Examining student achievement and interventions for underprepared vocational math students

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Examining student achievement and interventions for underprepared vocational math students

by

Diane K. Hargens

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Education (Educational Leadership)

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Iowa State University
Ames, Iowa
2013
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ABSTRACT

Math preparedness is a barrier to completion for many community college vocational students. With President Obama’s (2010) challenge to produce more graduates in order to ensure our nation succeeds in the 21st century, community colleges across the country have an increased focus on graduation or completion. This study was conducted to provide guidance to community college administrators, advisors, and faculty as they assist underprepared vocational math students become successful and graduate.

This study examined the characteristics of vocational math students who scored as underprepared on a college entrance examination for arithmetic as determined by the community college in this study. These underprepared vocational math students were then categorized into three levels of preparedness based on their entrance exam score and into career cluster areas based on their declared major. Analyses were conducted to examine the differences in the academic success among the three groups of students determined by level of math deficiency and among the career cluster groups based on majors.

Finally, this study investigated to what extent the success of underprepared vocational math students could be predicted by student characteristics such as age, gender, socioeconomic status, level of deficiency in math preparedness as well as interventions such as successfully completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participation in a consistent student support program.

Using an ex post facto quantitative research design and data from underprepared vocational math students enrolled in a midwestern community college from 2007–2012, this study employed descriptive statistics, analysis of variance, multinomial and binomial hierarchical logistic regression analyses.
CHAPTER 1. INTRODUCTION

Throughout the history of higher education in the United States, there have been concerns about access to higher education. These concerns have been addressed through many governmental programs including grants, student aid programs, the World War II G.I. Bill, and the 1965 Higher Education Act. Admissions policies at community colleges also have helped underserved students to access higher education. Community colleges are especially committed to access, having open-door policies that admit students who may be turned away from other institutions of higher education because they are underprepared for college-level work.

In the spring of 2010, Brock published an article in The Future of Children titled “Young Adults and Higher Education: Barriers and Breakthroughs to Success.” In this article, Brock stated, “Although access to higher education has increased substantially over the past forty years, student success in college—as measured by persistence and degree attainment—has not improved at all” (p. 109). Even though many barriers have been removed from students accessing higher education, the success of students accessing higher education is a great concern. A great deal of taxpayer support is spent on providing access to education.

In August of 2010, President Obama challenged the United States to produce 8 million more graduates by 2020 in order to ensure this nation succeeds in the 21st century. Many of the jobs of the 21st century require workforce training or higher education. President Obama stated making sure every one of this nation’s young people had the best education the world had to offer was “the single most important step we can take” to ensure the nation succeeds in the 21st century. President Obama wanted to make sure “our
graduates are ready for a career” (para. 21). In order to be ready for a career, students need to complete their education (or persist) and graduate. President Obama asked community colleges to increase the number of students earning associate degrees and certificates by 5 million. If community colleges are responsible for increasing the number of students earning associate’s degrees and certificates by 5 million, it would mean community colleges will be responsible for 60% of the graduates needed to reach the goal of 8 million college graduates by 2020. As a result, persistence and degree attainment has become the focus of community colleges across the nation.

Community colleges are critical for access to education. In looking at the history of community colleges, Koos studied community colleges (or junior colleges as some were called at that time) in the 1920s. Koos (1925) identified the following 10 points that captured the purpose and advantages of junior colleges:

- To give the first two years in curricula in (a) liberal arts and (b) preprofessional and professional work (where these professional curricula begin with the first college years).
- To assure instruction as good as or better than that on the same level in other higher education institutions.
- To provide terminal general education for those who cannot or should not go on to higher levels of training.
- To develop lines of semiprofessional training.
- To popularize higher education.
- To make possible the extension of home influences during immaturity.
- To afford more attention to the individual student.
• To improve the opportunities for laboratory practice in leadership.

• To foster the inevitable reorganization of secondary and higher education.

• To bring together into a single institution all work essentially similar in order to effect a better organization of courses and remove wasteful duplication.

As demonstrated in these 10 points, community colleges served a wide variety of needs and were truly comprehensive in nature. Boggs, in a 2004 article in *Change* Magazine, titled “Community Colleges in a Perfect Storm,” stated: “In the 100 years since their creation, these colleges have spread across the United States to become the largest sector of higher education, representing nearly 1,200 regionally accredited institutions within commuting distance of over 90% of the population” (p. 7). Community colleges fill a great need and provide access within commuting distance to students who otherwise may not have access. Community colleges are accessible in terms of cost, location, and their ability to serve the underprepared and underserved.

In addition to community colleges being comprehensive, they are also reflective of, and responsive to, their local communities. Many community colleges focus on providing skilled workers for the local workforce. They provide career technical education (vocational) programs that provide the training to make sure graduates are ready for a technical/vocational career. Community colleges play a critical role in the security and well-being of those communities, educating close to 60% of new nurses and 80% of firefighters, law enforcement officers, and other first responders (Boggs, 2004). Community colleges clearly are the economic engine that can ensure the nation succeeds in the 21st century.

Although community colleges have broken down the barriers to access for many Americans, the nation still battles the barriers to completion. One of those barriers to
completion of a community college degree is the level of preparedness of students. Statistics from the National Assessment of Adult Literacy (National Center for Education Statistics [NCES], n.d.b) from 2003 showed only 13% of adults age 16 and over were proficient in quantitative reasoning (Kutner, Greenberg, & Baer, 2005). A deficiency in quantitative reasoning (in many cases the ability to calculate simple addition, subtraction, multiplication, or division equations) is a barrier to graduation and program completion.

The U.S. Congress mandated the National Center for Education Statistics (NCES) produce an annual report, *The Condition of Education*. This report presents annual indicators of important developments and trends in U.S. education. The indicators focus on participation and persistence in education, student performance and other measures of achievement, the environment for learning, and resources for education. The NCES (2011) reported the National Assessment of Education Progress (NAEP) mathematics scaled score for 12th grade students in 2009 indicated 36% of 12th grade students scored below basic, 38% scored basic, 23% scored proficient, and only 3% scored as advanced (see Figure 1.1). “Basic” indicates partial mastery of fundamental skills, “proficient” indicates demonstration of competency, and advanced indicates superior performance. This means only 26% of the 12th grade students scored as demonstrating competency or above. Many of those 26% of students who were competent enrolled in 4-year universities, which left a large majority of students who were not competent in mathematics entering 2-year institutions or community colleges.

The NCES (2011) report also showed that when comparing Iowa students with the nation, the percentage of students at the advanced and proficient levels were not significantly
different. However, Iowa students had a lower percentage in the below basic level and a higher percentage at the basic level when compared with the nation.

The number of students entering college who do not have college level math skills has reached epidemic proportions. In fact, in a U.S. Department of Education report, Noel-Levitz (2006) reported nearly 75% of students entering 2-year colleges have low math scores. Even worse, one midwestern community college, described later in this study, examined the test scores of vocational math students who had registered for a developmental math course during the Fall of 2006. Of the 161 underprepared students who registered for the developmental math course, only 22 of those students eventually graduated within 4 years with a 2-year degree (Volk, Huffman, & Obermeyer, 2011). Four years is twice the amount of time students anticipate working toward graduation earning a 2-year degree. It is four
times longer than students anticipate working toward graduation earning a 1-year vocational diploma. It is clear that underprepared vocational math students can easily become discouraged and ultimately leave college without a degree.

A great deal of time, money, and effort is being spent trying to help underprepared vocational math students graduate. Providing the training and assistance necessary to help these students graduate will help ensure the nation succeeds in the 21st century.

**Problem**

With a large majority of students entering 2-year public institutions underprepared in mathematics, there is an urgent need to examine what can be done to assist these students in their academic success. Academic success, or higher education, is necessary to make sure young people have the skills necessary to graduate and succeed in the workforce.

Community colleges need to retain and graduate underprepared vocational math students. The overall retention rate for the Fall of 2009 cohort of students at public 2-year institutions was 60% for full-time students and 40% for part-time students, and the overall graduation rate was only 21%—all within 150% of normal time to complete (NCES, 2011). For a 2-year degree, 150% of normal time would mean the students would graduate within three years.

The graduation rate at community colleges has deteriorated. For the cohort of students enrolled in 1999 at all 2-year institutions, the completion rate was 29% compared to 27% in 2009 (NCES, 2011). The problem has gotten worse over the last 10 years. Assisting underprepared vocational math students persist and graduate will not only help the United States accomplish the goal of graduation and completion to ensure the nation succeeds in the
21st century, it will also help each student become employable. This, in turn, will allow the graduates to support their families.

**Purpose**

By analyzing the data from students who tested as underprepared in math, community college educators will be able to better understand how they can provide support so these students can persist and graduate. The purpose of this study was to examine the characteristics of students who have been identified as underprepared vocational math students in a midwestern community college. These characteristics included age, gender, ethnicity/race, socioeconomic status, declared major, and arithmetic entrance assessment score.

Once the arithmetic entrance assessment scores were identified, the level of the deficiency of the math preparedness was determined in order to evaluate if there were differences in these students’ success depending on the level of the deficiency. Based on a set score that was determined by the community college in this study to be necessary for success, the level of proficiency in math preparedness was determined. Based on the size of the gap in the deficiency, underprepared students were then divided into three categories: slightly underprepared, moderately underprepared, and severely underprepared. (See Definition of Terms for further clarification of student preparation levels.) The success of the students (as determined by their grades in MAT 772 – Applied Math course) was examined to determine if there was a significant difference in the academic success among the students who were slightly underprepared, moderately underprepared, and severely underprepared. MAT 772 – Applied Math was the lowest level math course that would qualify to fulfill the required math course for graduation in any vocational program at the
community college in this study. Pascarella and Terenzini (2005) found that, even though grades had their limitations, “college grades may well be the single best predictor” of student persistence and degree completion (p. 396).

This study then examined the underprepared vocational math students’ major plan of study and classified the students into 16 “Career Clusters™” as identified by the National Association of State Directors of Career Technical Education Consortium (NADCTEc, 2012). Student success was evaluated to determine if there were differences in success depending on students’ declared majors as defined by Career Cluster.

Finally, this study examined the demographic variables and various methods of intervention available at the community college in this study to assist the underprepared vocational math students in achieving success such as successfully completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participating in a consistent student support program. The student characteristics of age, gender, socioeconomic status, and level of math deficiency were analyzed along with the intervention variables of successfully completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participating in a consistent student support program to attempt to predict what type of outcome or level of academic success a student was likely to achieve. This study then tried to determine the strength of influence these characteristics and interventions have upon the level of academic success.

The findings of this study provide important information to assist educators support students who struggle with math. Supporting these students will help them persist and complete their program of study. Helping these underprepared vocational math students
graduate will help ensure the nation succeeds in the 21st century. McClenney (2004) explained, “The plain truth of the matter is that if students don’t succeed in developmental education, they simply won’t have the opportunity to succeed anywhere else” (p. 15).

**Research Questions**

The following research questions served as the focus of this study:

1. What are the characteristics of this study’s underprepared vocational math students such as age, gender, ethnicity/race, socioeconomic status, declared major of study, and level of deficiency in math preparedness based on the entrance assessment arithmetic scores?

2. Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the level of the deficiency in math as described by slightly underprepared, moderately underprepared, and severely underprepared (based on the entrance assessment arithmetic score)?

3. Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the declared major program of study as classified by Career Cluster?

4. To what extent do student characteristics of age, gender, race/ethnicity, socioeconomic status, level of deficiency in math preparedness based on the entrance assessment arithmetic scores, along with the intervention variables of completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and consistently participating in support services, predict academic success (as determined by the grade earned in the MAT 772 –
Applied Math course) for the underprepared vocational math students in this study?

**Background**

This study examined data from vocational math students enrolled in a publicly supported comprehensive community college in the Midwest. The community college in this study currently serves six counties with a combined population of about 180,000. This community college has a long history of providing programs to answer the needs of the people served in the community, starting with programs such as Dental Assisting, Medical Assisting, Production in Mechanical Draft and Design, and an Office of Occupational Coop (Rocklin, 1999).

Strong and stable leadership has been provided for the community college in this study, which has had only three presidents since its inception. The presidents, along with strong executive teams, have worked hard to make the college academically sound and yet meet the needs of the community. This community college has served not only the businesses and industry in the community, but also the unserved and the underserved population in the community. The community college in this study has operated on the belief that all individuals should be afforded the opportunity to improve the quality of their personal and community life through educational excellence. The current college catalog at the midwestern community college in this study states: “As a comprehensive community college, our mission is to provide quality education and to economically enhance the communities we serve” (Midwestern community college [pseudonym], 2012).

The fall enrollment at the midwestern community college in this study reached the highest enrollment in 2011 with 6,787 credit students. About 90% of the students enrolled in
this community college are from the state in which this community college is located. Approximately 57% of the students are female and 43% male. The average age of the student is 23 years old. The diversity of the students has increased, particularly among Hispanic students, because the area population continues to change. In Fall of 2008, the population of the students at this community college in this study was primarily White/Caucasian with approximately 16% being minority, 9% reporting as being Hispanic.

Many student achievement and learning services are available to students at the midwestern community college in this study. Developmental or remedial math courses are available. The Student Success Center offers staff tutoring, peer tutoring, and supplemental instruction tutoring. Computerized math software is available with the textbook and required to be purchased for the MAT 772 – Applied Math course. Extensive student support services are offered through the Carl Perkins Grant and TRIO programs.

