2009

Review of Student Performance in Developmental mathematics Courses Taught at Virginia Western Community College

T. Jonathan Bayer
Old Dominion University

REVIEW OF STUDENT PERFORMANCE IN DEVELOPMENTAL MATHEMATICS COURSES TAUGHT AT VIRGINIA WESTERN COMMUNITY COLLEGE

A Research Paper Presented to the Graduate Faculty of the

Department of Occupational and Technical Studies at

Old Dominion University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in

Occupational and Technical Studies

BY

T. JONATHAN BAYER

JULY 2009

APPROVAL PAGE

This research paper was prepared by T. Jonathan Bayer under the direction of Dr. John M. Ritz in OTED 636, Problems in Occupational and Technical Studies. It was submitted to the Graduate Program Director as partial fulfillment of the requirements for the Degree of Master of Science.

APPROVED BY: _____ DATE: _____

Dr. John M. Ritz
Advisor and Graduate Program Director

TABLE OF CONTENTS

Page

LIST OF TABLES

Number Page

LIST OF FIGURES

Number Page

CHAPTER I

INTRODUCTION

Virginia Western Community College is a two-year community college located in Roanoke, Virginia. The college serves students from the Roanoke Valley as well as surrounding areas. The main focuses of the college are student oriented learning, developing students for college courses, workforce development, transfer courses and transfer programs (Virginia Western, 2008). The faculty members of the college are primarily devoted to teaching students.

Virginia Western offers a variety of degree, certificate and career studies certificate programs. In addition the college has several articulation agreements with area colleges and universities. Virginia Western offers three separate types of degree programs: the Associate of Science (AS), the Associate of Arts (AA) and the Associate of Applied Science (AAS). Currently there is one major which confers the AA degree, five majors which confer the AS degree and nineteen majors which confer the AAS degree (Virginia Western, 2008). Within each major there are also opportunities to obtain specializations in specific areas. There are eleven certificate programs and thirty-five career studies certificates (Virginia Western, 2008). Virginia Western also has a variety of four year and graduate degree programs housed on campus which are offered through Radford University and Old Dominion University. These programs are offered through distance learning. Many students attend the college prior to transferring to a four-year college or university. Virginia Western has guaranteed acceptance agreements with several area schools including Old Dominion, Radford, Roanoke College, and Virginia Tech, as well as others.

All of the degree, certificate and career studies certificate programs have some form of mathematics pre-requisite, minimum mathematics requirement or particular mathematics courses essential to program completion. Students who have not had mathematics courses within the last three years are required to take the Computer Adapted Placement Assessment and Support Services test or COMPASS test to determine his or her respective mathematics course placement (Virginia Western, 2008). The majority of students who take the COMPASS test are placed into one of three developmental mathematics courses. Developmental mathematics courses contain material deemed pre-requisite knowledge to entering a credit level mathematics course. These courses are roughly equivalent to a pre-algebra course, a beginning algebra course and an intermediate algebra course. The main subjects of this study were these developmental mathematics courses.

STATEMENT OF THE PROBLEM

The purpose of this study was to determine changes that should be made by Virginia Western mathematics faculty to improve developmental mathematics instruction.

RESEARCH GOALS

This study is designed to answer the following questions:

1. Which areas of the Math 09 curriculum did students tend to perform unsatisfactorily?
2. Which areas of the Math 03 curriculum did students tend to perform unsatisfactorily?
3. Which areas of the Math 04 curriculum did students tend to perform unsatisfactorily?
4. Based upon the results of Goals 1-3, what improvements can be made in the Math 09, 03, and 04 curriculums and instruction to improve student success?

BACKGROUND AND SIGNIFICANCE

At Virginia Western, the Mathematics Department noticed the trend of low pass rates in the developmental courses. For fall 2007, spring 2008 and summer 2008 semesters, the overall average of pass rates, depending on whether or not students who withdrew were included in the average, was between 40% and 50% (Virginia Western Mathematics Department, 2009). This study was undertaken in response to this trend.

The course curriculum for each of the developmental courses has been standardized with a departmental final examination administered at the end of each course. The final examination consists of a combination of multiple-choice and free response questions. Students must have an average score of 75% on all tests including the final examination to receive a grade of S or satisfactory for the course. Students who score between 50% and 74% and meet the attendance requirements for the course receive an R or repeat for the course. Students who score below 50% or fail to meet the attendance requirements are awarded a U or unsatisfactory for the course. Students who receive the grade of U are also required to repeat the course.

Developmental mathematics faculty are met with a multitude of challenges while teaching these courses. Among these challenges are students: who have performed poorly in previous mathematics courses, who have diminished motivation and also have weak study skills with a poor foundation in mathematics (Eades & Moore, 2007). However it is still necessary that these students be given every opportunity to be successful in mathematics. To help facilitate student success, it is imperative that faculty

members teaching developmental mathematics courses do everything possible to improve the way they teach mathematics (Miles, 2000).

The results obtained at the completion of this study will be used to locate areas of the developmental mathematics curriculum which need to be improved. In addition, this research project will be used to assist faculty to make changes which improve developmental mathematics students' success rates. The results will also be used to justify making changes to the current developmental course curriculum. If there are areas of the curriculum where more than 50% of the students tend to do unsatisfactorily, this study will propose changes that can be implemented to improve the situation.

LIMITATIONS

The following limitations were followed in this study:

1. The study was based upon final examinations taken by students who were enrolled in Math 03, Math 04 and Math 09 developmental mathematics courses at Virginia Western Community College.
2. The study used data from fall 2008 and spring 2009 semesters.
3. Courses were taught by full-time and adjunct faculty members.

ASSUMPTIONS

The following foundational assumptions were made prior to conducting this study:

1. All students who were enrolled in developmental courses did not complete examinations. Students who failed to take the final examination were not considered in the study.

2. Students who enrolled in developmental mathematics courses did so because they were required to do so. This may have had an affect on students' motivation to do well in the course; however this study does not address the psychological well being and motivation of the students.
3. Taking the final exam was compulsory. All students who were enrolled in developmental mathematics courses had to take the final examination for the course.
4. It is likely students who enroll in developmental mathematics courses have mathematical knowledge/skill deficiencies.
5. Any content area question that is missed by more than 50% of the students who took the final examination was an area where students needed better instruction.

PROCEDURES

The procedures employed to conduct this study began with students taking final examinations in Math 03, Math 04 or Math 09, developmental mathematics courses in the fall 2008 or spring 2009 semesters. Examinations were graded by the instructor who administered them. The examinations were then gathered together in a central location by the head of the Mathematics Department at Virginia Western. The data used for analysis were collected directly from these final examinations.

All of the graded student examinations which were returned to the Virginia Western Mathematics Department were used in this study. First overall student performance was examined. The examinations were then dissected using a question by question analysis. Each question was examined to determine how well the question was written based upon the content being tested, how many students missed the question and the most common incorrect responses. The percentage of students who took the final

examination and number of students who passed or failed were also considered in this study.

DEFINITION OF TERMS

The following terms were used in this study:

Developmental mathematics: refers to prerequisite mathematics knowledge and skills necessary to begin credit level college mathematics courses.

Math 03: developmental mathematics course roughly equivalent to a basic algebra course (Virginia Western, 2008).

Math 04: developmental mathematics course roughly equivalent to an intermediate algebra course (Virginia Western, 2008).

Math 09: developmental mathematics course roughly equivalent to a preliminary course for basic algebra (Virginia Western, 2008).

Final Exam: a comprehensive examination administered at the end of a college course.

Multiple Choice Questions: questions that have four possible correct answers from which students choose the most correct answer.

Free Response Questions: questions that students must work through and answer without any solutions from which to choose.

SUMMARY AND OVERVIEW

The purpose of this study was to determine how developmental students perform in specific areas of mathematics and changes that could be made by the Virginia Western mathematics faculty to improve the pass rates in developmental mathematics courses. This research was conducted in response to the trend of low pass rates in these courses.

The research findings will be used to determine which areas of the developmental mathematics curriculum need to be improved.

In Chapter II, topics relevant to understanding and teaching developmental mathematics courses were reviewed. In Chapter III the methods and procedures utilized to obtain the data from the final examinations were made clear. Chapter IV provided a statement of conclusions about the final examination data that were analyzed and Chapter V detailed the recommendations for improving the developmental mathematics curriculum.

CHAPTER II

REVIEW OF LITERATURE

This chapter provides information about developmental mathematics courses. Topics covered include the purpose of developmental mathematics courses, problems students have in developmental mathematics, the number of students enrolled in developmental mathematics courses, factors that cause students to be unsuccessful in developmental mathematics courses and factors which may increase developmental mathematics students' success. The chapter concludes with a brief overview of the developmental program at Virginia Western Community College.

WHAT IS DEVELOPMENTAL MATHEMATICS?

College students often enter into their first year of college deficient in one or more academic areas. According to McCabe (2000), only 42% of the students who graduate from high school possess sufficient academic knowledge and skills to begin college-level work. To address the problem of student under-preparedness, colleges and universities offer remedial courses in mathematics and language arts as well as study-skill based orientation courses (Kull, 1999). These remedial education programs have existed since the higher education movement started in the United States (Kull, 1999). According to the National Center for Educational Statistics (2004), 76% of all colleges and universities offer at least one remedial course. Today in colleges and universities these courses are referred to as developmental courses.

