course

Instructions: Select appropriate response and enter comments where applicable

Question 1. I have mastered most of College Algebra taught so far (Chapter 1, 5.1 and 6.1) (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree

Question 2. I have mastered most of Basic Algebra Concepts (Section 0.2 – 0.6) (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree

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Question 3. Which Concepts of Basic Algebra do you need more help with? Rank in order of most help required the areas listed below (Number from 1 thru 5, 1 being the area you need more help with, you may omit any selections that do not apply)

1. 0.2 Integer Exponent
2. 0.3 Radicals
3. 0.4 Polynomials
4. 0.5 Factoring Polynomials
5. 0.6 Algebraic Fractions

Question 4. Which Concepts of College Algebra do you need more help with? Rank in order of most help required the areas listed below (Number from 1 thru 7, 1 being the area you need more help with, you may omit any selections that do not apply)

1. Linear Functions
2. Quadratic Functions
3. Complex Numbers
4. Inequality
5. Absolute Value
6. Synthetic Division
7. Systems of Linear Equations

Question 5. Is the math learning style instruction given to you on the first day of class helping you learn math better? (check one)

1. Yes
2. No
3. Not sure
Question 6. With which of the following are you having difficulties? Rank in order of most difficult the areas you are having problem with (Number from 1 thru 5, 1 being the most difficult for you, you may omit any selections that do not apply)

1. Word Problems
2. Homework Assignments
3. Take Home Workshops
4. Quizzes
5. Major Exam (such as midterm)

Question 7. Rank in order of most effective or helpful the following Online Resources (Number from 1 thru 6, 1 being the most helpful, you may omit any selections that do not apply)

1. Pre-Narrated Lectures
2. Recorded Classroom Lectures
3. Answers to past quizzes and exams
4. Math by Example
5. All of the Online Resources
6. None of the Online Resource

Question 8. Rank in order of most effective or helpful to you so far the following Learning Resources (Number from 1 thru 4, 1 being the most helpful)

1. Classroom Activities (5:00 – 6:15pm sessions)
2. Workshop Sessions (6:30 to 7:45 pm)
3. Online Resource (On Blackboard)
4. Homework Online

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APPENDIX F

ONLINE USAGE SURVEY

Name: College Algebra Survey – Online Usage - 64152 (64093)

Description: Please fill out this survey so that your instructor may obtain your feedback on your utilization of Online Resources

Instructions: Select appropriate response and enter comments where applicable

Use the following description to rate each statement:

**SA** = Strongly Agree, **A** = Agree, **N** = Neutral (I am not sure or don’t know), **D** = Disagree, and **SD** = Strongly Disagree

| 1. The on-line resource made a difference in me learning algebra. | SA | A | N | D | SD |
| 2. Doing the homework on-line helped me learn algebra. | SA | A | N | D | SD |
| 3. I preferred doing the homework on-line to doing it on paper and handing it to instructor for grading. | SA | A | N | D | SD |
| 4. The on-line narrated lectures were very helpful in my learning algebra. | SA | A | N | D | SD |
| 5. The Algebra by Example was very helpful in my learning algebra. | SA | A | N | D | SD |
| 6. The recorded classroom lectures were helpful in my learning algebra. | SA | A | N | D | SD |
| 7. The posting of the solutions and answers to quizzes and exams immediately after tests were very helpful in my learning algebra. | SA | A | N | D | SD |
Question 8. Which on-line resource was most useful or helpful to you and why?

Question 9. Which on-line resource was least useful or helpful to you and why?

Question 10. What were the best things about the on-line support you received in this class?

Question 11. What was the worst thing about the on-line support or resource and how would you improve it?

Question 12. Would you use the on-line support or resource if they were available in future math courses? Why? Why not?
APPENDIX G

POST-CLASS SURVEY

Name: College Algebra Survey – Post Class Assessment - 64152 (64093)

Description: Please fill out this survey so that your instructor may better understand the effectiveness of the instructional and assessment instruments used in college algebra this past semester

Instructions: Select appropriate response and enter comments where applicable

Question 1. The Online Resource(s) helped you learn college algebra. (circle one)

6. I strongly agree
7. I agree
8. Neutral (I am not sure or don’t know)
9. I disagree
10. I strongly disagree

Question 2. Rank in order of most effective or helpful the following Online Resources (Number from 1 thru 5, 1 being the most helpful, you may omit any selections that do not apply)

1. Math by Examples
2. Posted Solutions to Problems
3. Narrated Lectures
4. Review / Replay of Classroom Lectures
5. Interactive Online Homework

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Question 3. The Workshop Activities helped you learn college algebra.