When students apply for admission to community colleges, often they are required to take an assessment test to evaluate their academic skills. The assessment test is generally used to help place students in the appropriate courses. One of the most widely used assessment instruments used for placement in developmental or remedial courses is ACCUPLACER™ (Gerlaugh, Thompson, Boylan, & Davis, 2007). This test is published by the College Board (2012), and it adjusts the difficulty of follow-up questions based on students’ responses to the previous question. It is a cognitive assessment instrument.

The students in this study completed the College Placement Test (CPT) as their entrance assessment. According to the College Board (2013), this test measures the ability to perform basic arithmetic operations and to solve problems that involve fundamental arithmetic concepts. There are three types of arithmetic questions on the CPT:
• Operations with whole numbers and fractions; topics included in this category are addition, subtraction, multiplication, division, recognizing equivalent fractions and mixed numbers, and estimating.

• Operations with decimals and percentages; topics include addition, subtraction, multiplication, and division with decimals, as well as percentage problems, recognition of decimals, fraction and percentage equivalencies, and problems involving estimation.

• Applications and problem solving; topics include rate, percentage, and measurement problems, simple geometry problems, and distribution of a quantity into its fractional parts.

The scaled score on the CPT represents what the score would be if the test-taker answered 120 questions with a similar competency. For the midwestern community college in this study, the required scaled score needed to be placed, or advised to register, directly in the required vocational math course required for graduation was 57. A score below the scaled score of 57 indicated there was a need for remediation before attempting to complete the required math course.

In order to determine the appropriate required scaled score, the Developmental Education Taskforce formed at the midwestern community college in this study studied the effectiveness of the testing and the course work. The taskforce worked with the Institutional Research Department at the college to track and analyze data about students who had taken developmental courses. The taskforce researched placement scores from other institutions and consulted with the College Board, which provided the ACCUPLACER CPT. The College Board had developed “proficiency statements” that described the knowledge and
skills associated with specific ACCUPLACER ranges of scores by convening a panel of experts in each subject area to describe the knowledge and skills required to answer these items correctly. The College Board (2012) and their panel of experts recommended that students with a scaled score of about 57 had basic arithmetic skills and could:

- perform the basic arithmetic operations of addition, subtraction, multiplication, and division using whole numbers, fractions, decimals, and mixed numbers and
- make conversions among fractions, decimals, and percentages.

The taskforce, along with the math department faculty, determined the required scores recommended for success for each math course. For the MAT 772 – Applied Math course, a scaled score of 57 on the arithmetic CPT was recommended. An underprepared vocational math student, for this study, was defined as a student in a career and technical (vocational) program who earned a scaled score below 57 on the arithmetic CPT.

Developmental or remedial math courses are designed to help students improve their math skills before registering for the college-level math courses required for graduation in their program. At some institutions, students are required to enroll in the course to which they are assigned based on their placement test scores. In other institutions, students are free to enroll in the classes they select regardless of their entrance exam scores; even if their previous academic history indicates they should complete developmental education (Price & Roberts, 2008).

The policy at the midwestern community college in this study was to advise students who earn a scaled score of 56 or less on the arithmetic CPT to take a developmental or remedial mathematics course. The practice in place at this community college was to advise underprepared students to take the developmental math course, MAT 041--Basic Math.
However, students who scored below the required scaled score of 57 on the arithmetic CPT were given an option to sign an “Assumption of Responsibility” form. By signing this form, students acknowledge they have been advised to take the remedial math course prior to enrolling in MAT 772 – Applied Math and, if they decide not to take the remedial course, they assume all responsibility if they are not successful. Some students who have scored below the required score of 57 on the arithmetic CPT choose to sign the Assumption of Responsibility form and bypass the remedial or developmental course.

**Significance**

It is clear that many students come to community colleges academically underprepared. In order to help students succeed, community college administrators need to understand the correlations associated with student academic success and the underprepared math student. Factors such as student characteristics, the level of the deficiency in math preparedness, the major program of study, successfully completing a remedial math course, utilizing tutoring services, utilizing computer-aided math software, and participating in a consistent student support program all need to be considered by community college administrators when striving to meet the needs of a diverse student population.

Community college policymakers are ultimately the ones who can decide policy changes and admission practices to enhance the community college learning experience for the population of students underprepared in math. Policies such as requiring students to take a developmental math course, offering an Assumption of Responsibility form, requiring tutoring, requiring computer-aided math software, and providing support services need to be revisited. The ultimate success of the underprepared vocational math students will help
students persist and graduate, thereby accomplishing President Obama’s (2010) goal of increasing community college graduates by 5 million by the year 2020.

**Theoretical Perspective**

As a researcher focused on student success with potential support or interventions for vocational students underprepared in math in community colleges, it was important to identify the factors that would potentially be predictive of student success in persisting toward their academic goals. Astin’s (1993) input–environment–output (I–E–O) model provided the conceptual framework to organize and study the data (see Figure 1.2). It was critical to identify the variables and establish a research-based policy for supporting underprepared vocational math students.

The fundamental premise of Astin’s (1993) I–E–O model is that students have pre-existing characteristics or inputs (I) and their persistence is impacted by who they were before they entered college. The consideration of input characteristics when assessing student success helps in understanding the influence of students’ backgrounds and characteristics on their ability to persist to graduation. The environment (E) is what takes place while the student is in college. Student development or growth occurs as a result of the interaction between a student and the institutional environment. The present study modified Astin’s (1993) model. In this study, the environment (E) refers to the various interventions available to students to assist them with their academic success. This interaction is influenced by the characteristics of the student and the environment. The final component of Astin’s (1993) model is output (O) or outcome. Outcome variables need to be pre-determined and measurable. Astin’s (1993) model was developed to produce useful results for implementing educational practices and for deriving educational policy.
In this study, the input data available for the underprepared vocational math students were age, gender, ethnicity/race, socioeconomic status, declared major, and CPT arithmetic scaled scores. The CPT arithmetic scaled scores were then categorized into three levels of preparedness (slightly underprepared, moderately underprepared, and severely underprepared. The declared major programs of study were then categorized into the 16 “Career Clusters™” as identified by the National Association of State Directors of Career Technical Education Consortium (NADCTEc, 2012).

The environment component in this study consisted of the interventions available to underprepared vocational math students such as completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and consistently participating in support services.

*Figure 1.2. Concept map of underprepared vocational math student success.*
The output in this study included academic success and persistence based on the grade earned in the MAT 772 – Applied Math course. Academic success can be defined in different ways. Hagedorn and colleagues (Hagedorn 2005; Hagedorn & Cepeda, 2004; Hagedorn, Maxwell, & Hampton, 2002) used course completion when defining persistence in multiple studies of community college students. Course completion was defined as courses in which students enrolled and did not drop prior to the add/drop deadline, and in which they received a course grade of A, B, C, or P (pass). This definition is very applicable in the community college setting and is appropriate for measuring success in adult populations (Spanard, 1990). The definition of academic success for this study was based on the grade earned in the MAT 772 – Applied Math course, the minimum level math course required for graduation in vocational programs.

This model will be discussed more thoroughly in Chapter 2. Even though other models exist, Astin’s (1994) I–E–O model was used because it exemplifies the identification of differentiating multiple variables and their impact on student success. Based on this model, one could hypothesize interventions at the college can change the outcome of academic success and completion of students’ educational goals. In order to assist students in maintaining the goal of graduation, interventions at the college are extremely important.

**Research Design**

This study utilized an *ex post facto* research design. An *ex post facto* study “moves from outcomes to predictors, not from predictors to outcomes” (Light, Singer, & Willett, 1990, p. 135). Using this design, instead of an experimental design, data are collected after the fact because of the complexity of the factors involved and the inability to control all but a single independent variable from the influences of others.
Definitions of Terms

*Computer-aided math software:* for this study, MyMathLab software, which is an interactive online software that accompanies a Pearson Publishing math textbook. It contains multimedia learning aids (such as videos and animations) for selected examples and exercises in the text. Students can take tests in MyMathLab that generate a personalized study plan with links to practice exercises for the topics they need to study.

*CPT (Computerized Placement Test):* a College Board ACCUPLACER test designed to facilitate the evaluation and placement of college students. This test measures a student’s ability to perform basic arithmetic operations and to solve problems that involve fundamental arithmetic concepts.

*Developmental math course:* a math course below the level of a course that can be applied toward graduation. Often referred to as a remedial course, the intent of a developmental course is to raise a student’s skills to college level.

*MAT 772 – Applied Math:* the minimum required mathematics course for a vocational student at the community college in this study. Upon completion of this course, students should be able to:

- Use basic measuring devices;
- Express word statements as mathematical expressions;
- Evaluate numbers expressed in scientific notation;
- Convert measures within and between English and metric units;
- Perform arithmetic operations with English and metric units;
- Use ratios and direct/inverse proportions to solve application problems;
• Perform signed number operations;
• Use basic algebraic operations to evaluate algebraic expressions;
• Use equations to solve application problems;
• Apply angular measures and identify types of angles;
• Solve problems such as perimeter, area, volume, radius, circumference, and arcs; and
• Interpret data from graphs and express data in graphical form.

Remediation: activities designed to assist students in overcoming academic deficiencies. For this study the term remediation is used interchangeably with “developmental.”

Required math course: a general education course required by the community college in this study to meet the state requirements for general education. The required math course is the minimum level math course needed to graduate with any vocational degree at this community college.

Scaled score: indicates what the score would have been if the test-taker answered 120 questions with similar competency.

Student preparation levels:

Slightly underprepared: students who earned a scaled score of 31–45 on the arithmetic CPT. According to the College Board (2012),

Students at this level have basic arithmetic skills and can:

• perform the basic arithmetic operations of addition, subtraction, multiplication, and division using whole numbers, fractions, decimals, and mixed numbers; and
• make conversions among fractions, decimals, and percentages. (p. 12)

Moderately underprepared: students who earned a scaled score of 46–56 on the arithmetic CPT. According to the College Board (2012):
Students at this level have minimal arithmetic skills and can:

- perform simple operations with whole numbers and decimals (addition, subtraction, and multiplication);
- calculate an average, given integer values;
- solve simple word problems; and
- identify data represented by simple graphs. (p. 12).

Severely underprepared: students who earned a scaled score of 20–30 on the arithmetic CPT. According to the College Board (2012), students at this level do not have minimal arithmetic skills and cannot:

- perform simple operations with whole numbers and decimals (addition, subtraction, and multiplication);
- calculate an average, given integer values;
- solve simple word problems; or
- identify data represented by simple graphs.

Student support program: a program designed to provide guidance and encouragement needed to successfully graduate. Services include academic advising, tutoring, informational workshops, career exploration and planning, and social outings.

Students in the TRIO student support services program at the community college in this study are required to:

- Attend TRIO orientation;
- Meet with a TRIO advisor a minimum of three times a semester to “check in”;

Severely underprepared: students who earned a scaled score of 20–30 on the arithmetic CPT. According to the College Board (2012), students at this level do not have minimal arithmetic skills and cannot:

- perform simple operations with whole numbers and decimals (addition, subtraction, and multiplication);
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- perform simple operations with whole numbers and decimals (addition, subtraction, and multiplication);
- calculate an average, given integer values;
- solve simple word problems; or
- identify data represented by simple graphs.
- Attend a financial aid workshop first semester, then one more workshop per semester;
- Attend one cultural activity/event or campus visit per year; and
- Maintain a 2.0 cumulative grade point average.

*Tutoring:* small group or one-on-one intensive review of material covered in a course through a leader or tutor. This includes peer tutors and supplemental instruction (SI) where the leaders or model students attend all classes, take notes, and do class assignments.

*Underprepared vocational math student:* a student who registered for the required vocational math course for graduation (MAT 772 – Applied Math) and earned a scaled score of 56 or lower on the arithmetic CPT.

**Summary**

This study attempted to provide guidance to community college administrators, advisors, and faculty to assist underprepared vocational math students to be successful and complete their degree. Community college administrators need to understand how they can best provide support to students who struggle with math, because students who struggle with math often do not persist or graduate. Advisors need to understand how they can best advise underprepared vocational math students. Faculty need to examine the effectiveness of utilizing computer-aided math software and other interventions available to underprepared vocational math students. This study attempted to add to the academic research relative to college completion by focusing on vocational students underprepared in math at community colleges.
Chapter 1 provides an overview of the topic along with the problem and purpose of the study. The research questions were identified, the background of the community college in this study was discussed, and the significance of the study was identified. The conceptual framework that guided this study was identified. Finally, the research design was identified along with the definitions of terms used in the study.

Chapter 2 provides related research on underprepared vocational math students. It begins with an overview of the history of remedial education and college readiness. Characteristics of underprepared students and of developmental math students are identified. The effect of factors of socioeconomic status and level of math preparedness are examined as they relate to academic success. National Career Clusters, as developed by the NADCTEc (2012), were identified based on the students’ declared major of study. Chapter 2 then presents an investigation of the success of interventions such as completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participating in a consistent student services program. Finally, Chapter 2 concludes by examining the framework for this study and emerging practices to assist underprepared math students achieve success.

Chapter 3 presents the methodology used in this study. Hypotheses are identified. The methodological approach is laid out along with the data sources and sample selection. The variables and their coding are identified along with the procedures and methods for data analysis. Finally, data access and security along with ethical considerations and limitations of the study are identified. Comparative, inferential, and multivariate statistics, including descriptive statistics, analysis of variance (ANOVA), a hierarchical multinomial logistic
regression analysis, and a hierarchical logistic regression analysis, were used to examine the variables impacting vocational students underprepared in math and academic success.