Developmental mathematics refers to the mathematical knowledge and skills students should possess prior to entering a credit level mathematics course. In the past it has also been referred to as remedial mathematics or non credit-bearing mathematics. In

the late 1960's and early 1970's the number of colleges offering developmental mathematics courses increased dramatically (Lindberg, 1976). This was due at least in part to a large influx of students who were entering careers that required quantitative skills as well as, "an increase in the number and proportion of students with backgrounds not typical of traditional college populations" (Lindberg, 1976, p. 2). In addition to this many colleges and universities had high percentages of students, who were unable to successfully complete their coursework in mathematics (Friedlander, 1979). Currently institutions of higher education dedicate significant resources towards the teaching of developmental mathematics (Johnson & Kuennen, 2004).

Common developmental mathematics courses include some form of arithmetic or pre-algebra, a beginning algebra course, an intermediate algebra course and a geometry course. Colleges and universities offering developmental courses have all or some combination of the topics covered in these courses. Some institutions of higher learning also offer modular courses or courses designed to teach mastery of specific mathematical skills.

PURPOSE OF DEVELOPMENTAL MATHEMATICS

Today developmental mathematics courses are offered at universities and colleges for a variety of reasons. Many of the reasons are related to student success (Johnson & Kuennen, 2004). Purposes of developmental mathematics courses include: increasing poor performing students' knowledge and skills in mathematics, teaching students how to apply knowledge gained in one setting to another situation, preparing students who have not recently participated in an academic setting, helping students to develop a positive academic self-concept, helping students to develop positive attitudes towards the learning

of mathematics, teaching students that they can be successful in mathematics and teaching students self-efficacy (Johnson & Kuennen, 2004; Hall & Ponton, 2005). Among other reasons students enter postsecondary education lacking in basic mathematical knowledge and skills are "(a) They did not take the relevant courses in high school, (b) they took the relevant courses but did not master the content, and (c) they have forgotten much of the content that they once mastered" (Kinney, 2001, p. 10).

STUDENTS TAKING DEVELOPMENTAL MATHEMATICS COURSES

According to McCabe (2000), as cited in Fike and Fike's research, and Hackworth (2000), as cited by Miles, over 50% of the students beginning college are not prepared to do college level mathematics (Fike & Fike, 2007; Miles, 2000). Due to the large number of students graduating from high schools throughout the United States, who are deficient in mathematics, institutions of higher learning are being forced to offer more and more courses to improve the mathematical literacy of their student bodies. These developmental courses can represent a significant percentage of the mathematics courses being offered. Currently in the United States about 34% of the students who are enrolled in postsecondary mathematics courses are enrolled in developmental mathematics courses (Johnson, 2007). This means a large amount of the teaching resources being expended in colleges and universities are being spent on pre-college content. It is imperative these resources be spent as wisely as possible.

Nationwide, 30% of students entering colleges are forced to enroll in some form of developmental mathematics course (Hall & Ponton, 2005). While this is a staggering statistic, the situation is much worse in the nation's community colleges. In fact it is estimated that 57% of all students who attend a community college enroll in at least one

developmental mathematics course (AMATYC, 2007). While at first glance this sort of statistic might lead one to think society is currently going through some crisis or epidemic in which the nation's college students are not being properly prepared to enter college level mathematics courses, this might not be the case. The truth is this trend has been relatively similar throughout the last 35 years (Stein, 1976; Ajose, 1978; Friedlander, 1979; Cohen, 1985; McDonald, 1988; O'Connor & Morrison, 1997; Penny & White, 1998; Waycaster, 2001; Johnson, 2007). Students doing poorly in mathematics is not a new problem but an old problem which has yet to be solved. It is clear colleges and universities still have a long way to go toward improving the success rates of developmental mathematics students.

Significant research has been conducted on developmental education and developmental mathematics in particular. Research areas include pedagogical approaches, student learning in specific content areas, content delivery, and program effectiveness evaluations (Johnson, 2007). The research shows that large percentages of developmental mathematics students tend to be unsuccessful (AMATYC, 2007; Johnson, 2007; Lesik, 2007; Johnson & Kuennen, 2004, Waycaster, 2001; Seon & King, 1997). This leads to the question, "why is it that so many students are unsuccessful in developmental mathematics courses?"

STUDENT SHORTCOMINGS IN DEVELOPMENTAL MATHEMATICS COURSES

The reasons students are unsuccessful vary greatly. One of the biggest factors of students doing poorly in these courses has been poor student attendance (Johnson & Kuennen, 2004, Waycaster, 2001; Umoh & Eddy, 1994). Research clearly shows that if students fail to attend classes, it is less likely they will be successful. This is especially

true for mathematics courses since material learned one day is based upon the material learned on a previous day. It may be that students believe they have better attendance records than they actually have. In one study it was found that students indicated that they attended all or almost all of the extra help sessions offered for a developmental mathematics course; but records indicated that only one student had attended all the sessions and a very small percentage of students had attended all but one or two of the sessions (Wright, Wright, & Lamb, 2002). One way faculty might help improve students' attendance records would be to inform students about the necessity of attending class and how attendance affects success in the course. Perhaps regularly making students aware of the number of absences they have would also cause them to attend class more frequently.

Developmental mathematics students are not always aware of the reasons that they are not successful. Hall and Ponton (2005) suggest that some students have an inability to perform successfully in developmental courses because they are unable to recognize possible success limiting factors. Many barriers to mathematics success exist. Some of these barriers to mathematics achievement include: mathematics anxiety, test anxiety, perceived uselessness of algebra in everyday life, lack of student autonomy and student lack of confidence when it comes to mathematics (Higbee & Thomas, 1999).

The campus environment may be another contributing factor to developmental mathematics students being unsuccessful. There is a certain stigma attached to being in developmental courses. Students sometimes feel embarrassed to be enrolled in such a course (Higbee & Thomas, 1999). In addition to this the students who have to enroll in developmental courses tend to get less support than more traditional college students

(Umoh, 1994). This overall lack of support may be one reason developmental students are not as successful as their non-developmental counterparts (Umoh, 1994). Add to this the pessimistic attitudes faculty have towards teaching remedial students and it becomes clearer why it is harder for developmental students to succeed (Umoh, 1994). These negative attitudes in conjunction with the lack of support and feelings of embarrassment make it even more difficult for developmental students to succeed.

The use of calculators may be an explanation for the difference in students understanding as they leave high school compared to when they enter college. Students are usually allowed to use calculators throughout their high school mathematics careers; however they are not allowed to use them on the college placement test or in developmental mathematics courses (Schwartz, 2007). There is usually a disconnect between K-12 educators and college faculty when it comes to using the calculator. High school teachers see the calculator as a necessity to pass end of course tests while college faculty see the calculator as an instrument that allows students to do mathematics at a much higher level than they understand (Schwartz, 2007). Improving collaboration between high school teachers and college faculty will cause a more seamless transition between the standards expected at the high school level and those expected at the college level (AMATYC, 2007). This smoother transition would also improve students' success in college level courses (AMATYC, 2007).

METHODS TO IMPROVE SUCCESS

Most researchers agree that there are not any easy solutions to the problem of high failure rates in developmental mathematics courses. The complexity of the issues involved, combined with problems such as student apathy and students' over reliance on

graphing calculators, all come together to provide a challenge to faculty who are interested in seeing students succeed.

One idea prevalent in the developmental mathematics literature is the use of technology to enhance the delivery of content. If technology is going to be used in a developmental mathematics course it must be used properly. Learning with technology is different than learning from technology (Li & Edmonds, 2005). Technology can be used in many different ways to assist developmental mathematics students. It can be used in the form of improved delivery of the content, calculators to assist students making calculations, websites where students do their homework assignments, websites that provide tutoring services, online lectures which students can access after class has ended, calculator-based rangers and computer-assisted instruction (CAI) (Li & Edmonds, 2005; MacDonald, Vasquez & Caverly, 2002).

Much of the literature focuses on the correct use of technology in developmental mathematics. Technology cannot be used to supplement a student's mathematical knowledge base. It must be used as a tool and not as a crutch. Using the calculator correctly means allowing students the use of only a scientific calculator and changing the emphasis of the course from basic skill building to problem solving (MacDonald, Vasquez, & Caverly, 2002). Using the internet in a group setting can be problematic; however the internet can be used effectively as a tool to individualize instruction (Miles, 2000). Using the web correctly means providing students with the appropriate web-based technology based upon the students' mathematical level and course demographics (MacDonald, Vasquez, & Caverly, 2002).

Even though using technology in developmental mathematics courses has been explored by many researchers, it has produced mixed results. Testone (2005) found that students who used online resources provided by the publisher of the textbook did better than students who did not. However Jacobson (2006) found that having students do computer homework had no effect. He found that while students believed that doing computer homework helped them to better understand the content, final exam grades did not reflect this belief (Jacobson, 2006). For every study in which students did better using technology in developmental mathematics there is a study in which technology did not have any effect.

Another approach to improving developmental mathematics used by researchers has been to determine the traits of successful students and then use this information to help less successful students. Higbee and Thomas (1999) found that successful students tended to have certain behaviors: they developed, scheduled and carried out study plans, performed academically at the level they were capable of performing, had high levels of self-discipline, required little or no direction from others but were able to seek out help if they felt it to be necessary. One way to implement the findings of this study might be to provide students with training on how to develop and carry out a plan of study, the necessity of self-discipline when it comes to learning mathematics, techniques for improving self-discipline to study mathematics and the appropriate people and places to seek assistance when mathematical difficulties arise.