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree

Question 4. Rank in order of most effective or helpful the following Workshop Activities (Number from 1 thru 5, 1 being the most helpful, you may omit any selections that do not apply)

1. Group problem solving sessions
2. Working problems on own with instructor’s supervision
3. Math learning style skill development
4. Math skill development (study, learning style, test-taking skills, etc)
5. Quizzes and exam post analyses (going over problems after exam)

Question 5. The Classroom Sessions helped you learn college algebra. (Pre-Workshop Sessions from 5:00 pm to 6:15pm)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree
Question 6. Rank in order of most effective or helpful the following Classroom Activities (Number from 1 thru 5, 1 being the most helpful, you may omit any selections that do not apply)

1. Class lectures
2. Quizzes
3. Midterm Exam
4. Post Exam Reviews
5. Posttest

Question 7. Rank in order of most effective or helpful the following Learning Resources (Number from 1 thru 4, 1 being the most helpful)

5. Classroom Activities (5:00 – 6:15pm sessions)
6. Workshop Sessions (6:30 to 7:45 pm)
7. Online Resource (On Blackboard)
8. Homework Online

Question 8. About how many hours did you send online each week learning math (using course online resource)? (Fill in)

Question 9. The CMA test helped you understand your strengths and weaknesses going into the final exam.

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree
Question 10. The Basic / College Algebra by Example on-line helped you learn college algebra. (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree

Question 11. The take-home workshop helped you master the math concepts, formulas and skills required for college algebra. (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree

Question 12. The take-home workshop helped improve your grades on quizzes and exams. (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree
Question 13. Knowing your preferred math learning style helped you learn college algebra. (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree

Question 14. The Extended College Algebra program (classroom, workshop, on-line resource) helped you learn math compared to previous math classes you have taken. (check one)

1. I strongly agree
2. I agree
3. Neutral (I am not sure or don’t know)
4. I disagree
5. I strongly disagree
You are required to answer 25 out of 30 questions. You must answer all questions from Part I and Part II and any 5 from Part III.

Show work on this question booklet for Part II and Part III.

This Midterm exam consists of 30 Questions of which you must do 25:

1. Answer all 10 questions from Part I. (Multiple Choice)
2. Answer all 10 questions from Part II. (Typical Quiz type questions)
3. Answer any 5 questions from Part III. (Word Problems)

You have 2 hours for this exam.

DO NOT use a red ink pen or red lead pencil to take this quiz (Exams are graded with a red ink pen).

Circle or Box-in each answer for Parts I, II and III.

You may use the back of each sheet as work space but show all work in answer section.
Correct answers alone without showing work are worth only 50% of question points for Parts II and III.

**Part I - Answer all 10 Questions**

(Multiple Choice)

**Question 1.** Simplify the expression below and write without using negative exponents:

\[
\frac{(x^{-3}x^2)^2}{(x^{2}x^{-5})^{-3}}
\]

Select from one of the following:

(a) \(x^{11}\)

(b) \(x^5\)

(c) \(x^8\)

(d) \(x^{11}\)

**Question 2.** Factor the expression completely.

\(z^4 - 1\)

Select from one of the following:

(a) \((z^2 + 1)(z^2 - 1)\)

(b) \((z^2 + 1)(z - 1)(z + 1)\)

(c) \((z^4 - 1)(z - 1)(z + 1)\)

(d) \((z + 1)(z - 1)\)

**Question 3.** Solve the equation for \(x\).

\[4(5x + 2) - 18(x + 3) = -28\]

Select from one of the following:

(a) \(x = 9\)
(b) \( x = 11 \)
(c) \( x = 4 \)
(d) \( x = 16 \)

**Question 4.** Factor the expression completely.

\[
(2a + 3)^2 - (2a - 3)^2
\]

Select from one of the following:

(a) \( 2a - 9 \)
(b) \(-9\)
(c) \(0\)
(d) \(24a\)

**Question 5.** Do the operation and express the answer in \( a + bi \) form.

\[
\frac{3 + i}{2 - i \sqrt{5}}
\]

Select from one of the following:

(a) \( \frac{9 + \sqrt{5}}{9} - \frac{2 + 3 \sqrt{5}}{9}i \)
(b) \( \frac{6 + \sqrt{5}}{9} + \frac{2 - 3 \sqrt{5}}{1}i \)
(c) \( \frac{6 - \sqrt{5}}{9} + \frac{2 + 3 \sqrt{5}}{9}i \)
(d) \( \frac{6 - \sqrt{5}}{9} - \frac{2 - 3 \sqrt{5}}{7}i \)

**Question 6.** Factor the expression completely.

\[
42x^2 - 13xy - 40y^2
\]

Select from one of the following:
(a) \((7x - 8y)(5x + 6y)\)
(b) \((7x - 8y)(6x + 5y)\)
(c) \((5x - 8y)(6x + 7y)\)
(d) \((7x + 8y)(6x - 5y)\)

**Question 7.** Solve for \(x\).

\[
\left| \frac{8x - 2}{x} \right| = 7
\]

Select from one of the following:

(a) \(x = -30, x = -2\)
(b) \(x = \frac{2}{15}, x = 2\)
(c) \(x = 30, x = 2\)
(d) \(x = \frac{2}{15}, x = -2\)

**Question 8.** Use the square root property to solve the equation

\((x + 87)^2 - 9 = 0\)

Select from one of the following:

(a) \(x = -90, x = -84\)
(b) \(x = 3, x = 9\)
(c) \(x = 3\)
(d) \(x = 87, x = -87\)
Question 9. Rationalize the denominator and simplify.

\[
\frac{\sqrt{2}}{x - \sqrt{2}}
\]

Select from one of the following:

(a) \( \frac{\sqrt{2} x - 2}{x^2 + 2} \)
(b) \( \frac{\sqrt{2} x - 2}{x^2 - 2} \)
(c) \( \frac{\sqrt{2} x + 2}{x^2 - 2} \)
(d) \( \frac{\sqrt{2} x + 2}{x^2 + 2} \)

Question 10. Find the absolute value

\[|3 - 4i|\]

Select from one of the following:

(a) \(3\)
(b) \(4i\)
(c) \(25\)
(d) \(5\)

Part II - Answer all 10 Questions
Show all your work in each question space

Question 11. Use the quadratic formula to solve the equation.

\[x^2 - 15 = 0\]

Question 12. Perform the operation and simplify.

\[
\frac{1}{x - 8} + \frac{3}{x + 8} - \frac{3x - 8}{x^2 - 64}
\]
Question 13. Do the operation and express the answer in $a + bi$ form.

$$(4 + \sqrt{-16})(4 - \sqrt{-9})$$

Question 14. Do the operation and express the answer in $a + bi$ form.

$$\frac{1}{3 + i}$$

Question 15. Solve the inequality and write answer in interval notation.

$$\frac{6(x - 2)}{5} \geq \frac{3(x + 1)}{4}$$

Question 16. Solve the inequality and write answer in interval notation.

$$x^2 + 9x + 20 < 0$$

Question 17. Use completing the square to solve the equation

$$x^2 - 10x + 25 = 9$$

Question 18. Find all real solutions to the equation.

$$\sqrt{x^2 + 60} = x + 6$$

Question 19. Use synthetic division to complete the factorization of

$$\frac{2x^3 - 2x^2 - 91x + 4}{x - 4}$$

Question 20. Solve the system of equations by either substitution or elimination, if possible.

$$\begin{align*}
y &= 7x - 20 \\
3x - y &= 4
\end{align*}$$

Part III - Answer any 5 Questions
Show all your work in each question space

Question 21. A college student earns $25 per day delivering advertising brochures door-to-door, plus 50 cents for each person he interviews. How many people did he interview on a day when he earned $85.

Question 22. The average of 4 numbers is 125 and when 3 other numbers are added, they reduced the average to 110. Assuming the numbers added are the same values, what are the numbers?
Question 23. A merchant increases the wholesale cost of a washing machine by 10% to determine the selling price. If the washer sells for $425, find the wholesale cost.

Question 24. A computer store has fixed costs of $8625 per month and a unit cost of $760 for every computer it sells. If the store can sell all the computers it can get for $1335 each, how many much be sold for the store to break even? (The break-even point occurs when cost equals income.)

Question 25. A full-price ticket for a college basketball game costs $6.00, and a student ticket costs $4.25. If 496 tickets were sold, and the total receipts were $2498.25, how many tickets were students’ tickets?