Chapter 4 reports the findings of the study. The findings were based on the methodology laid out in Chapter 3. Chapter 5 presents discussions and conclusions of this study. Included is a summary of the findings, implications for practice, and recommendations for further research.
CHAPTER 2. REVIEW OF THE LITERATURE

Student success depends on many factors. Through a review of literature, several themes were identified that were relevant for this study. First, a brief history of remedial education and the definition of college readiness are explored. Characteristics of underprepared students and developmental math students are examined. The effect of socioeconomic status and level of preparedness factors are examined as they relate to academic success. National Career Clusters, as developed by the NADCTEc (2012), based on students’ declared major of study are identified. This chapter then presents an investigation into the success of interventions such as completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participating in a consistent student support services program. Finally, this chapter concludes by examining the conceptual framework for this study and emerging practices to assist underprepared math students achieve success.

Remedial education and developmental education are words that may have the same meaning for some people. However, Cross (1976) defined them separately. Cross argued that if the purpose of a program was to overcome academic deficiencies, it would be considered remedial; if the purpose was to develop the students, it would be considered developmental. For the purposes of this study’s discussion, whether the term used is remedial or developmental, it refers to academically unprepared for college-level work.

Remedial Education History

Remedial education has been part of higher education for a long time. Breneman and Haarlow (1998) examined the history of remedial education and reported the following:

- Harvard College provided tutors in Latin for incoming students in the 1630s.
• The first remedial program was offered to underprepared students at the University of Wisconsin in 1849 with remedial courses in reading, writing, and arithmetic.

• Junior colleges started to take over remedial education in the 20th century with the passage of the Higher Education Act of 1965, which provided the “open door” to access to higher education.

By the end of the 19th century, more than 40% of first-year students participated in programs that were designed for precollegiate work (Ignash, 1997). Clearly, the need for remedial education has been around for a long time.

Following the passage of the Civil Rights Act of 1964 and the Higher Education Act of 1965, competition increased for students among higher education institutions. Thousands of underprepared students enrolled in higher education from the 1960s to the 1980s because of the open admissions policies and government funding (Payne & Lyman, 1998, as cited by Albert, 2004).

College Readiness

College readiness has been measured in several ways, including transcript analysis (Adelman, 2006) and standardized test scores (ACT, 2005). However, placement decisions could be improved if advisors were able to use more than an initial assessment to place students. They need to look not only at cognitive test scores, but also at affective and personal information about students to develop more integrated intervention plans for underprepared students (Boylan, 2009).

Another measure for college readiness is remedial coursework enrollments. The NCES is the primary federal entity for collecting and analyzing data related to education in the United States and other nations. The NCES is located within the U.S. Department of
Education’s Institute of Education Sciences. The NCES utilized data from the National Postsecondary Student Aid Study (NPSAS) to examine remedial coursetaking. The data were self-reported by students. Self-reporting was used instead of transcript data because transcripts did not indicate whether courses were developmental or remedial (Sparks & Malkus, 2013). Therefore, these data may not have represented the entire need for all remediation. Prior research documented a gap between those who need remediation, those who enroll in remediation, and those who successfully complete remediation (Bailey, Jeong, & Cho, 2010).

The NCSE (Sparks & Malkus, 2013) studied students from Fall of 1995 and declared the following findings:

- Over three-quarters (78%) of higher education institutions that enrolled first-year students in Fall 1995 offered at least one remedial reading, writing, or mathematics course. All public 2-year institutions and almost all (94%) institutions with high minority enrollments offered remedial courses.

- Over one quarter (29%) of first-time first-year students enrolled in at least one remedial reading, writing, or mathematics course in Fall 1995. First-year students were more likely to enroll in a remedial mathematics course than in a remedial reading or writing course, irrespective of institutions attended.

- At most institutions, students do not take remedial courses for extended periods of time. Two-thirds of the institutions indicated that the average time a student took remedial courses was less than one year, 28% one year, and 5% more than one year.

In a very recent report on remedial course taking, released in January 2013 by the NCES, Sparks and Malkus reported that from the 1999–2000 to 2007–2008 academic years, there
was a net drop in the overall percentage of first-year undergraduate students who reported enrollment in remedial courses. Specifically, as shown in Figure 2.1, across all public and private institutions of higher education the percentage of first-year undergraduate students who reported enrollment in remedial coursework was lower in 2007–08 compared to 1999–2000 (20 vs. 26%). The percentage of first-year undergraduate students who reported enrollment in remedial coursework dropped even further for the 2003–04 year down to 19%, but increased some by approximately one percentage point to 20% in 2007–08. The term “first-year” indicates the respondent had accumulated credit hours that correspond to first-year status and does not correspond to the time enrolled in an institution.

Sparks and Malkus (2013) also compared institutional control, level, and selectivity and reported that for the 1999–2000 and 2007–08 academic years, larger percentages of students attending 2-year, public institutions reported enrollment in remedial courses than did those attending 4-year public institutions (1999–2000, 30.4% vs. 25.0%; 2007–08: 24.0 vs. 21.0%, respectively). Compared to 1999–2000, student-reported enrollment percentages in remedial coursework were lower at both 2-year and 4-year public institutions in 2007–08 (2-year: 30.0% vs. 24.0%; 4-year: 25.0% vs. 21.0%, respectively; see Table 2.1).

Table 2.1

<table>
<thead>
<tr>
<th></th>
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<td>17.0</td>
<td>18.8</td>
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<tr>
<td>Open admission</td>
<td>37.1</td>
<td>19.2</td>
<td>25.6</td>
</tr>
</tbody>
</table>


^Selectivity rating is based on whether the institution was open-admission (no minimum requirements), the number of applicants, the number of students admitted, the 25th and 75th percentiles of ACT and/or SAT scores, and whether or not test scores were required. Selectivity only applies to public or private not-for-profit institutions.
Based on the findings by Sparks and Malkus (2013), enrollment in remedial courses dropped for first-year undergraduate students between 1999–2000 and 2007–08 at almost every institution type, based on institutional control, level, and selectivity: (a) all institutions, (b) public institutions (2-year and 4-year), (c) private institutions (not-for-profit and for-profit 2-years or more) (d) very selective, moderately selective, and open admission 4-year institutions. However, for-profit less than 2-year private institutions reported that enrollment in remedial courses rose for first-year undergraduate students between 1999–2000 and 2007–2008.

Demographics of Underprepared Students

According to the NCES report (Sparks & Malkus, 2013), between 1999–2000 and 2007–08 there was an overall drop in remedial course enrollment among all students enrolled in public institutions (28.8 vs. 23.3%, respectively). Also between 1999–2000 and 2007–08 demographic characteristics for students as a whole, such as students’ gender, race/ethnicity, age, parents’ education, and dependency status, changed for students enrolled in remedial courses (see Table 2.2).

Age

With regard to age, between 1999–2000 and 2007–08 the percentage of first-year undergraduate students who reported that they enrolled in remedial courses dropped across all the age groups, but the percentage change wasn’t the same among the different age groups (ages 18 or younger, 24.4 vs. 23.7%; 19–23 years, 31.9 vs. 23.8%; 24–29 years: 34.7 vs. 22.0%; 30–39 years, 29.5 vs. 20.3%; and 40 or older, 24.9 vs. 18.4%, respectively).
### Table 2.2


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<td>19.9</td>
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<td>23.7</td>
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<td>32.2</td>
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<td>18 or younger</td>
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<td>19–23</td>
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<td>24–29</td>
<td>34.7</td>
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<td>30–39</td>
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<td>19.0</td>
<td>20.4</td>
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<td>Dependent students</td>
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<tr>
<td>Independent students</td>
<td>28.5</td>
<td>19.1</td>
<td>20.4</td>
</tr>
</tbody>
</table>

**Note.** Excludes students who attended more than one institution of higher education over the course of the academic year. “First-year” indicates the respondent has accumulated credit hours that correspond to first-year status; the term does not correspond to the time enrolled in an institution. Adapted from “First-Year Undergraduate Remedial Coursetaking: 1999–2000, 2003–04, 2007–08,” by D. Sparks & N. Malkus, 2013, *Statistics in Brief*, p. 2.

<sup>a</sup>Black includes African American, Hispanic includes Latino, and Asian/Pacific Islander includes Native Hawaiian; other includes Native American, Alaska Native and respondents having origins in a race/ethnicity not listed.

<sup>b</sup>Dependency status is federally defined for student aid purposes; a dependent student has access to his or her parents’ financial resources.
**Gender and Race/Ethnicity**

Lower percentages of both male and female students reported enrollment in remedial courses in 1999–2000 than in 2007–08 (28.5 vs. 21.6% for males, and 29.1 vs. 23 24.7% for females). For both males and females, lower percentages of White, Black, Hispanic, Asian/Pacific Islander, and other or two or more races reported taking a remedial course in 2007–08 than in 1999–2000 (Male: White: 24.3 vs. 19.9%; Black: 37.7 vs. 30.2%; Hispanic, 37.8 vs. 29.0%; Asian/Pacific Islander, 34.9 vs. 22.5%, other, or two or more races, 34.4 vs. 27.5%, respectively).

For males, even though lower percentages of race/ethnic groups reported taking remedial courses in 2007–08 compared to 1999–2000, in that time period, the race/ethnic group with the second highest percentage changed (1999–2000: Black, 38.3%; Asian/Pacific Islander, 35.3%; Hispanic, 34.8%; other or two or more races, 32.0%; and White, 24.7%, as compared to in 2007–08: Black, 28.7%; Hispanic, 28.3%; other or two or more races, 21.8%; Asian/Pacific Islander, 20.8%; and White, 18.7%, respectively. The Asian/Pacific Islander male group had the largest drop from 1999–2000 to 2007–08 (35.3 vs. 20.8%, respectively).

For females, even though lower percentages of race/ethnic groups reported taking remedial courses in 2007–08 compared to 1999–2000, in that time period the race/ethnic group with the highest percentage changed (in 1999–2000: Hispanic, 42.5%; Black, 37.7%; Asian/Pacific Islander, 35.6%; other or two or more races, 32.9%; and White, 23.7%, as compared to in 2007–08: other or two or more races, 32.2%; Black, 31.2%; Hispanic, 29.5%; Asian/Pacific Islander, 24.2%; and White, 21.0%, respectively). Of the females, the Hispanic female group had the largest drop from 1999–2000 to 2007–08 (42.5 vs. 29.5%, respectively).
Parents’ Education

With regard to the different levels of education attained by students’ parents, the percentage of first-year undergraduate students who reported they enrolled in remedial courses dropped from 1999–2000 to 2007–08 at all parental education levels. For example, in 1999–2000, 29.6% of first-year undergraduate students had parents with a high school diploma or equivalent compared to 24.7% in 2007–08. In 1999–2000 26.8% of first-year undergraduate students had parents with some postsecondary education compared to 23.8% in 2007–08. In 1999–2000, 27.5% of first-year undergraduate students had parents with a bachelor’s degree or higher compared to 20.4% in 2007–08.

In 1999–2000, there was a higher percentage of first-year undergraduate students who had parents with a bachelor’s degree or higher than for students who had parents with some postsecondary education (27.5 vs. 26.8%). In 2007–08, there was a larger percentage of first-year undergraduate students who had parents with some postsecondary education compared to students who had parents with a bachelor’s degree or higher.

Dependency Status

Consistent with the difference measured for all students, lower percentages of both dependent and independent first-year undergraduates reported they enrolled in remedial courses in 2007–08 than in 1999–2000 (dependent: 25.6 vs. 29.1%; independent: 20.4 vs. 28.5%, respectively).

The NCES has been conducting the NPSAS every three or four years. It will be very interesting to see the changes in demographics when the data for the next NPSAS is analyzed.
Developmental Math Students

Achieving the Dream (2012) is a national initiative designed to improve outcomes for community colleges. Over 80 colleges in 15 states are participating in the initiative. One of its goals is to help gather, analyze, and make better use of data to foster fundamental change in the education practices and operations of community colleges for the purpose of improving student outcomes (Bailey et al., 2010). The initiative started collecting data from students enrolling in the Fall 2003. The data came from the Integrated Postsecondary Education Data System (NCES, n.d.a).

The Achieving the Dream (2012) database classifies all beginning students into four math groups:

- no developmental education
- developmental education one level below the entry-level college course (Level I)
- developmental education two levels below the entry-level college course (Level II)
- developmental education three or more levels below the entry-level college course (Level III).

The first college-level course students must take after remediation is often referred to as a gatekeeper course. The goal of developmental education is to prepare students for the gatekeeper courses. However, many of those referred to developmental education fail to complete a college course because they never enroll in the developmental course. In some colleges, as is the case with the midwestern community college in this study, students can take courses in subjects for which the remedial course to which they were referred is not a prerequisite. In 75% of public 2-year colleges, students are required, in principle, to take remedial courses to which they are referred. The remaining 25% only recommend that
students take those courses (Parsad & Lewis, 2003). Many students ignore the advice and enroll directly into their gatekeeper course.

From the Achieving the Dream dataset, Bailey et al. (2010) found that 27% of the students referred to math remediation enrolled directly in a gatekeeper course. Those students passed their gatekeeper course at a slightly lower rate than did those students who enrolled in a gatekeeper course after they completed their developmental courses (Table 2.3).