Penny and White (1998) did similar research into the factors contributing to student success in developmental mathematics courses. They found some of the contributing factors to be: age (older students tended to be more successful), full time

enrollment while taking the course, success in a previous developmental course and enrollment in developmental mathematics courses taught by full-time female instructors. The strongest predictor of success turned out to be a student's success or failure in pre-requisite developmental courses (Penny & White, 1998). While the findings of this research can be helpful in determining if a student is more likely to succeed, there was little in the results that can be implemented by faculty members. Faculty members have little control over any of the success factors. In fact the only success related variable that can be controlled even indirectly by faculty is the hiring of more full-time faculty. While hiring more full-time faculty may contribute slightly to student success, it is unlikely this change alone will bring about a large amount of student success (Penny & White, 1998).

Faculty may have a larger affect on developmental mathematics courses through continuing their education. In a study conducted by Fike and Fike (2007) a connection was found between faculty education level and students' final grades. The researchers observed that faculty who held graduate degrees had higher student success rates than faculty who only had undergraduate degrees (Fike & Fike, 2007). Given these findings one suggestion might be to, "encourage and provide support to developmental education faculty who pursue degrees and graduate certificates" (Fike & Fike, 2007, p. 10). Examining the hiring practices for developmental mathematics faculty and raising the minimum requirements for employing developmental mathematics faculty may also lead to higher student success rates (Fike & Fike, 2007).

On the whole improving student success in developmental mathematics courses is a difficult task. While it has been shown that faculty can have some affect on student success in these courses, it is the students themselves who have the most control over the

factors that lead to their success. The hiring of more full time faculty with graduate degrees is one way to improve student success rates. Other methods of enhancing student success include teaching students study skills and techniques for improving self-discipline.

DEVELOPMENTAL MATHEMATICS AT VIRGINIA WESTERN

At Virginia Western Community College (VWCC) the developmental mathematics program has a standardized curriculum. Each developmental course, Math 09, Math 03 and Math 04, has a common course syllabus that outlines which topics should be covered, the order in which topics should be covered, the expected outcomes for the course, the same textbook and a common final exam created by the Mathematics Department.

Students are placed into mathematics courses based upon their score on the COMPASS test. COMPASS stands for Computer-adapted Placement Assessment and Support Services. Students typically take the test prior to their first semester of enrollment. Students who believe they were placed incorrectly can retake the test up to three times in one year. Once students are placed into a developmental mathematics course they must complete each of the following developmental courses before they are permitted to enroll in a credit course.

SUMMARY

In Chapter II, the review of literature, developmental mathematics was described in detail. Chapter II also characterized the purpose of developmental mathematics courses as assisting students to become prepared for credit level mathematics courses. Percentages of students having to take these courses were then presented. The reasons

why so many students are unsuccessful in these courses was outlined as well. Reasons included poor student attendance, affective barriers and the attitude of the campus community. Finally ways of improving developmental mathematics courses were identified. These included hiring more full time faculty with graduate degrees and teaching students various skills related to performing well in mathematics courses. The chapter ended with an overview of the developmental mathematics program at VWCC. In Chapter III the researcher will detail the methods and procedures undertaken in this research study. The focus will be on the population of the research study, how data were collected and the statistical analysis utilized in the study.

CHAPTER III

METHODS AND PROCEDURES

In Chapter III the methods and procedures of the research study are described and detailed. This chapter includes the population, the methods of data collection, the statistical analysis used in the study and a summary.

POPULATION

The population for this study was restricted to developmental mathematics students at Virginia Western Community College who were enrolled in a Math 09, Math 03 or Math 04 course in the fall 2008 or spring 2009 semesters. These students were placed into these courses based upon the score they received on the COMPASS test.

For both the fall 2008 and spring 2009 semesters a few instructors neglected to return their graded final exams back to the Math Department. Because of this, all of the graded final exams which were returned to the Virginia Western Math Department have been included in the study.

The total number of students enrolled in developmental mathematics courses in the fall 2008 semester was 862. Of these 862, 270 were enrolled in Math 09, 403 were enrolled in Math 03 and 189 were enrolled in Math 04 (Virginia Western Math Department, 2008). Only 520 of the 862 students were considered in this study.

The total number of students enrolled in developmental mathematics courses in the spring 2009 semester was 803. Of these 803, 212 were enrolled in Math 09, 376 were enrolled in Math 03 and 215 were enrolled in Math 04 (Virginia Western Math Department, 2009). Only 548 of the 803 students were considered in this study.

METHODS OF DATA COLLECTION

For the fall 2008 semester data were collected from 109 final exams out of 142 students in Math 09 courses, 199 final exams out of 298 students in Math 03 courses and 64 out of 80 students in Math 04 courses. For the spring 2009 semester data were collected from 118 out of 188 students in Math 09, 164 out of 231 Math 03 students and 100 out of 129 Math 04 students. For the fall 2008 semester data were collected from 6 out of 12 Math 09 courses, 13 out of 18 Math 03 courses and 4 out of 8 Math 04 courses. For the spring 2009 semester data were collected from 7 out of 8 Math 09 courses, 9 out of 16 Math 03 courses and 6 out of 10 Math 04 courses.

Data were collected from each examination on a question by question basis. Each individual question from each student's examination was inspected to see if the student answered it correctly or incorrectly. If a student received partial credit, the question was deemed to be incorrect. The questions were categorized according to the content area under which they fell and subsection of the content area being tested. For example a question could fall under the content area Solving Equations and the subsection 4-Step Equation. See Appendices A-C to observe a full breakdown of the question types for each examination. In addition to the question by question analysis, an overall inspection was conducted to ascertain which of the various content areas contained the majority of the incorrect questions.

In addition to the question by question analysis, the number of students who completed each course, the number who took the final examination and the numbers of students who passed or failed the final examination for each course were considered for

analysis as well. These were considered both on a course by course basis and for the entire sample.

STATISTICAL ANALYSIS

All of the developmental mathematics final examinations which were returned by instructors to the Virginia Western Math Department were considered in this study. Once all of the final exams had been reviewed various descriptive statistics were utilized to analyze the data. Descriptive statistics were used to determine which questions had the highest percentage of incorrect responses.

Descriptive statistics were employed to determine the percentage of students who took the final exam versus the number of students who should have taken the final exam based on the course roster. Statistics were also used to determine the percentage of students who passed the examination and those who failed the examination. The average number of incorrect responses for students who passed and the average number of incorrect responses for students who failed were examined too.

SUMMARY

In Chapter III, the methods and procedures involved in conducting this study were outlined. The population, methods of data collection and statistical analysis were described. The population under consideration for this study was the students enrolled in developmental mathematics courses at Virginia Western Community College. Data were collected from final examinations administered during the fall 2008 and spring 2009 semesters. Mainly descriptive statistics were used in the statistical analysis. The results of the study will be presented in Chapter IV.

CHAPTER IV

FINDINGS

In Chapter IV the study's findings were presented. The most frequently missed questions on each of the developmental final examinations were discussed in terms of content area and subtopic. Questions which over 50% of responders answered incorrectly were considered areas where curriculum and instructional improvement was necessary. Following the detailed discussion about the most frequently missed questions, the numbers of students enrolled in each course as well as the number of students who took the final examinations were presented.

MATH 09

The most frequently missed question on the Math 09 final examination for both the fall 2008 and spring 2009 semesters was question number 20. Question 20 involved solving a 3-step linear equation containing fractions. In the fall 2008 semester 83% of students and in the spring 2009 semester 80% of students answered question 20 incorrectly. Nine other questions were missed by over 50% of students on the Math 09 final examination in both semesters. Questions 8, 15, 19, 21, 22, 24, 30, 31 and 32, each had over 50% of students answer incorrectly in both the fall 2008 and spring 2009 semesters. Question 8 had students represent a problem situation with an algebraic expression. Questions 15 and 19 required students to properly use fractions. Question 21 was similar to question 20 where students had to solve an equation containing fractions. In question 22 students had to perform a metric conversion. Questions 24, 31 and 32 all required students to use decimals. Question 24 was an equation containing decimals, question 31 was an order of operations problem containing decimals and question 32 had

students dividing decimals. Question 30 involved finding the perimeter and area of a rectangle. To see a comparison between the fall 2008 and spring 2009 semesters of the percentage of students who missed each question on the Math 09 final examination see Table 1.1. To see a graphical representation of the percentage of students who missed each question on the Math 09 final examination see Figures 1.1 and 1.2.

The overall percentage of students who took the Math 09 final examination in the fall 2008 semester out of the total number of students who were enrolled in Math 09 courses was 77%. The percentage of students who took the Math 09 final examination during the fall 2008 semester and passed was 53% and the percentage who failed was 47%. The overall percentage of students who took the Math 09 final examination in the spring 2009 semester out of the total number of students who were enrolled was 63%. Out of the 63% who took the exam, 39% passed the final examination and 61% failed. Below in Tables 2.1 through 2.4 a further dissection of the number of students in each course and the percentages of students passing and failing the Math 09 final examination is provided.

MATH 03

The most frequently missed question on the Math 03 final examination for both the fall 2008 and spring 2009 semesters was question 13. Question 13 required students to find the equation of a line which was perpendicular to a given line and passed through a given point. Eighty percent of students in the fall 2008 semester and 78% of students in the spring 2009 semester missed question 13 on the Math 03 final examination. Fourteen other questions on the Math 03 final examination were answered incorrectly by over 50% of students in both the fall 2008 semester and the spring 2009 semester.