Question 26. (3) The length of a rectangle is 6 less than twice the width. If the perimeter is 60 inches, what are the dimensions?

Question 27. (3) If 12 pencils cost 42 cents, how much would 100 pencils cost?

Question 28. (3) A tank can be filled by one pump in 50 minutes and by another pump in 60 minutes. A third pump can drain the tank in 75 minutes. If all 3 pumps go into operation, how long will it take to fill the tank?

Question 29. (3) Two cars 720 km apart travel toward each other. One car travels 70 kph (kilometer per hour) while the other car travels at the rate of 50 kph. In how many hours will they meet?

Question 30 (3) How many quarts of a 50% solution of acid must be added to 20 quarts of a 20% solution of acid to obtain a mixture containing a 40% solution of acid?
Similar problems are generated each time a student takes or retakes the homework assignment and each student gets a set of similar but different problems.

**Question 1.** Simplify the radical expressions.
Math each expression in the left column with the corresponding answers in the right column.

<table>
<thead>
<tr>
<th>$-\sqrt[3]{8}$</th>
<th>-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-\sqrt[4]{81}$</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Question 2.** Perform the division and write the answer without using negative exponents

$$\frac{-16r^2x^5t^3}{20r^6s^2t^5}$$

Select the correct answer.

(a) $\frac{4s^3}{5r^4t^5}$

(b) $-\frac{4s^5}{5r^4t^6}$

(c) $-\frac{4s^3}{5r^4t^5}$

(d) $-\frac{4s^4}{5r^4t^5}$
Question 3. Factor the expression completely.

\[ 9z^2 - 121 \]

Question 4. Factor the expression completely.

\[ 64z^2 - 49 \]

Select the correct answer.
(a) \((8z + 7)(8z - 7)\)
(b) \((8z + 7)(8z + 7)\)
(c) \((8z + 7)(7 - 8z)\)
(d) \((8z - 7)(8z - 7)\)

Question 5. Factor the expression completely.

\[ 16z^2 + 40z + 25 \]

Select the correct answer.
(a) \(5(4z + 5)\)
(b) \((4z + 5)(4z - 5)\)
(c) \((4z + 5)^2\)
(d) \((4z - 5)^2\)

Question 6. Factor the expression completely.

\[ x^2 + 12x + 27 \]

Select the correct answer.
(a) \((x + 9)(x - 3)\)
(b) \((x - 9)(x - 3)\)
(c) \((x + 9)(x + 3)\)
(d) \((x + 9)(x + 9)\)

**Question 7.** Match the trinomials in the left column with the corresponding factored ones in the right column.

<table>
<thead>
<tr>
<th>(30r^2 - 41r \cdot s - 15s^2)</th>
<th>((3r - 5s)(10r + 3s))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(30r^2 - 29r \cdot s - 35s^2)</td>
<td>((3r - 5s)(10r + 7s))</td>
</tr>
</tbody>
</table>

**Question 8.** Factor the expression completely.

\(16r^2 - 4rs - 30s^2\)

Select the correct answer.

(a) \((3r - 2s)(8r + 10s)\)
(b) \((2r - 3s)(8r + 10s)\)
(c) \((2r - 3s)(10r + 8s)\)
(d) \((2r + 3s)(8r - 10s)\)

**Question 9.** Factor the expression completely.

\((a + b)^2 - 5(a + b) - 6\)

**Question 10.** Complete the factoring formula.

\(ex + fx =\)

Select the correct answer.

(a) \(x(e - f)\)
(b) \(x(e + f)\)
(c) \(x + e + f\)
(d) \(xe + f\)

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Homework 2 Answer Key

1. \(-\sqrt{81} \rightarrow -3\)
   \(-\sqrt{8} \rightarrow -2\)

2. c

3. \((3z + 11)(3z - 11)\)

4. a

5. c

6. c

7. \(30r^2 - 41rs - 15s^2 \rightarrow (3r - 5s)(10r + 3s)\)
   \(30r^2 - 29rs - 35s^2 \rightarrow (3r - 5s)(10r + 7s)\)

8. b

9. \((a + b - 6)(a + b + 1)\)

10. b
APPENDIX J

FINAL EXAM MATRIX

Name: College Algebra – Final Exam Matrix - 64152 (64093)

Description: This is a common final exam, prepared by about all the professors teaching college algebra (typically 5 or more) and graded by all in one sitting.

Instructions: Students are given 2 hours to complete about 35 questions.