Table 2.3

<table>
<thead>
<tr>
<th>Developmental math course</th>
<th>Never enrolled in developmental education (%)</th>
<th>Did not complete; never failed a course (%)</th>
<th>Did not complete; failed a course (%)</th>
<th>Completed sequenceb (%)</th>
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<td>17</td>
<td>45</td>
<td>59,551</td>
</tr>
<tr>
<td>Level II</td>
<td>24</td>
<td>13</td>
<td>32</td>
<td>32</td>
<td>38,153</td>
</tr>
<tr>
<td>Level III</td>
<td>17</td>
<td>23</td>
<td>44</td>
<td>17</td>
<td>43,886</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>11</td>
<td>29</td>
<td>33</td>
<td>141,590</td>
</tr>
</tbody>
</table>


aThe small percentage of those who were referred to Level I and never failed a course are likely to have enrolled in a lower level of remediation, passed that course, and left the system.

bSequence completion refers to the completion of Level I.

As shown in Table 2.4, the data in the Achieving the Dream dataset (Bailey et al., 2010) indicated that 50% of the math developmental education completers also completed a gatekeeper course. In order to complete the gatekeeper course, students must have first enrolled and then passed the course. Approximately two-thirds of the math developmental education completers enrolled and three-quarters of those who enrolled passed the gatekeeper math course. Failure to enroll was a greater barrier than failing or withdrawing from the course.
According to the Achieving the Dream dataset (Bailey et al., 2010), 59% of students were referred to developmental math: 24% to Level 1, 16% to Level II, and 19% to Level III. As shown in Table 2.4, many of those referred to math developmental education failed to complete the math gatekeeper course because they never even enrolled in the developmental course. However, when comparing students who entered the gatekeeper math course directly to those who followed the recommendations of first taking the math developmental courses, about 72% of those who went directly to the gatekeeper course passed the course whereas only about 27% of those who complied with the referral to the developmental course actually completed the gatekeeper course (Bailey et al., 2010). One could interpret this to mean the developmental course was an obstacle and created a barrier to the success of students. This could also be interpreted to mean that these students have a better understanding of their skills than an assessment tool indicates. In the Achieving the Dream dataset, of those students referred to math remediation and who never enrolled, only 61% enrolled in another course and 42% never earned a college credit within three years after their first term (Bailey et al., 2010).

Table 2.4

<table>
<thead>
<tr>
<th>Developmental Math Course</th>
<th>Remediation enrollment among those referred (%)</th>
<th>Gatekeeper pass rate among those referred (%)</th>
<th>Gatekeeper pass rate (%)</th>
<th>Gatekeeper completion (%)</th>
<th>Pass rate among those who enrolled in gatekeeper (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I</td>
<td>76</td>
<td>27</td>
<td>48</td>
<td>61</td>
<td>78</td>
</tr>
<tr>
<td>Level II</td>
<td>78</td>
<td>20</td>
<td>53</td>
<td>66</td>
<td>81</td>
</tr>
<tr>
<td>Level III</td>
<td>83</td>
<td>10</td>
<td>53</td>
<td>68</td>
<td>78</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>20</td>
<td>50</td>
<td>63</td>
<td>79</td>
</tr>
</tbody>
</table>

**Socioeconomic Status**

Bailey et al. (2010) studied data from the multiyear, national initiative (Achieving the Dream: Community Colleges Count) designed to improve outcomes for community college students. A total of 57 Achieving the Dream colleges participated in 2004. The colleges participating in this initiative served a higher proportion of African American and Hispanic students than did national and state public 2-year institutions overall (comparing IPEDS data). Bailey et al. reported:

Individuals at institutions serving high proportions of Black and economically disadvantaged students (measured by receipt of federal aid) generally have lower odds of passing to a higher level of remediation than their peer at colleges serving low proportions of these populations. (p. 266)

Similar results were found by Bahr (2012), who analyzed data that addressed the entire population of first-time college freshmen who began college attendance in Fall of 1995 at any of the 107 semester-system community colleges in California. Even though Bahr’s study took place at a community college system, because it studied only first-time students, it did not address returning students, which is a significant population served by community colleges. Bahr stated: “Community college students of historically disadvantaged groups disproportionately begin college at the lower end of the remedial hierarchy, where the chances of attaining college-level competency are also the lowest” (p. 685). Both Bailey et al. (2010) and Bahr (2012) found socioeconomic status had an effect on academic success.

Atwell, Lavin, Domina, and Levey (2006) studied data from the National Educational Longitudinal Study (NELS:88), which was a NCES (n.d.c) project. The NELS:88 data were representative samples of the nation’s students. Atwell et al.’s results showed:
Although students from families in the lowest quartile of socioeconomic status (SES) were more likely to undertake remedial coursework (52%) did so, nearly a quarter (24%) of the students from the highest quartile SES families also enrolled in remedial courses in college. Taking remedial or developmental courses in college is by no means limited to economically disadvantaged students. (p. 899)

Even though students in the lowest socioeconomic category are more likely to take remedial courses, remedial coursework is not limited to low socio-economic status students.

**Level of Preparedness**

When students apply for admission to community colleges, often they are required to take an assessment test to evaluate their academic skills. Scores on placement tests often are used by colleges to place beginning students into developmental courses. In his paper, “Challenge and Opportunity Rethinking Developmental Education in Community Colleges,” Bailey (2009) suggested there was no “national consensus about what level of skills is needed to be considered college ready or about how to assess that level” (p. 1). Different colleges have different cut scores for similar courses utilizing the same entrance exam.

Most colleges use cognitive tests, such as ACCUPLACER and COMPASS, to assess the knowledge of students as they enter college. One of the most widely used assessment instruments used for placement in developmental courses is ACCUPLACER™ (Gerlaugh et al., 2007). This test, published by the College Board, adjusts the difficulty of follow-up questions based on students’ responses to the previous question. It is a cognitive assessment instrument. The college in this study utilizes the ACCUPLACER™ test as their entrance exam.
Bahr (2012) conducted a study of students from a database maintained by the Chancellor’s Office of the California Community College (CCC) system. His study focused on all first-time college students in California’s 105 semester-based community colleges who began in Fall of 2001, Fall of 2002, or Fall 2003, and who reported a valid social security number. His study concentrated on the remedial sequence in community colleges, exploring associations between course-taking patterns, course outcomes, and attrition from the remedial math and remedial writing sequences. Bahr reported:

Although the likelihood of achieving college level competency varies with duration of enrollment, sizeable gaps in achievement are evident between low-skill and high-skill remedial math and writing students even at very high durations of enrollment. Hence, duration of enrollment cannot tell the whole story of why low-skill remedial students achieve college-level competency at much lower rates than do high-skill remedial students. (p. 672)

However, in Bahr’s study, the community college system had more than one developmental course required for the lower-skilled students. The midwestern community college examined in this study had only one level of developmental math courses available before taking the required college-level course.

The Community College Research Center analyzed Achieving the Dream data and found only 31% of students referred to developmental math courses completed the recommended sequence of courses within three years (Bailey et al., 2010). However, only 16% of the lowest level of developmental math students completed remediation when they began by enrolling in courses that were three or more levels below the college level.
Calcagno (2008) compared outcomes for community college students in Florida who scored just above the statewide cutoff score for developmental education on the CPT to those who scored just below it. These researchers found “students scoring just below the cutoff for the math test are slightly more likely to persist to their second year than those who scored just above the cutoff” (p. 17).

Based on these recent studies, the level of the deficiency in math preparedness does make a difference. The larger the deficiency, the less likely underprepared students are to succeed. However, slightly underprepared students are more likely to persist than are students who score just above the cutoff that determines if a student is prepared.

Program of Study

The NADCTEc (2012) was established to support an innovative system to prepare students to succeed in their education and their careers. The consortium found one of the keys to improving student achievement was to provide students with relevant contexts for studying and learning. Career Clusters were developed as an important organizing tool for schools to develop more effective curriculum. The 16 Career Clusters were identified as: Agriculture, Food & Natural Resources; Architecture & Construction; Arts, A/V Technology & Communications; Business Management & Administration, Education & Training, Finance, Government & Public Administration; Health Science, Hospitality & Tourism; Human Services; Hospitality & Tourism; Human Services; Information Technology; Law, Public Safety, Corrections & Security; Manufacturing; Marketing; Science, Technology, Engineering & Mathematics; and Transportation, Distribution & Logistics. As students declare their major, it would benefit them and it would be more effective to offer curricula specific to their interests.
Developmental Courses

Based on the score earned on the admission assessment test, students are often advised and, in some community colleges, required to enroll in developmental or remedial math courses. These developmental or remedial math courses are designed to help students raise their math skills before registering for the math course(s) required for graduation in their program.

In a recent study conducted in 2011 at the midwestern community college examined in this study, data were gathered from all the students who registered for a developmental math course during the 2006 Fall semester. Of the 161 students who had registered for this developmental math course, only 97 students passed the course with a grade of A to D and only 22 of those students eventually graduated (Volk et al., 2011). This was a very small percentage of the students who graduated within four years with a 2-year degree or 1-year diploma and didn’t take into account any of the students who refused to take the developmental course.

Bettinger and Long (2008) analyzed traditional-age (18- to 20-years-old) undergraduate college students who entered public colleges in Ohio as first-time freshmen during Fall of 1998. Although their study focused on students in Ohio, the patterns of enrollment in their study were similar to the national averages. The sample was limited to full-time students who either attended a 4-year college or were community college students who indicated on their community college application they intended to graduate from a 4-year college. Bettinger and Long (2008) summarized:

We estimate that students in remediation have better educational outcomes in comparison to students with similar backgrounds and preparation who were not
required to take the courses. . . . Math and English remediation are estimated to reduce the likelihood of dropping out after five years and increase the likelihood of completing a degree within four to six years. Lending further support to the results, as theory would predict, the estimates are more positive for the group of students on the margin of needing remediation than the general sample. (p. 761)

Bettinger and Long’s (2008) results also suggested underprepared students without the remedial courses were more likely to drop out of college and less likely to complete their degrees.

Developmental or remedial courses are one form of academic intervention. Not all scholars agree developmental courses are effective. In a U.S. Department of Education report, Noel-Levitz (2006) suggested developmental courses serve as barriers to achievement and that there are no harder courses to pass than one in developmental mathematics.

Lavin, Alba, and Silberstein (1981) conducted a study among 2-year college students. Their results showed placement in remedial courses did nothing to enhance student academic achievements. However, success in remedial courses did make a difference in that study. Students who passed at least one of their remedial courses were more likely to stay in college and were more likely to graduate than were similar students who did not take remedial coursework.

Schiel and Sawyer (2002) also analyzed data in a study conducted by ACT. Their study reported developmental mathematics courses were effective for those who completed them. However, only 21% of the students in their study completed their developmental coursework.

The national study conducted by Atwell et al. (2006) also concluded the gap in academic success had little to do with taking remedial classes in college. Instead, that gap reflected pre-existing skill differences carried over from high school. Atwell et al.’s research showed that, in 2-year colleges, taking remedial classes was not associated at all with lower chances of academic success, even for students who took three or more remedial courses.

Bailey (2009) studied developmental students in Florida. He reported “no statistically significant effect of math remediation on completing a certificate or associate degree” (p. 17). It is clear that it is not only important to have students enroll in developmental mathematics courses, students need to successfully complete them. Bailey also argued that students with similar placement scores need different types of intervention to prepare them for college level work.

Developmental or remedial math courses do not count toward the graduation requirements. Further, these courses add an additional expense. Some students cannot afford to take on the financial burden of paying for additional courses. Developmental level courses can delay graduation one semester or longer. Many students become discouraged because they are, from their perspective, wasting time that would be better spent working toward their goal. Some students believe they will never be able to reach their goal and choose to leave college. Developmental courses can be a negative factor in persistence and completion for
community college math students. Emerging practices at the end of this chapter may prove more beneficial.

**Tutoring Assistance**

Colleges generally use both peer tutors and professional tutors. Peer tutors are students who have already mastered the material and work for the college helping other students. Professional tutors generally are content experts and have previous teaching experience. There is no evidence to suggest that either peer or professional tutors are more effective (Maxwell, 1997).

Supplemental instructing peer tutors actually attend the lecture at the regular class times. The supplemental instructors then hold discussions outside of the class to re-enforce important concepts and answer questions. Boylan, Bonham, Claxton, and Bliss (1992) found developmental programs with the highest rates of student retention regularly used supplemental instruction to support students enrolled in difficult courses.

Gallard, Albritton, and Morgan (2010) studied an enhanced tutoring program at a community college in Florida. They found significantly higher developmental course completion rates of 15.5% with a return on investment to the college of 272%. This cost/benefit study showed early successful intervention pays off for students, the institution, and society as a whole.

**Computer-Aided Math Software**

A more recent development in delivering developmental education is computer-based or computer-aided instruction, in which students utilize computer software to complete course work. Students may use computer-aided math software for various reasons. Some instructors require computer-aided software for assignments. Sometimes students believe
that using a computer will help them learn the material easier (Lesh & Rampp, 2002).

Students may not have the luxury of easy access to a campus for tutoring services and can study from home using computer instruction. Computer based learning requires students to have independent learning skills, study discipline, time management skills, and a higher degree of motivation (Boylan, 2002). These are characteristics that many vocational students underprepared in math may not possess.

Jacobson (2006) conducted a study to address the effectiveness of textbook-based computer homework systems. He compared students who used the computer support program to students with the same instructors who did the normally assigned noncomputer homework. In Jacobson’s study, the computer homework sections had lower average exam scores than did the control group sections. However, in his study, the computer support program was assigned for out-of-class use and for periods of less than four weeks.