Table 1.1

Percentage of Students Missing Each Question on Math 09 Final Examinations

	Fall 2008	Spring 2009
1	26%	25%
2	14%	10%
3	17%	14%
4	54%	49%
5	39%	31%
6	46%	54%
7	28%	25%
8	68%	66%
9	42%	30%
10	50%	50%
11	45%	42%
12	62%	49%
13	24%	25%
14	38%	41%
15	53%	54%
16	39%	42%
17	23%	25%
18	39%	40%
19	73%	79%
20	83%	80%
21	57%	56%
22	53%	58%
23	32%	30%
24	64%	64%
25	49%	58%
26	40%	43%
27	50%	36%
28	29%	37%
29	44%	34%
30	57%	51%
31	79%	73%
32	62%	53%
33	27%	34%

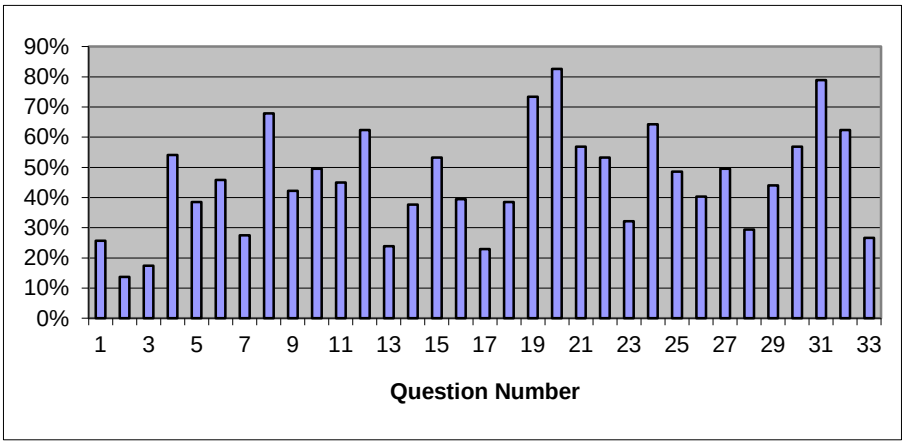

Figure 1.1

Percentage of Students Missing Each Question
Math 09 Final Examination Fall 2008

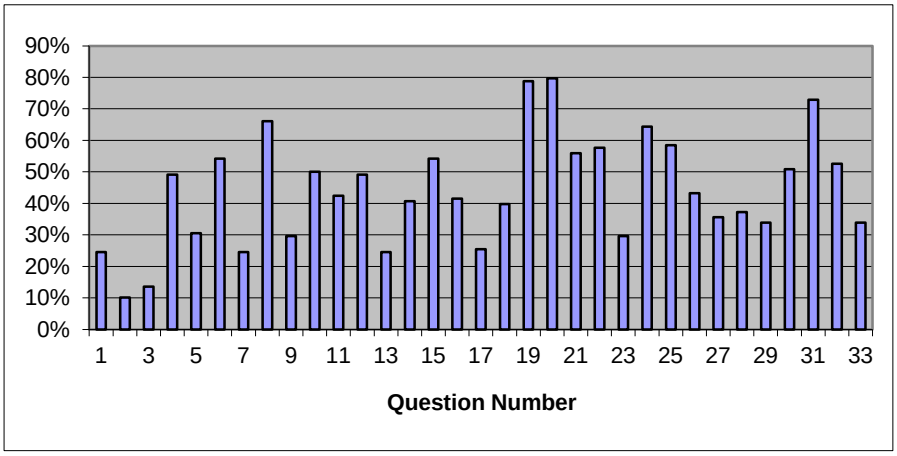

Figure 1.2

Percentage of Students Missing Each Question
Math 09 Final Examination Spring 2009

Table 2.1

Student Numbers for Math 09 in Fall 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F
Students Enrolled	23	22	24	25	25	23
Students Tested	18	20	18	16	19	18
Students Who Passed	6	10	9	9	15	9
Students Who Failed	12	10	9	7	4	9

Table 2.2

Student Numbers for Math 09 in Spring 2009 Semester

	Course A	Course B	Course C	Course D	Course E	Course F	Course G
Students Enrolled	29	27	29	24	27	25	27
Students Tested	17	15	15	11	20	17	23
Students Who Passed	7	7	3	4	7	13	5
Students Who Failed	10	8	12	7	13	4	18

Table 2.3

Student Percentages Math 09 Fall 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F
Students Tested	78%	91%	75%	64%	76%	78%
Students Who Passed	33%	50%	50%	56%	79%	50%
Students Who Failed	67%	50%	50%	44%	21%	50%

Table 2.4

Student Percentages Math 09 Spring 2009 Semester

	Course A	Course B	Course C	Course D	Course E	Course F	Course G
Students Tested	59%	56%	52%	46%	74%	68%	85%
Students Who Passed	41%	47%	20%	36%	35%	76%	22%
Students Who Failed	59%	53%	80%	64%	65%	24%	78%

These questions were numbers 5, 7, 10, 11, 12, 14, 15, 22, 24, 25, 30, 31, 32 and 34. Question 5 required students to represent a problem situation with an algebraic expression. Question 7 occupied students with the task of solving an inequality where both sides had to be divided by a negative number. Questions 10, 11, 12, 14 and 15 all involved ideas about graphing linear equations in two variables from finding the slope of a line and graphing a line to finding the equation of a line given enough information. Question 22 and 24 both involved polynomial expressions. Question 22 required students to multiply two binomials and question 24 required students to divide a trinomial by a binomial. Questions 25 and 30 involved factoring polynomial expressions. Questions 31 and 32 had students solve a quadratic equation using factoring. Finally question 34 involved multiplying two rational expressions. A graph representing the percentage of students who missed each question is presented in Figures 2.1 and 2.2 on the next page. A comparison between the percentage of students who missed each question for both the fall 2008 and spring 2009 semester is presented in Table 3.1.

Table 3.1

Percentage of Students Missing Each Question on Math 03 Final Examination

	Fall 2008	Spring 2009
1	46%	65%
2	26%	35%
3	21%	31%
4	35%	31%
5	61%	67%
6	30%	32%
7	59%	63%
8	45%	50%
9	42%	40%
10	63%	68%
11	57%	59%
12	60%	65%
13	80%	78%
14	55%	52%
15	68%	67%
16	37%	37%
17	22%	30%
18	33%	35%
19	29%	34%
20	11%	19%
21	45%	50%
22	52%	62%
23	36%	45%
24	65%	73%
25	55%	54%
26	45%	37%
27	29%	37%
28	19%	27%
29	38%	41%
30	57%	53%
31	62%	63%
32	62%	62%
33	50%	46%
34	57%	63%
35	11%	15%
36	19%	20%
37	33%	33%
38	22%	24%

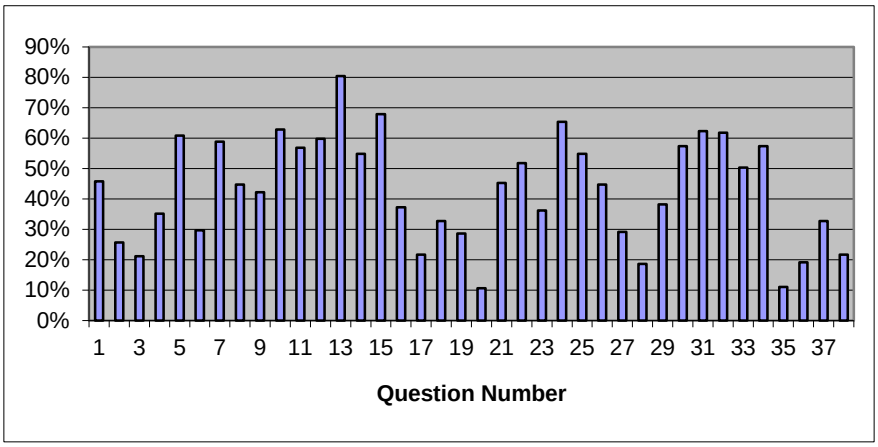

Figure 2.1

Percentage of Students Missing Each Question
Math 03 Final Examination Fall 2008

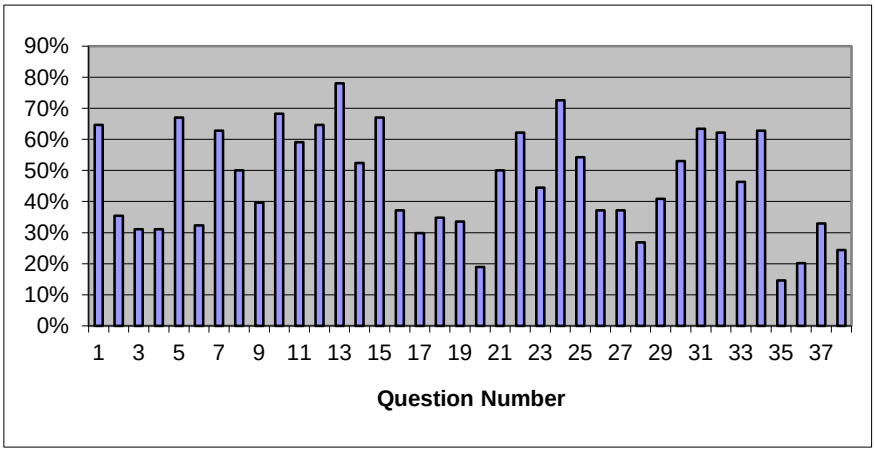

Figure 2.2

Percentage of Students Missing Each Question
Math 03 Final Examination Spring 2009

In Math 03 courses the overall percentage of students who took the Math 03 final examination in the fall 2008 semester out of the total number of students enrolled in Math 03 courses was 67%. Of the 67% of students who took the final examination, 32% passed and 68% failed. In the spring 2009 semester 71% of enrolled students took the final examination of which 34% passed the final examination and 66% failed the final examination. In Tables 4.1 through 4.4 a further dissection of the number of students in each course and the percentages of students passing and failing the Math 03 final examination is provided.