Table 34

*Final Exam Scoring Matrix*

<table>
<thead>
<tr>
<th>Part</th>
<th>Question Type</th>
<th>Question List</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Matching of Graphs with Formulas</td>
<td>1 – 10</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Multiple Choice</td>
<td>11 – 25</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Quiz Types and Word Problems</td>
<td>Quiz 26 – 33</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Word 34 – 35</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Point</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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## APPENDIX K

### MPL MEANING

**Table 35**

*Math Placement Levels Descriptions*

<table>
<thead>
<tr>
<th>MPL</th>
<th>Meaning</th>
<th>Course that will raise level (A grade of C- or better will raise MPL to (x))</th>
<th>Or take this MPExam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deficiency in Fundamental Skills</td>
<td>64151 College Math (3) 64152 + 64093 College Algebra with Supplemental Workshop (4)</td>
<td>Basic Algebra</td>
</tr>
<tr>
<td>2</td>
<td>Deficiency in College Level Mathematics Skills.</td>
<td>64151 College Math (3) 64152 College Algebra (4)</td>
<td>College Algebra</td>
</tr>
<tr>
<td>3</td>
<td>Ready for some General Education (GE) MATH courses, (see specific prerequisites)</td>
<td>64152 College Algebra (4)</td>
<td>College Algebra</td>
</tr>
<tr>
<td>4</td>
<td>Prepared for Precalculus or any General Education MATH course, MATH req. met for GE II &amp; IIA but may still need additional course.</td>
<td>64181 Precalculus (5)</td>
<td>Precalculus</td>
</tr>
<tr>
<td>5</td>
<td>General Education MATH requirement met for GEIII; MATH &amp; ANSK met for GEII &amp; IIA, ready for Calculus I (64251).</td>
<td>64251 Calculus I (6)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Successfully completed Calculus I</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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APPENDIX L

SEI SURVEY QUESTIONS

Student Evaluation of Instruction (SEI) Questions

Administered by the Office of Institutional Research at SUNY New Paltz.

(questions 3 – 22 are Likert Scales)

1. Is this a required course?

2. Is this course in my major field of study?

3. The instructor contributed toward making me a more, educated informed.

4. The instructor made the objectives of the course clear

5. The instructor achieved the stated objectives of the course outline

6. The instructor clearly informed students how they would be evaluated

7. The instructor was well prepared for class

8. The instructor made effective use of examples and/or illustrations

9. The instructor was confident and competent with the subject matter

10. The instructor raised challenging and interesting questions/problems

11. The instructor stimulated students' interest in the subject matter

12. The instructor treated students with fairness and concern

13. The instructor was actively helpful and concerned with students' progress
14. The instructor was easy to approach for help outside of class

15. The instructor was available for meeting with students during office hours

16. The instructor adjusted his/her teaching to reflect the students' level of comprehension

17. The instructor gave assignments that were appropriately related to the course

18. The instructor gave exams that were appropriately related to the course material

19. The instructor returned students' work/exams within a reasonable timeframe

20. The instructor gave helpful, instructive feedback (beyond grade) on graded material

21. The instructor showed enthusiasm for both teaching and for the subject matter

22. The instructor overall, was an effective teacher
**APPENDIX M**

**WORKSHOP USAGE SURVEY**

Name: College Algebra Survey – Workshop Usage - 64152 (64093)

Description: Please fill out this survey so that your instructor may obtain your feedback on your utilization of Workshop Resources.

Instructions: Select appropriate response and enter comments where applicable.

Use the following description to rate each statement:

**SA** = Strongly Agree, **A** = Agree, **N** = Neutral (I am not sure or don’t know), **D** = Disagree, and **SD** = Strongly Disagree.

<table>
<thead>
<tr>
<th>1. The workshop sessions made a difference in my learning algebra.</th>
<th>SA</th>
<th>A</th>
<th>N</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Doing the weekly workshop assignments helped me learn algebra.</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>3. I preferred doing the workshop rather than homework assignments on-line.</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>4. Working in study groups during the workshop was very helpful in my learning algebra.</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>5. The word problem sessions of the workshops were very helpful in my learning algebra.</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>6. The workshop sessions immediately after the classroom lectures were helpful in my learning algebra.</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>7. The workshop sessions were more useful than working with math tutors or math help in the math lab.</td>
<td>SA</td>
<td>A</td>
<td>N</td>
<td>D</td>
<td>SD</td>
</tr>
</tbody>
</table>
Question 8. Which workshop activity was most useful or helpful to you and why?