There is an inverse relationship between the amount of computer technology used in a developmental course and pass rates in that course (Boylan, 2002). Instructors who reported using computers as a supplement to classroom instruction had significantly lower failure rates than did those who reported using computers to provide the majority of classroom instruction in Boylan’s (2002) study.

Greater use of technology, or computer-aided instruction, was one of the emerging promising practices suggested by Golfin, Jordan, Hull, and Ruffin (2005) in a report published by the U.S. Department of Education’s Office of Vocational and Adult Education. Golfin et al. suggested using technology as a supplement to classroom instruction as well as integrating technology into classroom and lab instruction. They did not recommend using technology alone. Integrating technology into the classroom and lab instruction assists
students who may not feel comfortable accessing technology alone at home. Moreover, utilizing technology may be a burden to low-income students who may not be familiar with technology or may not own a computer at home.

**Student Support Services**

Pascarella and Terenzini (2005) suggested that institutions can aid the academic adjustment of poorly prepared students by providing extensive instruction in academic skills, advising, counseling, and comprehensive support services. However, there are many roadblocks to providing student support services. Support services do not generate any revenue and they are quite expensive for colleges to support.

Comprehensive support and retention programs offer a wide variety of services and programs that are intended to promote academic adjustment, persistence, and degree completion. These programs often have been supported by federal and state agencies. The federal Student Support Services (SSS) program, one of the clusters of the TRIO programs, is a great example of this. According to the US Department of Education (2012):

The Federal TRIO Programs (TRIO) are Federal outreach and student services programs designed to identify and provide services for individuals from disadvantaged backgrounds. TRIO includes eight programs targeted to serve and assist low-income individuals, first-generation college students, and individuals with disabilities to progress through the academic pipeline from middle school to postbaccalaureate programs. TRIO also includes a training program for directors and staff of TRIO projects. (para. 1)

SSS projects are truly comprehensive. All SSS projects must provide: academic tutoring, advice about postsecondary course selection, information about student financial aid
programs, and assistance in completing financial aid applications. The SSS projects also may provide individualized counseling and academic information, activities, and instruction designed to acquaint students with career options; exposure to cultural events; and mentoring programs.

The midwestern community college in this study was a recipient of a federal TRIO SSS grant. The program provided funding for basic skills instruction, tutoring, academic advising, transfer and graduate school counseling, and mentoring to disadvantaged students. At this community college, in order to remain eligible for these student support services, students must:

- Attend TRIO orientation,
- Meet with their advisor a minimum of three times a semester,
- Attend a financial aid workshop each semester,
- Attend one cultural activity/event or campus visit per year,
- Maintain a 2.0 cumulative grade point average.

Each student received one-on-one assistance and support based on his or her needs.

Zhang and Chan (2007), found that more than two-thirds of full-time freshmen who received services from SSS at community colleges persisted to their second year of college and 9% of these students earned an associate’s degree at the end of two years. Consistent student support services help students persist and graduate.

**Emerging Practices**

Many practices have been attempted to reform remedial education so that greater numbers of students go on to earn a college degree, but few have been evaluated in a way that establishes a causal relationship between the reforms and educational attainment (Levin
& Calcagno, 2008). One exception to that was a learning community program at Kingsborough Community College in Brooklyn, New York (Brock, 2010). A learning community is where educators make the course material taught in class more meaningful to students by linking the information covered in one class to the discussions and assignments in another class. In a national project called Opening Doors, Scrivener et al. (2008) conducted a study of such a learning community. They found that students who participated in the learning community “passed more courses and earned more credits during their first semester, moved more quickly through remedial English requirements, and were more likely to take and pass an English skills assessment test that was required for graduation (as cited in Brock, 2010, pp. 117–118). However, the learning community did not have an immediate effect on persistence.

Washington State’s Integrated Basic Education and Skills Training (I-BEST) program showed another way to make course material more meaningful to students by linking the information covered in one class to the discussions and assignments of another class. This method integrated basic English or math skills into college-level career or technical training. Jenkins, Zeidenberg, and Kienzel (2009) found I-BEST students had higher persistence rates, earned more occupational credits toward a college credential, and showed greater increases on remedial education tests.

Another approach to reforming remedial education was to accelerate the pace for students moving through remedial education. Colleges may assign short-term review courses for students who test just below the level required for entry into specific college level courses. Recent research has suggested that the faster students progress toward a credential, the more likely they are to complete college (Bowen, Chingos, & McPherson, 2009).
First-year student orientation programs are becoming more common in colleges. However, a national survey of entering community college students found that 32% did not attend a freshman orientation program and half did not meet with or recall seeing an academic adviser during their first 4 weeks of college (Community College Survey of Student Engagement, 2007). These orientation programs provide students guidance to available resources, such as information about which courses to take, how to add or drop courses, how to apply for financial aid, and how to adjust to campus life.

Game-based learning, such as computer and video games, can allow students to experience learning that stresses immersion in a practice, supported by structures that lead to skills and innovative thinking. Digital games are seen as excellent tools for facilitating and support situated learning of students (Admiraal, Huizenga, Akkerman, & ten Dam, 2011). Some colleges have redesigned their math courses, replacing some or all of the traditional course structure with self-paced online learning modules (Epper & Baker, 2009). In some cases, students can access these modules at any time from any location as long as they have access to a computer. In other cases students access these modules during a structured lab time.

There should be a balanced instructional approach that promotes all strands of mathematical learning. The Mathematical Association of America and the American Mathematical Association of Two-Year Colleges recommended replacing traditional college algebra courses with modeling-based courses in which students solve problems situated in real-world contexts by creating and interpreting mathematical models (Katz, 2007). Studies consistently have suggested that application-oriented instruction may support mathematical proficiency but does not improve procedural fluency (Hodara, 2011). One of the challenges
is to find approaches that improve students’ math understanding as well as their performance on tests of math achievement.

Squires, Faulkner, and Hite (2009) conducted a study at Cleveland State Community College, working with the National Center for Academic Transformation (NCAT) to redesign the college’s math courses. With the redesigned courses, students met in a class 1 hour each week and worked in a computer lab outside of class 2 hours each week. Each course contained 10 to 12 modules. All students were expected to complete all aspects of the course, including attendance, homework, quizzes, and tests, with a score of 70 or better. For each module, students watched instructional videos, completed homework, and passed a quiz. Course completion rates in the developmental courses rose from 54% to 72%.

Jenkins, Speroni, Belfield, Jaggars, and Edgecombe (2010) studied the Community College of Baltimore County. This community college adopted an accelerated learning program (ALP) in which students placed in upper-level developmental courses were mainstreamed into the required college level courses and simultaneously enrolled in an ALP course (taught by the same instructor) that met immediately following the required course. They limited the ALP course to only eight students. Jenkins et al. (2010) found that the students who enrolled in the ALP companion course were significantly more likely to take and pass the required course than were those who enrolled in a regular developmental course first.

Bryk and Treisman (2010) summed it up well when they stated, “Math should be a gateway, not a gatekeeper, to a successful college education” (p. 1). Students need to see math as an essential aspect of everyday lives. Bryk and Treisman reported remedial math
was an obvious place to help students develop the knowledge, skills, and social connections for success beyond the math classroom.

**Framework**

As this study focused on student success along with potential support or interventions for underprepared vocational math students in community colleges, it was important to identify the factors that potentially would be predictive of student success in persisting towards their academic goals. The fundamental premise of Astin’s (1993) I–E–O model is that students have pre-existing characteristics or inputs and that their success is impacted by who they were before they entered college. The consideration of input characteristics when assessing student persistence helps in the understanding of the influence of students’ backgrounds and characteristics on their ability to persist to graduation. The environment in the I–E–O model is what takes place when the student is in college. Student development or growth occurs as a result of the interaction between a student and the institutional environment. This interaction is influenced by the characteristics of the student and the environment. The final component of the I–E–O model is output or outcome. The I–E–O model provided the theoretical framework to organize and study the data. It was critical to identify the variables and establish a research-based policy for supporting underprepared vocational math students. Astin’s (1993) I–E–O model was developed to produce useful results for implementing educational practices and for deriving educational policy.

Astin’s (1993) I–E–O model was adapted for use in this study. The environment aspect of the model still referred to what takes place when the student is in college; however, in this study, it also referred to the various interventions available to students to assist them with their academic success.
Utilizing a hierarchical multinomial logistic regression analysis, this study followed the method used in Bahr’s (2008) study of the long-term outcomes (credential attainment and transfer) of students who remediated successfully in mathematics. The hierarchical linear model (Bryk & Raudenbush, 1987), measures change and correlations of change. This hierarchical linear model is a two-stage model. This two-stage conceptualization allows researchers to model individual change, predict future development, assess the quality of measurement instruments for distinguishing among growth trajectories, and study systematic variation in growth trajectories as a function of background characteristics and experimental treatments (Bryk & Raudenbush, 1987).

Bean and Metzner (1985), Nora and Cabrera (1996), Tinto (1975, 1993), and others have assisted researchers with identifying independent variables to use in regression models examining student persistence and success. All of these factors, and more, are important to student persistence. This study is based on a secondary data set that contained limited factors.

**Summary**

Student success depends on many factors. This chapter provided an outline of related research. It began with a brief overview of the history of remedial education and college readiness. Characteristics of underprepared students and developmental math students were described. The effect of such factors as socioeconomic status and level of math preparedness were examined as they relate to academic success. Career Clusters, developed by the NADCTEc (2012), on which students’ declared majors of study are based, were identified. This chapter then described the success of interventions on student success such as
completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participating in a consistent student support services program.

This chapter concluded with emerging practices such as participating in a learning community, utilizing the I-Best model, learning communities (linking the information covered in one class to the discussions and assignments of another), accelerating the pace of students moving through remedial education, initiating a freshman orientation program, utilizing game-based learning, redesigning math courses by replacing the traditional course structure with self-paced online learning modules or minimizing in-class instruction and utilizing outside labs, and adopting an ALP in which students are placed into upper-level courses and enroll in an ALP course immediately following the required course.

Finally, this chapter examined the framework used for this study. This study attempted to build upon prior research in order to add to the knowledge of vocational students underprepared in math and their academic success.
CHAPTER 3. METHODOLOGY

This study was designed to provide guidance to community college administrators and advisors to assist underprepared vocational math students to become successful and complete their degree. This chapter provides an overview of the methodology that guided this study. In addition, this chapter includes the research questions and hypotheses, population and sample, data sources and data collection, a description of the variables that were analyzed, and data analysis procedures.

Based on the objectives of this study, the following research questions were addressed:

1. What are the characteristics of this study’s underprepared vocational math students such as age, gender, ethnicity/race, socioeconomic status, declared major of study, and level of deficiency in math preparedness based on the entrance assessment arithmetic scores?

2. Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the level of the deficiency in math as described by slightly underprepared, moderately underprepared, and severely underprepared (based on the entrance assessment arithmetic score)?

3. Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the declared major program of study as classified by Career Cluster?

4. To what extent do student characteristics of age, gender, race/ethnicity, socioeconomic status, level of deficiency in math preparedness based on the
entrance assessment arithmetic scores, along with the intervention variables of completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and consistently participating in support services, predict academic success (as determined by the grade earned in the MAT 772 – Applied Math course) for the underprepared vocational math students in this study?

**Hypotheses**

A hypothesis is offered for research questions 2, 3, and 4 in this study; research question 1 does not require a hypothesis because it is descriptive in nature. According to Creswell (2009) hypotheses are predictions about the outcomes of the results. The null hypothesis makes a prediction that there is no relationship or no difference exists between groups on a dependent variable. The hypotheses for this study have been written in the null form.

H$_{01}$ (for research question 2): There are no differences in the mean academic success (as determined by the grade earned in the minimum required vocational math course) of underprepared vocational math students based on the size of the gap of the deficiency on their level of math preparedness, described as slightly underprepared, moderately underprepared, and severely underprepared (based on their arithmetic CPT scaled score).

H$_{02}$ (for research question 3): There are no differences in the mean academic success (as determined by the grade earned in the minimum required vocational math course) of underprepared vocational math students based on the various majors of study, as classified by Career Clusters.
H₀₃ (for research question 4): Success, defined by the level of success in MAT 772 – Applied Math, cannot be predicted when examining factors such as age, gender, ethnicity/race, socioeconomic status, level of math preparation based on the entrance assessment arithmetic scores, along with the intervention variables of completing a developmental math course (MAT 041 – Basic Math), utilizing tutoring services, utilizing computer-aided math software, and participation in a consistent student support services program.

Methodological Approach

This study sought to elaborate on previous research regarding underprepared vocational math students’ academic success by formulating a model and then testing it through the data. In this study, outcomes were hypothesized before data collection based on previous research and then the data were analyzed to see if the results supported or challenged the existing research.

A quantitative approach was used in this study to test the hypothesized relationships among the variables. This study utilized an *ex post facto* research design, because the data were collected after the fact instead of through the use of an experimental design. An *ex post facto* study “moves from outcomes to predictors, not from predictors to outcomes” (Light et al., 1990, p. 135). The *ex post facto* research design was chosen because of the complexity of the factors involved and the inability to control all but a single independent variable from the influences of the other variables. Observations were made based on normal conditions to study if there was a statistically significant relationship in the variables.

The study was based on a positivist approach to research. The characteristics of a positivist approach, as described by LeCompte and Preissle-Goetz (1993) and McMillan and
Schumacher (1997), include a detached role of the researcher, a generalization of results to similar phenomena, a focus on measurement and quantification, and the use of procedures to correlate and predict phenomena. A logical positivist philosophy contends there is a single objective reality that is separate from the beliefs of individuals (McMillan & Schumacher, 1997). This study was based on the premise of a logical positivist philosophy.