MATH 04

The two questions most frequently answered incorrectly on the Math 04 final examination were question 4 and question 24. Both questions were answered incorrectly by 84% of students in both the fall 2008 semester and the spring 2009 semester. Question 4 required students to subtract rational expressions with unlike denominators. Question 24 required students to solve a radical equation containing a square root. Thirteen other questions were missed by more than 50% of students in both the fall 2008 and spring 2009 semesters. These questions were numbers 1, 10, 14, 15, 17, 18, 19, 22, 23, 25, 26, 28 and 30. Question 1 had students solve an absolute value inequality. Question 10 had students solve a radical equation. Questions 14 and 15 involved linear equations in two variables. Question 17 had students graph an inequality in two variables. Questions 18 and 19 involved simplifying radical expressions. Question 18 involved rationalizing the denominator prior to simplifying. Questions 22 and 23 required students to simplify complex numbers containing an imaginary part. Questions 25 and 26 required students to solve quadratic equations.

Table 4.1

Student Numbers for Math 03 in Fall 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F	Course G	Course H	Course I	Course J	Course K	Course L	Course M
Students Enrolled	29	21	23	23	22	23	21	23	24	21	21	25	22
Students Tested	19	16	11	14	13	14	13	16	14	14	20	19	16
Students Who Passed	6	9	1	2	7	3	4	5	9	1	8	4	5
Students Who Failed	13	7	10	12	6	11	9	11	5	13	12	15	11

Table 4.2

Student Numbers for Math 03 in Spring 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F	Course G	Course H	Course I
Students Enrolled	29	20	24	29	24	31	23	24	27
Students Tested	28	15	14	24	11	20	9	21	22
Students Who Passed	12	4	5	3	5	6	5	6	9
Students Who Failed	16	11	9	21	6	14	4	15	13

Table 4.3

Percentages for Math 03 in Fall 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F	Course G	Course H	Course I	Course J	Course K	Course L	Course M
Students Tested	66%	76%	48%	61%	59%	61%	62%	70%	58%	67%	95%	76%	73%
Students Who Passed	32%	56%	9%	14%	54%	21%	31%	31%	64%	7%	40%	21%	31%
Students Who Failed	68%	44%	91%	86%	46%	79%	69%	69%	36%	93%	60%	79%	69%

Table 4.4

Percentages for Math 03 in Spring 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F	Course G	Course H	Course I
Students Tested	97%	75%	58%	83%	46%	65%	39%	88%	81%
Students Who Passed	43%	27%	36%	13%	45%	30%	56%	29%	41%
Students Who Failed	57%	73%	64%	87%	55%	70%	44%	71%	59%

Question 25 required factoring or using the square root method to solve while question 26 required the use of the quadratic formula. Question 28 had students graph a quadratic function. Finally question 30 required students to use the Pythagorean Theorem to solve a problem containing a right triangle. A comparison between the percentage of incorrect answers for each question between the fall 2008 and spring 2009 semesters is located in Table 5.1. A graphical representation of the percentage of students who missed each question is located in Figures 3.1 and 3.2.

In the fall 2008 semester the overall percentage of students who took the Math 04 final examination out of the total number of students enrolled was 80%. Of the 80% of students who took the Math 04 final examination 49% passed and 51% failed. Seventy-eight percent of the students who were enrolled in Math 04 courses during the spring 2009 semester took the final examination. Out of the 78% who took the final examination, 31% passed and 69% failed. In Tables 6.1 through 6.4 a further dissection of the number of students in each course and the percentages of students passing and failing the Math 04 final examination is provided.

SUMMARY

In Chapter IV the findings of the research project were reported. On the Math 09 final examination questions involving fractions, decimals and solving equations were found to be the ones that over 50% of students missed the most frequently. Specifically the questions which contained a mixture of these concepts were the ones students tended to miss. On the Math 03 final examination questions involving graphing linear equations in two variables, solving quadratic equations, factoring out the greatest common factor and operations with polynomial expressions were shown to be the ones that over 50% of students missed the most frequently. The greatest number of questions missed by over 50% of students came from the content area

Table 5.1

Percentage of Students Missing Each Question on Math 04 Final Examination

	Fall 2008	Spring 2009
1	72%	61%
2	38%	32%
3	42%	38%
4	84%	84%
5	56%	39%
6	20%	21%
7	42%	44%
8	19%	27%
9	48%	54%
10	86%	79%
11	31%	37%
12	39%	52%
13	36%	29%
14	72%	64%
15	75%	74%
16	39%	48%
17	61%	60%
18	73%	66%
19	58%	54%
20	44%	51%
21	42%	42%
22	56%	56%
23	64%	75%
24	84%	84%
25	64%	78%
26	53%	66%
27	28%	37%
28	58%	63%
29	48%	61%
30	42%	57%
31	20%	29%
32	11%	30%
33	17%	30%

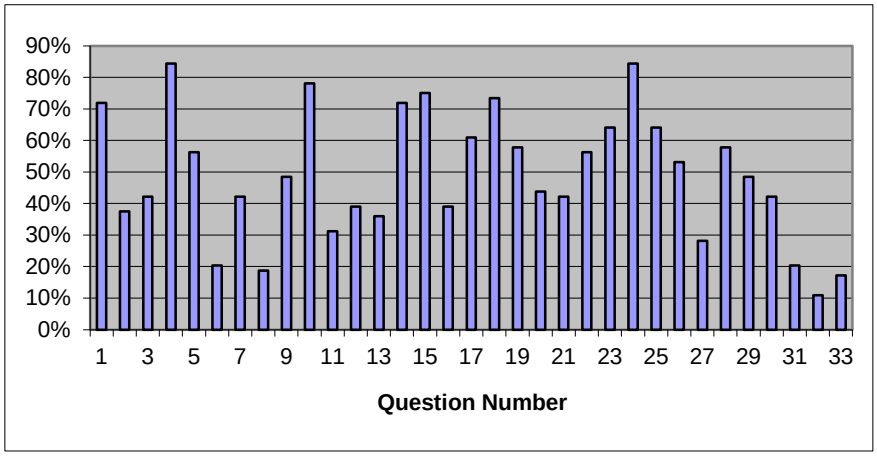

Figure 3.1

Percentage of Students Missing Each Question
Math 04 Final Examination Fall 2008

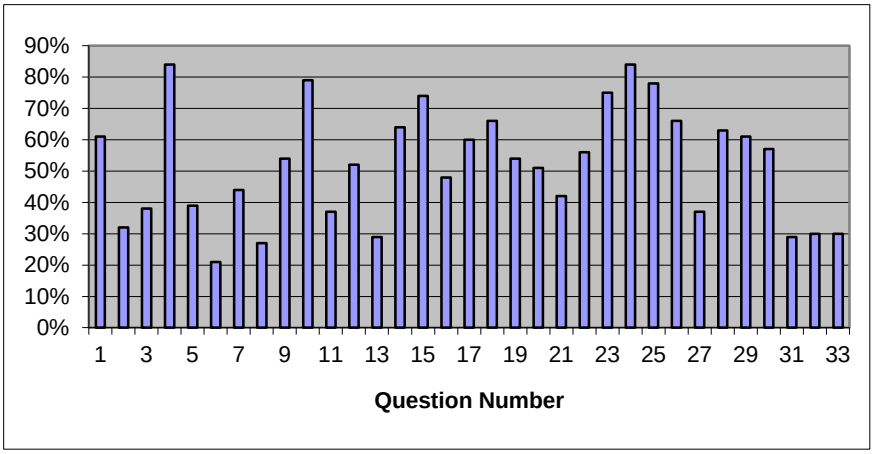

Figure 3.2

Percentage of Students Missing Each Question
Math 04 Final Examination Spring 2009

Table 6.1

Student Numbers for Math 04 in Fall 2008 Semester

	Course A	Course B	Course C	Course D
Students Enrolled	24	25	16	15
Students Tested	19	22	14	9
Students Who Passed	12	10	6	3
Students Who Failed	7	12	8	6

Table 6.2

Student Numbers for Math 04 in Spring 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F
Students Enrolled	22	23	24	21	15	24
Students Tested	20	17	16	16	12	19
Students Who Passed	5	7	5	6	2	6
Students Who Failed	15	10	11	10	10	13

Table 6.3

Percentages for Math 04 in Fall 2008 Semester

	Course A	Course B	Course C	Course D
Students Tested	79%	88%	88%	60%
Students Who Passed	63%	45%	43%	33%
Students Who Failed	27%	55%	57%	67%

Table 6.4

Student Numbers for Math 04 in Spring 2008 Semester

	Course A	Course B	Course C	Course D	Course E	Course F
Students Tested	91%	74%	67%	76%	80%	79%
Students Who Passed	25%	41%	31%	38%	17%	32%
Students Who Failed	75%	59%	69%	62%	83%	68%

graphing linear equations in two variables. On the Math 04 final examination the content areas found to be the most in need of improvement were radical expressions and equations, quadratic equations and expressions, complex numbers and linear equations in two variables. The content area of linear equations in two variables was missed frequently on both the Math 03 and Math 04 final examinations.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study was undertaken as a result of low pass rates in developmental courses at Virginia Western Community College. The purpose of this study was to determine which areas of the Math 09, Math 03 and Math 04 curriculum students tended to perform the least satisfactorily. The study was also undertaken to decide on any improvements that could be made to improve student success rates based upon the findings about which areas of the curriculum students tended to perform the least satisfactorily. In Chapter V, a summary of the entire study will be given, conclusions will be presented and finally recommendations will be made about possible improvements to the developmental mathematics curriculum and instruction at Virginia Western Community College.