Question 9. Which workshop activity was least useful or helpful to you and why?

Question 10. What were the best things about the workshop sessions?

Question 11. What were the worst thing about the workshop sessions and how would you improve it?

Question 12. Would you use the workshop study format if they were available in future math courses? Why? Why not?
Answer all 10 questions. Each question is worth the same point; some questions are easier than other - built-in curve - You have 45 minutes to do this quiz.

DO NOT use a red ink pen or red lead pencil to take this quiz (Exams are graded with a red ink pen).

Answers all questions on this answer booklet and show all work (solutions, right triangle, graphs, formula used etc.)

Circle or underline each answer

You may use the back of each sheet as work space but show all work in answer section

Answers alone without showing work is worth only 50% of question points.
Do all questions from Part I and Part II and any 2 from Part II

**Part I**
Do all 4 Basic Algebra Questions

Question 1 (1 point) Simplify the expression
\[ \sqrt{8x^2y} - x\sqrt{2y} + \sqrt{50x^2y} \]
Question 2 (1 point) Rationalize the denominator
\[ \frac{14\sqrt{2}}{2 - 3} \]

Question 3. (1 point) Factor completely the expression: \( x^4 - 81 \)

Question 4. (1 point) Perform the operation and simplify:
\[ \frac{x^2 + 5x + 6}{x^2 + 6x + 9} \cdot \frac{x + 2}{x^2 - 4} \]

Part II
Do all 4 College Algebra Questions

Question 5. (1 point) Solve by completing the square \( 2x^2 + 2x - 4 = 0 \)

Question 6. (1 point) Use the quadratic formula to solve the equation \( 3x^2 = 1 - 4x \)

Question 7. (1 point). Perform the operation and give answer in \( a + bi \) form for:
\[ (11 + \sqrt{-25})(2 - \sqrt{-36}) \]

Question 8. (1 point) Perform the operation and give answer in \( a + bi \) form for:
\[ \frac{2 + i}{3 - i} \]

Part III
Do any 2 of 3 Questions

Question 9. (1 point) The length of a rectangle is three times its width. If the perimeter is 80 feet, what are the dimensions?

Question 10. (1 point) Mr. Smith, a cyclist, rode from his home to his office at the average speed of 18 miles per hour. On his return home form his office, using the same route, he averaged 12 miles per hour. If the total round trip took 5 hours, what was the distance from his home to his office? (hint: let x be his distance from home to office)

Question 11. (1 point) How many ounces (oz) of pure alcohol (100% alcohol content) must be added to a 42-oz solution of containing 10% alcohol to make a solution containing 40% alcohol?
APPENDIX O

EXIT SURVEY

Name: College Algebra Survey – Pre-Final Survey - 64152 (64093)

Description: Please fill out this survey so that your instructor may obtain a deeper understanding of contributing factors to your learning college algebra

Instructions: To be folded into Post Interview Questions

Question 1. Compared to traditional mathematics classes, how was Extended College Algebra Different? In what way did it help your understanding of mathematics? Give an example.

Question 2. Describe any personal factors that may have caused you to perform less than your best on homework, quizzes, and midterm or posttest exams?

Question 3. Now that you have completed this course, what preparations do you wish you had before taking this class?

Question 4. Did knowing about your learning style affect your performance in this course? Explain why or why not.

Question 5. Which of these learning resources helped you the most and in what way?
(a) Classroom Lectures
(b) Workshop Sessions
(c) On-line Support on Blackboard
Question 6. Did the take-home workshop assignments affect your performance in this course? Explain why or why not.

Question 7. Describe how each of the following has influenced your performance on the Posttest:

(a) Homework review
(b) Quizzes review
(c) Workshop Assignments review
(d) Midterm review and
(e) CMA Test

Question 8. Describe how you think each of these will help your performance on the final exam:

(a) Homework review
(b) Quizzes review
(c) Workshop Assignment review
(d) Midterm review and
(e) CMA Test

Question 9. Which features of Blackboard (on-line support – see comprehensive list on next page) do you use the most to help learn this course and why?
Blackboard Resources:

1. Narrated Pre-recorded lectures
2. Class Recorded Lectures
3. Basic Algebra by Examples
4. College Algebra by Examples
5. Homework Examples with Answers
6. Word Problems Examples
7. Answers to Fall 2004 Quizzes and Midterm tests
8. Answers to past years Quizzes and Exams
9. CMA Test
10. Q&A Session
11. Study Group on Blackboard
12. Take-Home Workshop Answers
13. In-Class Workshop Questions
14. Formula Sheet Examples
15. Interactive Study Guide for Midterm Exam
16. Expanded Syllabus with Summary Formulas by Topics
17. Special Workshop: Circles
18. Special Workshop: Transformation of Functions
APPENDIX P

POST-COURSE INTERVIEW

Name: College Algebra Survey – Post Course Interview - 64152 (64093)

Description: Please fill out this survey so that your instructor may obtain a deeper understanding of contributing factors to your learning college algebra

Instructions: Post Final Exam Interview Questions – Given at the end of the semester and before final grades are posted.

1. Describe your overall learning experience
2. Tell me about your classroom experience
3. Tell me about your workshop experience
4. Describe your on-line experience
5. If you were to recommend this course to a friend, what would you say?
6. Describe your overall performance
7. What have you learned about yourself and mathematics from taking this course?
8. If you were to recommend an instructor for this course, what characteristics would you want to see?
APPENDIX Q

SELF-ANALYSIS EXAMPLE

Self Analysis: Formula Sheets Preparation Example

Exam - Self Analysis Survey - CMA Integration by Using Formula Sheets to prepare for exam.

Type "Yes" of "No" to the Following Questions for each Questions of _____________

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Did you get it right?</th>
<th>Did your Formula sheets contain the needed formula(s)?</th>
<th>Did your Formula sheets contain and example for this problem?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5</td>
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<td>7</td>
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<td>8</td>
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<td>9</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How will you use the knowledge gain here to prepare for the next test?
APPENDIX R

CAPSOL STYLES OF LEARNING ASSESSMENT

Source: http://www.stylesoflearning.com

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A copy of the instrument is obtained by making a request from either of the following:

1. e-mail: capsol@stylesoflearning.com
2. Fax: (419) 589-6930
3. Toll-Free Phone: (800) 578 6930

This survey instrument evaluates all the learning styles in appendix C with some additional styles of learning.
APPENDIX S

INTERVIEW CODE MATRIX

Table 36

*Interview Code Matrix*

<table>
<thead>
<tr>
<th>Interview Statements / Questions</th>
<th>Interview Codes</th>
<th>Research Questions</th>
</tr>
</thead>
</table>
| 1. Describe your classroom experience | classroom aid online resource  
classroom aid textbook  
classroom and workshop combination  
classroom experience negative  
classroom experience positive  
classroom group work  
classroom learning strategy  
classroom participation  
classroom preparation  
classroom recorded lectures  
instruction and positive learning outcome  
instructional strategy  
teacher good quality  
teacher negative quality  
teaching and learning styles  | 2, 3, 4, and 7 |
| 2. Describe your workshop experience | workshop and learning style  
workshop and performance  
workshop concept learning  
workshop experience negative  
workshop group work  
workshop individual work  
workshop positive experience  
workshop resources  | 3, 4, 5, and 7 |
| 3. Describe your on-line experience | online and learning style  
online and performance  
online as communication tool  
online experience negative  
online experience positive  
online homework  
online resources  | 3, 4, and 7 |

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<table>
<thead>
<tr>
<th>Question</th>
<th>Dislikes</th>
<th>Likes</th>
<th>Resources and Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. If you were to recommend this course to a friend, what would you say? (likes and dislikes)</td>
<td>dislikes</td>
<td>likes</td>
<td>4 and 7</td>
</tr>
<tr>
<td>5. Describe your overall learning experience</td>
<td>impacts on learning outcomes</td>
<td>learning style and its impact</td>
<td>3, 6 and 7</td>
</tr>
<tr>
<td></td>
<td>most helpful learning resources</td>
<td>overall learning experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>overall performance</td>
<td>performance contributors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>performance inhibitors</td>
<td>performance resource</td>
<td></td>
</tr>
<tr>
<td></td>
<td>best ways of learning math</td>
<td>what was learned about math</td>
<td></td>
</tr>
<tr>
<td></td>
<td>what was learned about self</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Describe your overall performance</td>
<td></td>
<td></td>
<td>1, 3, and 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. What have you learned about yourself and mathematics from taking this course?</td>
<td></td>
<td></td>
<td>1, 3 and 7</td>
</tr>
</tbody>
</table>
REFERENCE LIST


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