The literature reviewed in chapter 2 provided an overview of characteristics of underprepared developmental math students. Characteristics such as gender, age, race/ethnicity, socioeconomic status, declared major, and CPT entrance assessment arithmetic scaled scores of the underprepared vocational math students in this study were explored.

The review of literature also provided background about students’ ability to overcome deficiencies including the ability to overcome the deficiency based on the size of the gap in the deficiencies. In addition, National Career Clusters, developed by the NADCTEc (2012) as an important organizing tool for schools to develop more effective curriculum, were identified. Finally, this review provided literature regarding interventions that may support success of the underprepared vocational math students such as completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and consistently utilizing student support services.

Data Sources

This study utilized longitudinal data from a midwestern community college. Three sources of data were used. The management information system of the college provided much of the data. The Director of Institutional Research compiled the following information: student ID number, birthdate, gender, federal Pell grant eligibility as an indicator for socioeconomic status, ethnicity/race, major program of study, arithmetic CPT scaled score,
MAT 041 – Basic Math course grade, MAT 772 – Applied Math course grade, semester registered for MAT 772 – Applied Math, and participation in a consistent student support program (TRIO). The Student Success Coordinator provided paper sign-in records, which included student names, dates, and hours of participation in tutoring services, as the second source of data. The division chair for Math and Science provided records, including student names and hours, for the amount of usage of a computer-aided math software program (MyMathLab).

**Sample and Delimitations**

The site of this study was a medium-sized (enrollment of approximately 6,500 students per semester) public community college in a midwestern city with a population of approximately 80,000 people. The service area for this community college encompassed six counties with a total population of approximately 180,000. The students in this study were enrolled in the community college during the terms of Spring 2007 through Spring 2012. From the initial cohort of students who had enrolled in this community college from Spring semester 2007 to Spring semester 2012, students who had not registered for MAT 772 – Applied Math (the lowest level math course required for graduation in vocational programs) were removed. Only students who had registered for the vocational math course (MAT 772 – Applied Math) remained in this study.

Of the vocational math students in this community college who enrolled during the 2007–12 academic years, those who had not completed the (CPT) were removed from the study, as the prior skill level of those students was not known. Of the vocational math students who had completed the arithmetic CPT \((N = 3,313)\), those who had earned a scaled score of 57 or higher also were removed from the study; 57 was the required score
determined by the Developmental Education Taskforce at this community college to be prepared for the required MAT 772 – Applied Math course. These delimitations left only the vocational students underprepared in math \((n = 1,156)\). Stratification of the sample was not conducted. The makeup of underprepared students might not have been representative of the entire population accessed.

**Variables**

A variable code table is included (Table 3.1) to identify the variables and the corresponding codes that were used in the analysis of the data for this study. The student characteristic variables, or attribute variables, include gender, ethnicity, race, program of study (major), and date of birth. These characteristics were self-reported by the students on their application for admission to the community college in this study. These data were included in the secondary data set given to the researcher.

The date of birth was subtracted from the first day of the semester in which the student began the MAT 772 – Applied Math course, giving the age of each student at the time each began the Applied Math course. The age was then recoded to reflect if the student was a traditional-age student (24 years of age or younger) or a nontraditional student (25 years of age or older (age)). For the purpose of this study, traditional students were classified as those students whose age was 24 years or younger. These students tend to enter college immediately following high school, remain financially dependent on their parents, and live on college campuses (Jinkens, 2009).
Table 3.1

**Variable Descriptions and Coding**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age is 24 and younger Age is 25 and older</td>
<td>0 = Traditional 1 = Nontraditional</td>
</tr>
<tr>
<td>Gender</td>
<td>Gender of student is male or female</td>
<td>0 = Male 1 = Female</td>
</tr>
<tr>
<td>White</td>
<td>Race/ethnicity is White or Non-White</td>
<td>0 = Non-White 1 = White</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Race/ethnicity is Hispanic or non-Hispanic</td>
<td>0 = Non-Hispanic 1 = Hispanic</td>
</tr>
<tr>
<td>Black</td>
<td>Race/ethnicity is Black or non-Black</td>
<td>0 = Non-Black 1 = Black</td>
</tr>
<tr>
<td>Asian+</td>
<td>Race/ethnicity is Asian and other or non-Asian and other</td>
<td>0 = Non-Asian and other 1 = Asian and other</td>
</tr>
<tr>
<td>ses</td>
<td>Received a Pell grant the year they took MAT772 or didn't receive a Pell grant</td>
<td>0 = Pell grant recipient 1 = Non-Pell grant recipient</td>
</tr>
<tr>
<td>major</td>
<td>Career Cluster or major program of study</td>
<td>0 = General Studies 1 = Agriculture, Food &amp; Natural Resources 2 = Architecture &amp; Construction 3 = Arts, A/V Technology &amp; Communications 4 = Business Management &amp; Administration 5 = Education &amp; Training 6 = Finance 7 = Government &amp; Public Administration 8 = Health Science 9 = Hospitality &amp; Tourism 10 = Human Services 11 = Information Technology 12 = Law, Public Safety, Corrections &amp; Sec. 13 = Manufacturing 14 = Marketing 15 = Science, Tech., Engineering &amp; Math 16 = Transportation, Distribution &amp; Logistics</td>
</tr>
<tr>
<td>level</td>
<td>Level of preparedness in math as determined by CPT arithmetic scaled score</td>
<td>0 = Severely underprepared 1 = Moderately underprepared 2 = Slightly underprepared</td>
</tr>
<tr>
<td>DevMath</td>
<td>Student failed or didn't take, borderline passed, or passed MAT 041 – Basic Math</td>
<td>0 = failed or didn't take or complete 1 = earned a grade of C–, D+, D or D– 2 = earned a grade of C or higher</td>
</tr>
</tbody>
</table>
Table 3.1 (continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>tutor</td>
<td>Student utilized tutoring services or didn't utilize the service</td>
<td>0 = didn't utilize tutoring services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = did utilize tutoring services</td>
</tr>
<tr>
<td>compmath</td>
<td>Student utilized computer-aided math software or didn't utilize the software</td>
<td>0 = didn't utilize the math software</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = utilized the math software</td>
</tr>
<tr>
<td>supportserv</td>
<td>Student utilized TRIO services or didn't utilize the service</td>
<td>0 = didn't utilize TRIO services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = did utilize TRIO services</td>
</tr>
<tr>
<td>Mat772gr</td>
<td>Grade earned in MAT772 – Applied Math</td>
<td>0 = failed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = D–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 = D+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 = C–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 = C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 = C+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 = B–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 = B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 = B+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 = A–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 = A</td>
</tr>
<tr>
<td>Mat772level</td>
<td>Student failed, borderline passed, or passed MAT 772 – Applied Math course</td>
<td>0 = failed or didn't take or complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = earned a grade of C–, D+, D or D–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = earned a grade of C or higher</td>
</tr>
<tr>
<td>Mat772pf</td>
<td>Student failed or passed MAT 772 – Applied Math</td>
<td>0 = failed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = passed with D– or above</td>
</tr>
</tbody>
</table>

When IPEDS data are reported to the state, the data are first broken down as to what students reported or declared as their ethnicity. Students who declared their ethnicity as Hispanic are reported as Hispanic. If students reported anything other than Hispanic as their ethnicity, then their race is examined and reported. Therefore, ethnicity and race have been reported together in this study.

The student characteristic variables, or attributes, were obtained from the community college’s MIS system. Socioeconomic status (ses) was based on students’ eligibility for federal Pell benefits as reported in the secondary data set. The CPT arithmetic scaled score
was determined by the score students earned on their arithmetic CPT assessment test as reported in the secondary data set. The level of math preparedness (level) value was determined by recoding the CPT score using the criteria suggested by the College Board (which provided the ACCUPLACER CPT) for the below minimal arithmetic skills, minimal arithmetic skills, or adequate arithmetic skills levels as previously described.

Active or manipulated variables for this study included the grade students earned when completing the developmental math course (MAT 041 – Basic Math) (devmath), whether or not the student utilized tutoring services (tutor), whether or not the student utilized computer-aided math software (compmath), and whether or not the student participated in a consistent student support or TRIO program (supportserv). The grade earned in MAT 041 – Basic Math, was then recoded into three levels of success: failed or didn’t complete; borderline passed (passed with a C–, D+, D, or D–; the college catalog at this community college identifies students with a C as average achievement); or passed (with a grade of C or higher).

The test variable or dependent variable was the grade earned for the lowest level vocational math course required for graduation in vocational programs (MAT 772 – Applied Math). The grade earned in MAT 772 – Applied Math, was then recoded into three levels of success (mat772level): failed or didn’t complete; borderline passed (passed with a C–, D+, D, or D–; the college catalog at this community college identifies students with a C as average achievement); or passed (with a grade of C or higher). After further investigation, this grade was again later recoded (mat772pf) as pass or fail. Students at the community college in this study can graduate with a D– in MAT 772 – Applied Math.
The variables in this study were classified into three categories: nominal, dichotomous, and ordinal. The nominal variable was program of study. Program of study or major consisted of 17 areas or 16 Career Cluster and one General Studies Category (0 = General Studies; 1 = Agriculture, Food & Natural Resources; 2 = Architecture & Construction; 3 = Arts, A/V Technology & Communications; 4 = Business Management & Administration; 5 = Education & Training; 6 = Finance; 7 = Government & Public Administration; 8 = Health Science; 9 = Hospitality & Tourism; 10 = Human Services; 11 = Information Technology; 12 = Law, Public Safety, Corrections & Security; 13 = Manufacturing; 14 = Marketing; 15 = Science, Technology, Engineering & Mathematics; and 16 = Transportation, Distribution & Logistics).

The dichotomous variables in this study were age, gender, race/ethnicity, and socioeconomic status. In order to identify age, the student’s age was dummy coded as a dichotomous variable (0 = 24 or younger, 1 = 25 or older). The student’s gender was dummy coded as a dichotomous variable (0 = male, 1 = female). Race/ethnicity was dummy coded as dichotomous variables: Race/ethnicity: White (0 = Non-White, 1 = White); Race/ethnicity: Hispanic (0 = Non-Hispanic, 1 = Hispanic); Race/ethnicity: Black (0 = Non-Black, 1 = Black); Race/ethnicity: Asian and other (0 = Non-Asian and other, 1 = Asian and other). The “Asian and other” category consisted of students who declared as Asian or other, or refused to indicate their race/ethnicity. In order to identify socioeconomic status, the students’ eligibility for federal Pell benefits were also dummy coded as a dichotomous variable (0 = Pell grant eligible, 1 = not Pell grant eligible). In identifying whether a student utilized tutoring services, a dummy coded variable was used (0 = didn’t utilize tutoring services, 1 = utilized tutoring services). Dummy coding was also used in determining whether or not a
student utilized computerized math software (0 = didn’t utilize computerized math software, 1 = utilized computerized math software) as well as in determining if a student participated in consistent student support services or TRIO services (0 = didn’t participate in TRIO services, 1 = did participate in TRIO services). Academic success was added later based on the grade earned in the lowest level math course required for graduation in a vocational program (MAT 772 – Applied Math) (0 = failed, 1 = pass).

There were four ordinal variables in this study. The level of preparedness (0 = severely underprepared, 1 = moderately underprepared, and 2 = slightly underprepared) was based on the CPT arithmetic scaled score (ranging from 20–56). Academic success in MAT041 was based on the grade earned in the developmental math course MAT 041 – Basic Math; (0 = failed, 1 = borderline pass, and 2 = pass. Academic success (mat772gr) in MAT 772 – Applied Math was first based on the grade earned in the lowest level math course required for graduation in a vocational program (MAT 772 – Applied Math; 0 = F or dropped, 1 = D–, 2 = D, 3 = D+, 4 = C–, 5 = C, 6 = C+, 7 = B–, 8 = B, 9 = B+, 10 = A–, and 11 = A). Academic success when then recoded (mat772level) to reflect the level of academic success (0 = failed, 1 = borderline pass, and 2 = pass). The community college in this study identified a C grade as average achievement. Average achievement for this study is considered success. A borderline pass indicates below average achievement.

Data Analysis Procedures and Methods

The Statistical Package for Social Sciences® (SPSS 19) from International Business Machine (IBM) was the computer software program utilized in this study. The data from the midwestern community college in this study provided to the researcher as an Excel™ spreadsheet were loaded into the SPSS 19 software to perform data analysis.
Exploratory Data Analysis

Exploratory data analysis was conducted to determine if there were problems in the data such as outliers, non-normal distributions, problems with coding, missing values, and/or errors inputting the data.

Descriptive Statistics

The purpose of the descriptive analysis was to explore the nature of the community college students who were underprepared vocational math students by describing and summarizing the characteristics of the students in this study. The descriptive statistics of the students in this study do not necessarily accurately reflect the student body as a whole at this community college or other community colleges.