SUMMARY

The main purpose of this research study was to determine changes that could be made to improve curriculum and instruction in Virginia Western's developmental mathematics courses. There were four research goals at the outset of this study. The first three goals had to do with determining areas of the developmental course curriculums where students were performing poorly at Virginia Western Community College. The instrument used to determine this was the departmental final examinations for Math 09, Math 03 and Math 04 courses. The fourth goal involved using the information concluded from the first three goals to improve the curriculum in all three developmental courses.

Developmental mathematics can be characterized as the mathematical knowledge and skills students accrue through completing an Algebra 1 and Algebra 2 course in high school. Common developmental courses include arithmetic, pre-algebra, elementary

algebra, intermediate algebra and geometry. The term developmental is used primarily in community colleges and can also be interpreted as the information and skills a student should have learned before attempting a credit level college course.

Developmental mathematics courses are a necessary part of the college curriculum for several reasons. Reasons include poor student performance in mathematics, poor transfer of mathematical ideas from one situation to another situation, student unpreparedness for credit level mathematics courses, students' poor perception of their mathematical abilities as well as many others (Johnson & Kuennen, 2004; Hall & Ponton). The main purposes of developmental mathematics courses are to improve student success in generalizing mathematical ideas and improve student success in credit level mathematics courses.

A large percentage of college and university students are enrolled in developmental mathematics courses. According to Johnson (2007) approximately 34% of students who are enrolled in a mathematics course at a college or university are enrolled in a course that is considered to be developmental. The situation is even worse at the nation's community colleges, where approximately 57% of students enroll in at least one developmental mathematics course prior to leaving the community college (AMATYC, 2007). Over the past 35 years this trend of students not being properly prepared to enter into a credit level mathematics course has been similar (Stein, 1976; Ajose, 1978; Friedlander, 1979; Cohen, 1985; McDonald, 1988; O'Connor & Morrison, 1997; Penny & White, 1998; Waycaster, 2001; Johnson, 2007).

The answers to the question, "Why are so many students unsuccessful in developmental mathematics courses?" were wide-ranging. One of the biggest factors

contributing to poor student performance was poor attendance (Johnson & Kuennen, 2004; Waycaster, 2001; Umoh & Eddy, 1994). The current study supported attendance as a main reason for students being unsuccessful in developmental mathematics courses. In the study the percentage of students completing the Math 09 course for the fall 2008 semester was 77% and for the spring 2009 semester was 63%. The percentage of students completing the Math 03 course for the fall 2008 semester was 67% and for the spring 2009 semester was 71%. The Math 04 course boasted of the highest percentage of students completing the course with 80% of students completing in the fall 2008 semester and 77% completing for the spring 2009 semester.

Another reason contributing to developmental mathematics students being unsuccessful was the social environment of colleges and universities. Students enrolled in developmental courses may be embarrassed to be in such courses (Higbee & Thomas, 1999). In addition to being embarrassed, developmental students may feel a general lack of support from the college or university (Umoh, 1994). Add to this the fact that faculty often have pessimistic attitudes towards teaching students who are considered to be developmental and all of these conditions come together to make developmental students feel like they do not belong in the college environment (Umoh, 1994).

Calculators may be another factor adversely affecting student success in developmental mathematics courses. While students are allowed to use calculators throughout their high school mathematics careers; usually they are not allowed to use calculators when they enter college level mathematics courses (Schwartz, 2007). Improved collaboration between high school teachers and college faculty will assist

students in the transition between high school and college mathematics courses (AMATYC, 2007).

Easy solutions do not exist to improving success rates in developmental mathematics courses. One idea which has been the subject of much of the developmental mathematics research is the use of technology. Technology in the form of content delivery technologies, calculators, tutoring websites, websites where students do homework assignments, online lectures, calculator-based rangers and computer-assisted instruction or CAI have been used to assist developmental mathematics students in being more successful (Li & Edmonds, 2005; MacDonald, Vasquez & Caverly, 2002). The problem with using technology to assist in developmental students' success is that in the research it has produced mixed results. Studies exist in which technology produced an effect on student success and studies exist in which technology did not have any effect.

One approach to improving success in developmental mathematics courses involves determining the traits of students who were successful in developmental mathematics courses and providing training to students based upon these successful traits. According to Higbee and Thomas (1999) successful students tended to develop, schedule and carry out study plans, they also performed at the level they were capable of performing, were self-directing and could seek out help if they felt it to be necessary and had plenty of self-discipline. Training could be offered to students that assisted them in developing and carrying out a plan of study, showing students where the best places to seek assistance is, should they require it, the necessity of self-discipline as it pertains to learning mathematics and methods of improving self-discipline.

Penny and White (1998) found other factors that contributed to success to be age, full time enrollment, previous developmental mathematics success and being enrolled in a developmental course being taught by full-time female instructors. The problem with implementing any changes based upon these factors was that they are largely uncontrolled by the faculty members themselves. If faculty promoted the hiring of only females to teach developmental courses, this may viewed as discriminatory to both males and females. Discriminatory to females because they are being asked to teach the developmental courses and not the credit courses and discriminatory to males because they are not being asked to teach the developmental courses. Faculty may be able to encourage students to become full time students but it may not be in the students' best interest to be enrolled full time. Penny and White (1998) found that the biggest success predictor was a student's success or failure in pre-requisite developmental courses. This is further evidence that students need to be successful in developmental mathematics courses so that they can be successful in the mathematics courses they take afterwards.

Developmental mathematics faculty, who choose to continue their education, may have an affect on their students' success in developmental mathematics courses. According to a study conducted by Fike and Fike (2007), a relationship exists between a faculty member's education level and their students' final grades. As instructors' education levels increased students success rates increased, faculty who held graduate degrees had students who scored higher than faculty who held only undergraduate degrees (Fike & Fike, 2007).

Improving student success rates in developmental mathematics courses can be a complicated task for faculty member. While faculty can have a small affect on student

performance in developmental mathematics courses; it is ultimately students who have the greatest amount of control of the factors which support their success. The appropriate use of technology may be one way faculty can aid students in developmental mathematics courses. Another way may be to offer students training based upon the traits of successful developmental mathematics students. There is one surety when it comes to the dilemma of improving student performance in developmental mathematics courses it has been a problem for over thirty years and will continue to be a problem for years to come.

CONCLUSIONS

This study was concerned with student performance on final examinations in three developmental mathematics courses at Virginia Western Community College. The Math 09 final examination tested students on the concepts of whole numbers, integers, rational numbers, order of operations, square roots, solving equations, simple polynomial expressions and descriptive statistics. The Math 03 final examination tested students on the concepts of solving linear equations, solving inequalities, algebraic expressions, graphing linear equations, exponents, operations using polynomial expressions, factoring polynomials, solving quadratic equations, simplifying rational expression, operations using rational expressions and geometry. The Math 04 final examination tested students on the concepts of solving compound inequalities, simplifying rational expressions, operations with rational expressions, rational functions, quadratic functions, linear systems of equations, linear equations in two variables, simplifying radical expressions, simplifying complex numbers, solving quadratic and radical equations, factoring polynomials and concepts related to geometry.

The first research goal of this study was to determine which areas of the Math 09 curriculum students tended to perform unsatisfactorily. To answer this question the Math 09 final examinations were carefully inspected to find questions which were missed by more than 50% of students. On the Math 09 final examination ten questions were missed by more than 50% of students. Four out of the ten questions that more than 50% of students answered incorrectly contained fractional expressions including Question 20 which was the most frequently missed question on the Math 09 final examination. Another four of the ten questions contained decimal expressions. This leads to the conclusion that more time needs to be spent teaching fractions and decimals. Three of the ten questions required students to solve a linear equation in one variable. However it is complicated determining why students were unable to solve the equations. This was because one of the three contained decimals and the other two contained fractions, so it was difficult to conclude whether students had difficulty solving the equations or difficulty working with the fractional and decimal expressions. In spite of this difficulty, it is clear that more time needs to be spent teaching students how to solve equations containing fractions and decimals. The third most frequently missed question had students find the perimeter and the area of a rectangle. It was difficult to know if students missed the question because they were unable to find the area, the perimeter or both. One of the questions, Question 22, required students to perform a metric conversion. This skill is fairly simple in comparison with the other material being covered in the Math 09 curriculum. Perhaps students were not reviewed on this prior to the final examination and were not properly prepared because of its simplicity. It is also possible to consider a metric conversion as a decimal problem. Clearly students already had difficulty with

decimals and this may have been the reason they answered the metric conversion question incorrectly. Overall, questions related to the concepts of fractions and decimals seemed to present the most difficulty to students. These two concepts are areas of the Math 09 curriculum which need improvement. A secondary concept that may have given students difficulty as well was solving equations. Since three of the ten questions which were answered incorrectly by more than 50% of students involved solving equations, solving equations needs to be identified as a weakness for students and an area of the Math 09 curriculum which needs improvement.

The second research question of this study involved determining which areas of the Math 03 curriculum students tended to perform unsatisfactorily. To answer this question the Math 03 final examinations were inspected to determine which questions were the most frequently missed by students. On the Math 03 final examination there were fifteen questions which more than 50% of students answered incorrectly. Six of the fifteen questions, including Question 13 which was the most frequently missed, were questions containing concepts related to graphing linear equations in two variables. The concepts related to graphing linear equations were by far the most missed on the Math 03 final examination. Out of the remaining 9 questions, two questions contained concepts related to simplifying polynomials, two questions contained concepts related to factoring polynomials, two questions required students to solve a quadratic equation, one question required students to multiply two rational expressions, one had students represent a problem situation with an algebraic equation and one question had students solve an inequality. The two problems where students were required to solve quadratic equations were the only two quadratic equation problems on the Math 03 final examination. This

means solving quadratic equations was definitely a content area where the curriculum and instruction could be improved.

More than 50% of students missed questions on each subtopic of graphing linear equations in two variables except the subtopic of finding the slope between two points. It is clear graphing linear equations in two variables is the content area where the most improvement to the Math 03 curriculum and instruction can be made. This leads to the conclusion that more time needs to be spent on the content area of graphing linear equations in two variables. Two other content areas in the Math 03 curriculum that need to be improved are the subtopic greatest common factor part of the content area factoring, and the subtopics of multiplying and dividing polynomial expressions part of the content area exponents and polynomials.

The third research question of this study involved determining which areas of the Math 04 curriculum students tended to perform unsatisfactorily. To answer this question the Math 04 final examinations were inspected to determine which questions were the most frequently missed by students. A total of fifteen questions on the Math 04 final examination were answered incorrectly by more than 50% of students. Four of the questions came from the content area of radical expressions and equations. These four included one of the questions missed by 84% of the students who took the examination. Three of the questions came from content area of graphing linear equations which was the most missed content area on the Math 03 final examination. Three of the questions involved quadratic equations and functions. This was another content area where students did poorly on the Math 03 final examination. Again all of the questions related to quadratic equations and functions were missed by over 50% of students on the Math 04

final examination, just as they were on the Math 03 final examination. Two of the questions came from the content area of complex numbers. One question came from the content area of solving compound inequalities and one question came from the content area of simplifying rational expressions. There were only two questions concerning complex numbers on the Math04 final examination. Since students did poorly on all of the material related to complex numbers, this was a content area which needs improvement. Other content areas of the Math 04 curriculum which can use improvement were radical expressions and equations, graphing linear functions, quadratic equations and functions, solving compound inequalities and simplifying rational expressions.

RECOMMENDATIONS

This study was undertaken to determine which content areas of the Math 09, Math 03 and Math 04 curriculum were the most in need of improvement and decide what could be done to improve instruction in these areas. However, there were too many areas of the curriculum which needed improvement to successfully improve all of those areas. Instead it is suggested that the Virginia Western Mathematics Department focus on the content areas in each course which had the largest number of questions missed by over 50% of students. The content areas that contained the largest number of questions answered incorrectly by over 50% of students are areas of the curriculum and instruction in need of improvement and by focusing on a smaller number of content areas it is more likely improvement will occur.

In the Math 09 curriculum it is suggested that the Virginia Western Mathematics Department focus on the content areas of decimals, fractions and solving equations

containing decimals and fractions. These content areas were the ones found to be most in need of improvement. It is recommended that departmental meetings be held to discuss ways of enhancing the Math 09 curriculum and instruction so that students perform better on future examinations. If possible allotting more time to be spent throughout the course on decimals, fractions and equations containing decimals and fractions as well as various instructional activities based upon these content areas will be beneficial to students.

To improve the Math 03 curriculum it is suggested the Virginia Western Mathematics Department focus on the content areas of graphing linear equations in two variables, solving quadratic equations, operations with polynomial expressions and factoring the greatest common factor out of a polynomial expression. These were the content areas that were found to be the most in need of enhancement. The content areas of graphing linear equation in two variables and solving quadratic equations should have particular attention paid to them. Attention should be paid to graphing linear equations in two variables because the greatest number of questions missed by over 50% of students came from this content area. Solving quadratic equations should be considered carefully because all of the questions related to this topic on the Math 09 final examination were questions missed by over 50% of the students. It is again suggested that the Virginia Western Mathematics Department hold meetings to determine the best methods for improving the Math 03 curriculum and instruction in these content areas. While spending more time on these content areas would be beneficial it is clear that more needs to be done especially on graphing linear equations in two variables.

Improving the Math 04 curriculum and instruction is going to be a more difficult undertaking than improving the Math 09 and Math 03 curriculums. This is partially due

to the number of concepts on which over 50% of students answered incorrectly and partially due to the number of content areas from only one question. It is recommended that the content areas graphing linear equations in two variables, solving quadratic equations and functions, radical expressions and equations and complex numbers be the content areas of the Math 04 curriculum and instruction where enhancement is sought. Graphing linear equations in two variables was a content area in both the Math 03 and Math 04 curriculums which had over 50% of students missing questions. This is clearly a general area of weakness for the developmental mathematics courses at Virginia Western Community College. It is recommended that department meetings be held to discuss this one content area for both the Math 03 and Math 04 courses. It is also recommend that meetings be held to address how the other content areas solving quadratic equations and functions, radical expressions and equations and complex numbers can be improved.

After considering the pass rates on final examinations for each of the developmental courses at Virginia Western, it is clear that a training program may be necessary to assist developmental mathematics students in their approach to taking developmental mathematics courses. One method for doing this is to have students undergo a training program based upon the traits of successful developmental students (Higbee & Thomas, 1999). The program would present students with ways of being successful in a developmental mathematics course. Students could be taken through the process of designing, scheduling and implementing a plan of study for a test (Higbee & Thomas, 1999). Students could also be shown all of the possible resources for receiving help when problems understanding the curriculum occur. Other possible topics which might be covered include the following: the importance of attending each class, the

importance of completing homework assignments, how to effectively complete homework assignments, how to identify areas of misunderstanding, seeking assistance when studying for a test and how to effectively study for a test.

The success of Virginia Western developmental mathematics students is in part the dependent upon the curriculum and instruction given in developmental mathematics courses. Based upon the final examinations of developmental courses, this study found areas of the Math 09, Math 03 and Math 04 curriculum and instruction which were in need of enhancement. Recommendations for improving these areas included more time being spent on the problem content areas and departmental meetings to decide on the best ways of improving curriculum and instruction in these content areas. Further studies may be necessary to more clearly establish augmentations to the developmental curriculums which will benefit students and cause them to be more successful.

REFERENCES

Ajose, S. (1978). A review of research on the effectiveness of remedial mathematics programs in two year colleges. *ERIC Document Reproduction Service No. ED164017.*

American Mathematical Association of Two-Year Colleges (AMATYC) (2007). *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College.* American Mathematical Association of Two-Year Colleges. Retrieved February 27, 2009, from http://www.amatyc.org/Crossroads/CRRV6/BC_V6_home.htm.

Fike, D. & Fike, R. (2007). Does faculty employment status impact developmental mathematics outcomes? *Journal of Developmental Education,* 31(1), 2-11.

Eades, C. & Moore, W. (2007). Ideas in practice: Strategic note taking in developmental mathematic. *Journal of Developmental Education,* 31(2), 18-26.

Friedlander, J. (1979). Developmental mathematics. *Junior College Research Review. ERIC,* 2-6.

Hall, M. & Ponton, M. (2005). Mathematics self-efficacy of college freshman. *Journal of Developmental Education,* 28(3), 26-33.

Higbee, J. & Thomas, P. (1999). Affective and cognitive factors related to mathematics achievement. *Journal of Developmental Education,* 23(1), 8-16, 32.

Jacobson, E. (2006). Computer homework effectiveness in developmental mathematics. *Journal of Developmental Education,* 29(3), 2-8.

Johnson, M. & Kuennen, E. (2004). Delaying developmental mathematics: The characteristics and costs. *Journal of Developmental Education,* 28(2), 24-29.

Johnson, P. (2007). What are we developing? A case study of a college mathematics program. *School Science and Mathematics,* 107(7), 279-292.

Kinney, P. (2001). Developmental theory: Application in a developmental mathematics program. *Journal of Developmental Education,* 25(2), 10-18, 34.

Kull, K. (1999). A developmental education survey: Results of a national survey of program design and mathematical instruction. *Research and Teaching in Developmental Education,* 16(1), 57-80.

Lesik, S. (2007). Do developmental mathematics programs have a causal impact on student retention? An application of discrete-time survival and regression-discontinuity analysis. *Research in Higher Education,* 48(5), 583-608.

Li, Q. & Edmonds, K. (2005). Mathematics and at-risk adult learners: Would technology help? *Journal of Research on Technology in Education,* 38(2), 143-166.

Lindberg, K. (1976), Preparatory mathematics programs in departments of mathematics. *Unpublished Paper.* Wayne State University, Detroit.

MacDonald, L. Vasquez, S. & Caverly, D. (2002). Techtalk: Effective technology use in developmental mathematics. *Journal of Developmental Education*, 26(2), 36, 37.

McCabe, R. H. (2000). No one to waste: A report to public decision-makers and community college leaders. Washington, DC: Community College Press.