Descriptive analyses were conducted in answering the research question #1: What are the characteristics of this study’s underprepared vocational math students such as age, gender, ethnicity/race, socioeconomic status, declared major of study, and level of deficiency in math preparedness based on the entrance assessment arithmetic scores? Frequencies were utilized to describe demographic characteristics such as age, gender, race/ethnicity, socioeconomic status, major program of study as identified by Career Cluster, and level of preparedness. Ordinal independent variables were examined for normal distribution. “Screening continuous variables for normality is an important early step in almost every multivariate analysis, particularly when inference is a goal” (Tabachnick & Fidell, 2007, p. 79). Because the age variable was highly skewed, age was then dummy coded as a dichotomous variable of traditional and nontraditional age.
Inferential Statistics

Inferential statistical analyses also were conducted to determine if there was a significant relationship between each of the independent variables and the dependent variable. Cross-tabulations, a chi-square analysis, and a phi test were utilized. A cross-tabulation analysis provides information about the counts and expected counts in the frequencies of each independent variable in relationship to the dependent variable, a Pearson chi-square analysis indicates whether one can be confident that the difference is not due to chance, and the phi test is a measure of the effect size (Morgan, Leech, Gloeckner, & Barrett, 2007).

An ANOVA procedure was used to investigate research questions #2 and #3: Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the level of the deficiency in math as described by slightly underprepared, moderately underprepared, and severely underprepared (based on the entrance assessment arithmetic score)? Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the declared major program of study, as classified by Career Cluster?

If a significance difference was found, post hoc tests were then conducted to determine where there was a significant difference. Tukey HSD (honesty significant differences) tests were used if the Levene’s test for equal variance was not significant, and the Games-Howell test was used if the Levene’s test for equal variance was significant. Many statisticians recommend using the Tukey HSD test if the Levene test is not significant and the Games-Howell test if the Levene test was not significant (Morgan et al., 2007).
A multinomial logistic regression analysis was first utilized in answering research question #4: *To what extent do student characteristics of age, gender, race/ethnicity, socioeconomic status, level of deficiency in math preparedness based on the entrance assessment arithmetic scores, along with the intervention variables of completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and consistently participating in support services predict academic success (as determined by the grade earned in the MAT 772 – Applied Math course) for the underprepared vocational math students in this study?* A multinomial logistic regression analysis attempts to predict a dependent variable from a combination of several other variables. Logistic regression has the ability to analyze continuous, discrete, and dichotomous variables concurrently, without assuming a linear relationship between the variables (Tabachnick & Fidell, 2007).

This study examined whether the level of academic success in MAT 772 – Applied Math (the minimum level math course required for graduation in vocational programs) could be predicted well from a combination of several of the other variables. The variables available were age; gender; socioeconomic status; level of math preparedness (slightly underprepared, moderately underprepared, and severely underprepared) of underprepared vocational math students, based on their arithmetic CPT scaled score; as well as interventions such as the level of success in a developmental math course; utilization of tutoring services; utilization of computer-aided math software; and participation in consistent support services (TRIO). In this study, it was assumed that all of the predictor variables listed were important and the highest possible multiple correlations of these variables with the dependent variable were determined.
The major assumptions of multinomial logistic regression analysis include: the relationship between each of the predictor variables and the dependent variable is linear, the errors are normally distributed, the variance of the residuals (difference between actual and predicted scores) is constant, and there is minimal multicollinearity (Morgan et al., 2007). Multicollinearity occurs when there are high intercorrelations among some of the sets of predictor variables. When variables are highly correlated, they can produce issues of multicollinearity when they are combined in a regression to predict an outcome, such as with a correlation of .90 and above (Tabachnick & Fidel, 2007). Multicollinearity was checked, and there were no high correlations among any of the variables.

When the analysis was conducted, there was a large percentage (46.9%) of dependent variable levels by subpopulations with zero frequencies. This was due to the limited number of participants in the study (N = 1,156) and the large number of independent variables and dependent variables. The model was not a good fit. Therefore, the dependent variable was recoded as only two outcomes, pass or fail. Students at the community college in this study can graduate with a D– in MAT 772 – Applied Math.

A hierarchical logistic regression analysis was then conducted utilizing the dependent variables of pass or fail for MAT 772 – Applied Math. The logistic model was examined for goodness-of-fit using the Hosmer and Lemeshow test, “where a good model produces a nonsignificant chi-square” (Tabachnick & Fidel, 2007, p. 459) and a value that is not significant at $p > .05$. This analysis is appropriate for categorical outcome variables—in this study whether students passed or failed MAT 772 – Applied Math.
Data Access and Security

The data for this study were compiled by community college employees. The Director of Institutional Research gathered initial data, including name, student identification number, as well as other demographic and intervention data, about the students. The director then provided the data in an Excel spreadsheet to the Associate Dean of Instruction (in this case, the researcher). For the same years, the Student Success Coordinator provided the Associate Dean of Instruction sign-in sheets for mathematics tutoring, which included student names as well as dates and hours during which students received tutoring. The Associate Dean of Instruction then compiled the hours each student had been tutored and entered the number of hours in the Excel spreadsheet. The division chair for Math and Science provided the Associate Dean of Instruction a password to pull the list of student names and the hours spent utilizing computerized mathematics from the computer-aided math software (MyMathLab). The Associate Dean of Instruction then entered the hours spent into the spreadsheet.

The names and student identification numbers were then removed from the Excel spreadsheet. After the names and student identification numbers had been removed, the data in the Excel spreadsheet were then transferred over to the SPSS software. No names or identification numbers were ever entered into the SPSS software in case the researcher needed assistance for research purposes.

The raw data accessed, with no student names or identification numbers, were loaded into the SPSS software with the students numbered from 1 to 3,313. Human subjects’ approval was received from the midwestern community college where the students were enrolled and from the Iowa State University Institutional Review Board (IRB; see appendix).
The researcher was aware of the sensitive nature of data and continued to comply with all restrictions on the use of data. No student data were reported without aggregating the data to at least five cases in order to maintain the anonymity of the individuals whose information was in the dataset.

**Limitations**

The data for this study were from a secondary dataset collected from a midwestern community college. The findings regarding students in a midwestern community college may be very different than those for students in other areas around the country today and may not be representative of other institutions that may be far more diverse.

The demographic information was gathered through self-reporting and relied on the honesty and ability of the students to correctly interpret and answer the questions. In some cases, language barriers may have been a factor. The application for admission was completed in English.

The size of the study was small. A national study would provide more variability in student demographics. In this study, the category of “Asian and other” for race/ethnicity consisted of students that declared as Asian or other, or refused to indicate. Extreme caution should be used when interpreting data in this category.

College readiness can be measured in many ways including transcript analysis, cognitive test scores from standardized tests, and personal information about students. In this study, student math preparedness was measured by one assessment: the student’s score on a computerized placement test taken upon admission to college. Some students may not have realized the importance of the placement test and, therefore, may not have put forth their full effort. The potential lack of effort taking the assessment could have skewed the data.
Therefore, caution must be used when considering math preparedness in the data in this study.

In this study, academic success was measured by grades earned in a specific course. Because success was based on a grade received for a course instead of a common assessment, caution should be used. Not all courses may have been graded the same. However, all instructors were given a suggested rubric for grading.

One of the limitations to using a secondary data set is that there are certain limitations to the data available. All of the variables a researcher would like to include may not be available. More variables, such as math courses taken in high school, grades earned in those math courses in high school, overall grade point average, parents’ education, number of hours worked, and dependency status, would have been valuable to this study. Those factors could have contributed to the success of the participants and enriched this study.

The sample size in this study was too small to effectively utilize the multinomial logistic regression model. Therefore, a logistic regression model with a dichotomous dependent variable needed to be utilized. This limited the variability of the results.
CHAPTER 4. FINDINGS

This chapter presents the findings of the analysis conducted with the data for the underprepared vocational math students at a midwestern community college. The analysis focused on data for the 1,156 students who registered Spring 2007 through Spring 2012 for the minimum level math course required for vocational programs in order to graduate.

These students had completed the CPT upon admission to the college and had earned scaled scores on the CPT that were below the score determined by the college’s Developmental Education Taskforce to be appropriate for success. This taskforce studied the effectiveness of the testing and the coursework, worked with the Institutional Research Department at the college to track and analyze data about students who had taken developmental courses, researched placement scores from other institutions, and consulted with the College Board, which provided the ACCUPLACER CPT. A student with a score of 57 was determined by the taskforce to be ready to take the lowest college level math course required for graduation in vocational programs.

As described in the research questions guiding this study, the analysis examined the characteristics of the underprepared vocational math students. The differences in the mean academic success of underprepared vocational math students based on the size of the gap of the deficiency on their level of math preparedness (slightly underprepared, moderately underprepared, and severely underprepared; based on their arithmetic CPT scaled score) were analyzed. Also examined were the differences in the mean academic success of underprepared vocational math students based on student major as classified by Career Cluster. In addition, the analysis determined to what extent student characteristics, as well as interventions of completing a developmental math course, utilizing tutoring services,
utilizing computer-aided math software, and consistently participating in support services, predicted academic success (as determined by grades in the minimum level math course required for vocational students to graduate). This chapter presents the findings of these analyses.

Descriptive Statistics

The first research question asked: What are the characteristics of this study’s underprepared vocational math students such as age, gender, ethnicity/race, socioeconomic status, declared major of study, and level of deficiency in math preparedness based on the entrance assessment arithmetic scores? Data from the cohort of the underprepared vocational math students at the community college in this study during the spring of 2007 through the spring of 2012 were analyzed to address this question. Findings include descriptive statistics for the student characteristics.

The descriptive statistics for the characteristics for the 1,156 underprepared vocational math students are provided in Table 4.1. The majority of the students were traditional age (age 24 or younger) and comprised 56.6% (n = 654) of the vocational students underprepared in math. Nontraditional students (age 25 or older) comprised 43.4% (n = 502) of the students studied.

The majority of the underprepared vocational math students in this study were female. Female students comprised 56.7% (n = 655) of the students, and male students comprised 43.3% (n = 501). Community colleges have helped increase the representation of female and minority students in the fields of science, technology, engineering, and mathematics (STEM; Starobin & Laanan, 2005). The National Science Foundation has played an important role and has funded programs such as STEM. Among one midwestern
Table 4.1

*Characteristics of Underprepared Vocational Math Students*

<table>
<thead>
<tr>
<th>Variable</th>
<th>$n$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional (age 24 or younger)</td>
<td>654</td>
<td>56.6</td>
</tr>
<tr>
<td>Nontraditional (age 25 or older)</td>
<td>502</td>
<td>43.4</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>501</td>
<td>43.3</td>
</tr>
<tr>
<td>Female</td>
<td>655</td>
<td>56.7</td>
</tr>
<tr>
<td>Ethnicity/Race</td>
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</tr>
<tr>
<td>Hispanic</td>
<td>156</td>
<td>13.5</td>
</tr>
<tr>
<td>White</td>
<td>797</td>
<td>68.9</td>
</tr>
<tr>
<td>Black</td>
<td>60</td>
<td>5.2</td>
</tr>
<tr>
<td>Asian and other</td>
<td>143</td>
<td>12.4</td>
</tr>
<tr>
<td>Socioeconomic status</td>
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</tr>
<tr>
<td>Pell grant eligible</td>
<td>830</td>
<td>71.8</td>
</tr>
<tr>
<td>Non-Pell grant eligible</td>
<td>326</td>
<td>28.2</td>
</tr>
<tr>
<td>Career Cluster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture, Food &amp; Natural Resources</td>
<td>44</td>
<td>3.8</td>
</tr>
<tr>
<td>Architecture &amp; Construction</td>
<td>73</td>
<td>6.3</td>
</tr>
<tr>
<td>Arts, A/V Technology &amp; Communication</td>
<td>19</td>
<td>1.6</td>
</tr>
<tr>
<td>Business Management &amp; Administration</td>
<td>90</td>
<td>7.8</td>
</tr>
<tr>
<td>Education &amp; Training</td>
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<td>1</td>
</tr>
<tr>
<td>Finance</td>
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<td>1</td>
</tr>
<tr>
<td>Health Science</td>
<td>243</td>
<td>21</td>
</tr>
<tr>
<td>Human Services</td>
<td>63</td>
<td>5.4</td>
</tr>
<tr>
<td>Information Technology</td>
<td>50</td>
<td>4.3</td>
</tr>
<tr>
<td>Law, Public Safety, Corrections &amp; Security</td>
<td>95</td>
<td>8.2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>18</td>
<td>1.6</td>
</tr>
<tr>
<td>Transportation, Distribution &amp; Logistics</td>
<td>94</td>
<td>8.1</td>
</tr>
<tr>
<td>General Studies</td>
<td>181</td>
<td>15.7</td>
</tr>
<tr>
<td>Level of preparedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severely underprepared</td>
<td>348</td>
<td>30.1</td>
</tr>
<tr>
<td>Moderately underprepared</td>
<td>545</td>
<td>47.1</td>
</tr>
<tr>
<td>Slightly underprepared</td>
<td>263</td>
<td>22.8</td>
</tr>
</tbody>
</table>
state’s community colleges, the number of female STEM students increased from 31% in 2008 to 51% in 2012 (Iowa Department of Education, 2012).

The majority of the underprepared vocational math students in this study (68.9%, n = 797) declared their ethnicity/race as White. Hispanic students comprised 13.5% (n = 156), Blacks comprised 6.0% (n = 60), and Asian and “other” students comprised 12.4% (n = 143) of the sample.

In this study, socioeconomic status was based on students’ eligibility for federal Pell benefits as reported in the secondary data set. Students eligible for federal Pell benefits were considered low-income students. Almost three-quarters 71.8% (n = 830) of the underprepared vocational math students in this study were considered low-income students. The non-low-income students comprised 28.2% (n = 326) of the students.