McDonald, A. (1988). Developmental mathematics instruction: Results of a national survey. *Journal of Developmental Education*, 12(1), 8-15.

Miles, C. (2000). Developmental mathematics traditions and alternatives: An interview with Bob Hackoworth. *Journal of Developmental Education,* 23(3), 20.

National Center for Educational Statistics. (2004) Indicator 18: Remediation and degree completion. *The Condition of Education 2004*. U.S. Department of Education.

O'Connor, W. & Morrison, T. (1997). Do remedial mathematics programmes improve students' mathematical ability? *Studies in Educational Evaluation,* 23, 201-207.

Penny, M. & White, J. (1998). Developmental mathematics students' performance: Impact of faculty and student characteristics. *Journal of Developmental Education,* 22(2), 2-12.

Schwartz, A. (2007). New Standards for Improving Two-Year Mathematics Instruction. *Education Digest: Essential Readings Condensed for Quick Review*, *73*(2), 39-42.

Seon, Y., & King, R., (1997). Study Skills Can Make a Major Difference. *Unpublished Paper,* Prince George's Community College.

Stein, S. (1976). Mathematics for the captured student. *Two Year College Mathematics Journal,* 4(3), 62-71.

Testone, S. (2005). Using publisher resources to assist developmental mathematics students. *Research and Teaching in Developmental Education,* 21(2).

Umoh, U. & Eddy, J. (1994). Factors related to student retention in community college developmental education mathematics. *Community College Review,* 22(2), 37 Retrieved February 3, 2009 from Teacher Reference Center database.

Virginia Western Community College (2008). *Virginia Western Community College General Catalog 2008-2009.*

Virginia Western Community College Math Department (2005-2009). *Internal Department Course Statistics*.

Waycaster, P. (2001). Faactors impacting success in community college developmental mathematics courses and subsequent courses. *Community College Journal of Research & Practice*, 25: 403-416.

Wright, G., Wright, R., & Lamb, C. (2002). Developmental mathematics education and supplemental instruction: Pondering the potential. *Journal of Developmental Education,* 26(1), 30-35.

APPENDIX A

Table 7.1. Test Matrix for Math 03 Exam

Question Number	Content Area	Subtopic
1	Solving Linear Equations in One Variable	4-Step Equation
2	Solving Linear Equations in One Variable	3-Step Equation
3	Solving Equations	Literal Equation
4	Algebraic Expressions and Equations	Problem Solving/Representing a Situation with an Algebraic Expression
5	Algebraic Expressions and Equations	Problem Solving/Representing a Situation with an Algebraic Equation
6	Solving Inequalities in One Variable	3-Step Inequality
7	Solving Inequalities in One Variable	1-Step Inequality/Dividing by a negative number
8	Graphing Linear Equations in Two Variables	Find the Slope Between Two Points
9	Graphing Linear Equations in Two Variables	Find the Slope Between Two Points
10	Graphing Linear Equations in Two Variables	Parallel Lines
11	Graphing Linear Equations in Two Variables	Graphing an Equation of the form $ax + by = c$
12	Graphing Linear Equations in Two Variables	Graphing an Equation of the form $y = mx$
13	Graphing Linear Equations in Two Variables	Find the Equation of a Perpendicular Line Passing Through a Given Point
14	Graphing Linear Equations in Two Variables	Find the Equation of a Line Given its Slope and a Point it passes through
15	Graphing Linear Equations in Two Variables	Find the Equation of a Line Given its Slope and a Point it passes through
16	Exponents and Polynomials	Interpreting Negative Exponents
17	Exponents and Polynomials	Raising Monomials to Powers and Multiplying Monomials

Question Number	Content Area	Subtopic
18	Exponents and Polynomials	Interpreting Negative Exponents (only variable expression)
19	Exponents and Polynomials	Multiplying and Dividing Monomials
20	Exponents and Polynomials	Scientific Notation
21	Exponents and Polynomials	Subtracting Polynomials
22	Exponents and Polynomials	Multiplying two Binomials
23	Exponents and Polynomials	Multiplying a Binomial and a Trinomial
24	Exponents and Polynomials	Dividing Polynomials
25	Factoring Polynomials	Greatest Common Factor
26	Factoring Polynomials	Factoring through Grouping
27	Factoring Polynomials	Difference of Squares
28	Factoring Polynomials	A Trinomial of the form $x^2 + bx + c$
29	Factoring Polynomials	A Trinomial of the form $ax^2 + bx + c$
30	Factoring Polynomials	Greatest Common Factor and A Perfect Square Trinomial
31	Solving Quadratic Equations	Factorable Quadratic of the form $ax^2 + bx = 0$
32	Solving Quadratic Equations	Factorable Quadratic of the form $ax^2 + bx = c$
33	Rational Expression	Dividing a Polynomial by a Monomial
34	Rational Expression	Multiplying Two Rational Expressions
35	Geometry	Two Parallel Lines Cut by a Transversal
36	Geometry	Complementary and Supplementary Angles
37	Geometry	Vertical Angles

(Table 7.1 continued)

Question Number	Content Area	Subtopic
38	Geometry	Finding Angle Measures/Isosceles Triangles

(Table 7.1 continued)

APPENDIX B

Table 7.2. Test Matrix for Math 04 Exam

Question Number	Content Area	Subtopic
1	Solving Compound Inequalities	Absolute Value Inequality
2	Rational Functions	Finding Vertical Asymptotes
3	Simplifying Rational Expressions	Dividing Rational Expressions
4	Simplifying Rational Expressions	Subtracting Rational Expressions Unlike Denominators
5	Simplifying Rational Expressions	Complex Fraction
6	Solving Equations	Literal Equation
7	Graphing Quadratic Functions	Transformational Graphing
8	Quadratic Functions	Substitution/Evaluating
9	Radical Expressions	Evaluating Rational Exponents
10	Radical Equations	Solving Radical Equations
11	Systems of Linear Equations	Solve the System
12	Systems of Linear Equations	Solve the System
13	Linear Equations in Two Variables	Find the Slope of a Line Given Two Points
14	Linear Equations in Two Variables	Find the Equation of a Line Given a Slope and a Point
15	Linear Equations in Two Variables	Perpendicular Lines
16	Linear Equations in Two Variables	Graph the Line
17	Linear Inequalities in Two Variables	Graph the Inequality

Question Number	Content Area	Subtopic
18	Radical Expressions	Rationalizing the Denominator and/or Simplifying a Radical
19	Radical Expressions	Simplifying a Cube Root
20	Radical Expressions	Simplifying a Radical Expressions
21	Radical Expressions	Rationalizing the Denominator
22	Complex Numbers (Imaginary Part)	Complex Conjugates
23	Complex Numbers (Imaginary Part)	Simplifying and Adding Complex Numbers
24	Radical Equations	Solving a Square Root Equation
25	Solving Quadratic Equations	Square Root Method to Solve
26	Solving Quadratic Equations	Quadratic Formula
27	Factoring Binomials	Perfect Square Trinomials
28	Quadratic Functions	Graphing Quadratic Functions
29	Geometry	Similar Triangles
30	Geometry	Right Triangles Pythagorean Theorem
31	Geometry	Triangle Congruence
32	Geometry	Find the Volume of a Cylinder
33	Systems of Linear Equations	Application Problem
34	Systems of Linear Equations	Application Problem

(Table 7.2 continued)

APPENDIX C

Table 7.3. Test Matrix for Math 09 Exam

Question Number	Content Area	Subtopic
1	Whole Numbers	Dividing Whole Numbers
2	Solving Linear Equations in One Variable	1-Step Equation
3	Integers/Exponents	Evaluating an Integer Expression with Exponents
4	Integers/Order of Operations	Evaluating an Integer Expression using the Order of Operations
5	Integers/Order of Operations	Evaluating an Integer Expression using the Order of Operations (fraction bar)
6	Solving Linear Equations in One Variable	2-Step Equation
7	Solving Linear Equations in One Variable	1-Step Equation
8	Problem Solving	Using Algebraic Expressions to Represent a Problem Situation
9	Substitution	Substitution Involving Integers and Exponents
10	Polynomials	Combining Like Terms
11	Polynomials	Distributive Property
12	Polynomials	Determining Coefficients
13	Solving Linear Equations in One Variable	3-Step Equation
14	Fractions and Decimals	Changing a Fraction to a Decimal
15	Fractions	Simplify a Fraction with Variables
16	Fractions	Multiplying Fractions
17	Fractions	Dividing Fractions

Question Number	Content Area	Subtopic
18	Fractions	Subtracting Fractions
19	Fractions	Subtracting Fractions Containing Variables
20	Solving Linear Equations in One Variable	3-Step Equation Involving Fractions
21	Solving Linear Equations in One Variable	3-Step Equation Involving Fractions
22	Unit Conversion	Metric Conversions
23	Proportions	Solving an Proportion Equation
24	Solving Linear Equations in One Variable	1-Step Equation Involving Decimals
25	Percent	Finding the percent of a number
26	Square Roots	Simplifying Radical Expressions (Subtraction)
27	Decimals	Rounding Decimals
28	Fractions, Decimals and Percents	Change a fraction to a decimal
29	Fractions, Decimals and Percents	Change a percent to a decimal
30	Perimeter and Area	Find the Perimeter and Area of a Rectangle
31	Decimals/Order of Operations	Evaluating a Decimal Expression using the Order of Operations
32	Decimals	Dividing Decimals
33	Mean, Median and Mode	Find the Mean of a Data Set

(Table 7.3 continued)