The largest percentage of the underprepared vocational math students in this study had a declared major in the Health Science Career Cluster. Health Science students comprised 21.0% (n = 243) of the students; students with a General Studies major were 15.7% (n = 181); Law, Public Safety, Corrections & Security were 8.2% (n = 95); Transportation, Distribution & Logistics were 8.1% (n = 94); Business Management & Administration were 7.8% (n = 90); Architecture & Construction were 6.3% (n = 73); Human Services were 5.4% (n = 63); Information Technology were 4.3% (n = 50); Arts, A/V Technology & Communication and Manufacturing were both 1.6% (n = 19 and n = 18, respectively); and Education & Training along with Finance were both 1.0% (n = 11 for both) of the sample. As a side note, the percentage of students declaring a major in the General Studies category (15.7%, n = 181) was of some concern, as it raised questions about
the appropriateness of them enrolling in MAT 772 – Applied Math (a math course for vocational programs), which will be discussed in more detail in Chapter 5.

In this study, the largest percentage of the students in the sample were moderately underprepared, comprising 47.1% \((n = 545)\) of all the underprepared vocational math students. Students who were severely underprepared comprised 30.1% \((n = 348)\) and those who were slightly underprepared comprised 22.8% \((n = 263)\) of the sample.

**Inferential Statistics**

After determining the frequencies of the demographic characteristics of the underprepared vocational math students and the frequencies of the level of success in the required math course for graduation (MAT 772), a cross-tabulation analysis comparing actual counts and expected counts was conducted. Pearson chi-square tests were conducted to determine if there were statistically significant differences in the counts and expected counts between the variables. Assumptions were checked and met. In each category, all frequency counts exceeded five observations. Phi was determined to indicate the strength of the association between the variables. The results are provided in Table 4.2.

Investigating whether traditional or nontraditional students differed on their level of success, the chi-square results indicated that traditional- and nontraditional-age students were significantly different on their level of success in MAT 772 – Applied Math \((\chi^2 = 5.76, df = 2, N = 1,156, p = .056)\). Traditional students were, under the null hypothesis, more likely than expected to fail and less likely to pass MAT 772 – Applied Math. Nontraditional students, under the null hypothesis, were less likely than expected to fail and more likely to pass MAT 772 – Applied Math. Phi, which indicates the strength of the association between the variables, was .071, and thus, the effect size was considered to be small (Cohen, 1988).
Table 4.2

Underprepared Vocational Math Students and Level of Success

<table>
<thead>
<tr>
<th>Variable</th>
<th>MAT 772 success level</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Fail or drop</td>
<td>Borderline pass</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional (age 24 or younger)</td>
<td>654</td>
<td>228</td>
<td>157</td>
</tr>
<tr>
<td>Nontraditional (age 25 or older)</td>
<td>502</td>
<td>142</td>
<td>137</td>
</tr>
<tr>
<td>Totals</td>
<td>1,156</td>
<td>370</td>
<td>294</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>501</td>
<td>168</td>
<td>138</td>
</tr>
<tr>
<td>Female</td>
<td>655</td>
<td>202</td>
<td>156</td>
</tr>
<tr>
<td>Ethnicity/Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>156</td>
<td>53</td>
<td>44</td>
</tr>
<tr>
<td>White</td>
<td>797</td>
<td>241</td>
<td>196</td>
</tr>
<tr>
<td>Black</td>
<td>60</td>
<td>21</td>
<td>16</td>
</tr>
<tr>
<td>Asian and other</td>
<td>58</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pell grant eligible</td>
<td>830</td>
<td>276</td>
<td>209</td>
</tr>
<tr>
<td>Non-Pell grant eligible</td>
<td>326</td>
<td>94</td>
<td>85</td>
</tr>
</tbody>
</table>

In investigating whether males and females differed on their level of success, as shown in Table 4.2, the chi-square results indicated that males and females were significantly different at the \( p = .08 \) level on their level of success in MAT 772 – Applied Math (\( \chi^2 = 4.94, df = 2, N = 1,156, p = .084 \)). Male students, under the null hypothesis, were more likely than expected to fail and less likely to pass MAT 772 – Applied Math. Female students, under the null hypothesis, were less likely than expected to fail and more likely to pass MAT 772 – Applied Math. Phi, which indicates the strength of the association between the variables, was .065, and thus, the effect size was considered to be small.

Also shown in Table 4.2 is the chi-square statistic for ethnicity/race. White students and Asian and other students were different on their level of success in MAT 772 – Applied Math. Under the null hypothesis, White students, \( \chi^2 = 6.08, df = 2, N = 1,156, p = .048 \), were
less likely to fail and more likely to pass MAT 772 – Applied Math. Under the null hypothesis, Asian and other students, $\chi^2 = 11.744$, $df = 2$, $N = 1,156$, $p = .003$, were less likely to pass and more likely to fail MAT 772 – Applied Math. Phi, which indicates the strength of the association between the variables, was .078 for White students and .108 for Asian and other students. Thus, the effect size was considered to be small.

As shown in Table 4.2, in investigating whether Pell grant eligible and non-Pell grant eligible students differed on their level of success, the chi-square results indicated there was not a significant difference between Pell grant eligible and non-Pell grant eligible students on their level of success in MAT 772 – Applied Math.

In answering research questions #2 and #3, a one-way ANOVA procedure was utilized. The ANOVA procedure assumes that the three independent variable groups are independent of the population, evenly distributed, and have equal variances (Morgan et al., 2007). Because the number of observations varied for each group, a Levene’s test of homogeneity of variance was used to determine whether the three groups had equal variances.

The second research question asked: Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math course) of underprepared vocational math students based on the level of the deficiency in math as described by slightly underprepared, moderately underprepared, and severely underprepared (based on the entrance assessment arithmetic score)? A one-way ANOVA was utilized to evaluate the differences in the mean academic success of the underprepared vocational math students based on the gap of the deficiency on their level of math preparedness. This procedure was used to determine if there was a relationship between the size of the deficiency gap and the
dependent variable, academic success (as determined by the grade earned in the MAT 772 – Applied Math, the minimum level math course required for graduation in vocational programs).

In order to examine the differences in mean academic success of the underprepared vocational math students, the arithmetic CPT scaled scores of the students were identified. The CPT scaled score shows what the score would have been if the test-taker had answered 120 questions with a similar competency. The students were then sorted by their level of math preparedness. A student earning a scaled score of 46–56 was classified as slightly underprepared, 31–45 moderately underprepared, and 20–30 severely underprepared. This was based on the recommendations of the College Board (which provided the ACCUPLACER CPT) of the criteria to be used to determine whether a student had below minimal arithmetic skills, minimal arithmetic skills, or adequate arithmetic skills.

A statistically significant difference was found among the three levels of preparedness on the grade earned in MAT 772 – Applied Math, $F(2, 1153) = 4.04, p = .018$. As shown in Table 4.3, the mean grade earned in MAT 772 – Applied Math was 3.07 for students who were classified as severely underprepared, 3.67 for students who were classified as moderately underprepared, and 3.68 for students who were classified as slightly underprepared. Based on how grades were coded for the analysis ($0 = F$ or dropped, $1 = D−$, $2 = D$, $3 = D+$, $4 = C−$, $5 = C$, $6 = C+$, $7 = B−$, $8 = B$, $9 = B+$, $10 = A−$, and $11 = A$), the mean scores represented a letter grade of approximately a D+ or C−.

In this analysis, the Levene’s test of homogeneity was significant, which means the assumption of equal variances could not be justified. Therefore, a post hoc Games–Howell test was conducted. Using the Games-Howell post hoc test (see Table 4.4), there was a
Table 4.3

**Means and Standard Deviations of Grades Earned in MAT 772 by Level of Math Preparedness**

<table>
<thead>
<tr>
<th>Level of preparedness</th>
<th>n</th>
<th>Grade in MAT 772</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M*</td>
</tr>
<tr>
<td>Severely underprepared</td>
<td>348</td>
<td>3.07</td>
</tr>
<tr>
<td>Moderately underprepared</td>
<td>510</td>
<td>3.67</td>
</tr>
<tr>
<td>Slightly underprepared</td>
<td>298</td>
<td>3.68</td>
</tr>
<tr>
<td>Total</td>
<td>1,156</td>
<td>3.49</td>
</tr>
</tbody>
</table>

*Grades were coded as 0 = F or dropped, 1 = D–, 2 = D, 3 = D+, 4 = C–, 5 = C, 6 = C+, 7 = B–, 8 = B, 9 = B+, 10 = A–, and 11 = A.

Table 4.4

**One-Way Analysis of Variance Summary Table Comparing Student Level of Math Preparedness with Grade Earned in MAT 772**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of preparedness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>2</td>
<td>90.044</td>
<td>45.022</td>
<td>4.044</td>
<td>.018</td>
</tr>
<tr>
<td>Within groups</td>
<td>1153</td>
<td>12836.869</td>
<td>11.133</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1155</td>
<td>12926.913</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A statistically significant difference was found on the grade earned in MAT 772 – Applied Math between the severely underprepared students and both the moderately underprepared students ($p = .047$, $d = .18$) and the slightly underprepared students ($p = .020$, $d = .18$). According to Cohen (1988), this is a small or smaller than typical effect size, which indicates strength of the relationship. In this situation, even though there was a significant relationship found, the difference was less than the difference between a letter grade of C– and D+ and was not considered a practical significance.
A cross-tabulation analysis was conducted comparing actual counts and expected counts based on the level of math preparedness and the level of success in MAT 772. Pearson chi-square tests were conducted to determine if there were statistically significant differences in the counts and expected counts between the variables. Assumptions were checked. In each category all frequencies contained more than five observations. Phi was determined to indicate the strength of the association between the variables. The results are provided in Table 4.5.

Table 4.5

*Frequencies in Level of Underpreparedness of Vocational Math Students*

<table>
<thead>
<tr>
<th>Level of preparedness</th>
<th>MAT 772 success level</th>
<th>$\chi^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Fail or drop</td>
<td>Borderline pass</td>
</tr>
<tr>
<td>Severely underprepared</td>
<td>348</td>
<td>128</td>
<td>90</td>
</tr>
<tr>
<td>Moderately underprepared</td>
<td>545</td>
<td>161</td>
<td>120</td>
</tr>
<tr>
<td>Slightly underprepared</td>
<td>263</td>
<td>81</td>
<td>84</td>
</tr>
</tbody>
</table>

Severely underprepared, moderately underprepared and slightly underprepared students differed on their level of success in MAT 772 – Applied Math, $\chi^2 = 9.49$. $df = 4$, $N = 1,156$, $p = .050$. Severely underprepared students, under the null hypothesis, were more likely to fail and less likely to pass MAT 772 – Applied Math. Moderately underprepared and slightly underprepared students were less likely to fail and more likely to pass MAT 772 – Applied Math. Phi, which indicates the strength of the association between the variables, was .091 and thus, the effect size was considered to be small.

The third research question asked: *Are there differences in the academic success (as determined by the grade in the MAT 772 – Applied Math) of underprepared vocational math*
students based on the declared major program of study as classified by Career Cluster? A one-way ANOVA was utilized to evaluate the differences in the mean academic success of the underprepared vocational math students (as determined by the grade earned in the MAT 772 – Applied Math), based on the students’ declared major (as categorized by the national 16 Career Cluster areas). In examining the data for this research question, the Levene’s test of homogeneity was not significant, which means the assumption of equal variances was justified. Therefore, a post hoc Tukey test was conducted.

A statistically significant difference was found between two of the students’ declared majors (as categorized by Career Cluster) and the grade earned in MAT 772 – Applied Math, \( F(12, 979) = 2.437, p = .004 \). Mean grades in MAT 772 – Applied Math for the various Career Cluster areas are shown in Table 4.6. The mean grade in MAT 772 – Applied Math was 2.18 (equivalent to a grade letter of D) for students in the Architecture & Construction Career Cluster and 5.91 (equivalent to a grade letter of C+) for students in the Finance Career Cluster.

A question answered by the post hoc Tukey HSD Test was whether these discrepancies between observed and expected counts were larger than one might expect by chance. Post hoc Tukey HSD tests (see Table 4.7) indicated that the Architecture & Construction Career Cluster group and the Finance Career Cluster group differed significantly in their grades \( (p < .05, d = 1.12; \text{see Table 4.6}) \). According to Cohen (1988), this is a much larger effect than usual. This also has practical significance in that a grade of D and a grade of a C+ have different meanings in terms of academic success.
Table 4.6

Means and Standard Deviations of Grades Earned in MAT 772 by Student Major

<table>
<thead>
<tr>
<th>Student major</th>
<th>n</th>
<th>Grade in MAT 772</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Food &amp; Natural Resources</td>
<td>44</td>
<td>4.25</td>
<td>3.383</td>
</tr>
<tr>
<td>Architecture &amp; Construction</td>
<td>73</td>
<td>2.18</td>
<td>3.093</td>
</tr>
<tr>
<td>Arts, A/V Technology &amp; Communication</td>
<td>19</td>
<td>3.42</td>
<td>3.271</td>
</tr>
<tr>
<td>Business Management &amp; Administration</td>
<td>90</td>
<td>3.72</td>
<td>3.566</td>
</tr>
<tr>
<td>Education &amp; Training</td>
<td>11</td>
<td>3.18</td>
<td>2.926</td>
</tr>
<tr>
<td>Finance</td>
<td>11</td>
<td>5.91</td>
<td>2.809</td>
</tr>
<tr>
<td>Health Science</td>
<td>243</td>
<td>3.51</td>
<td>3.396</td>
</tr>
<tr>
<td>Human Services</td>
<td>63</td>
<td>3.79</td>
<td>3.178</td>
</tr>
<tr>
<td>Information Technology</td>
<td>50</td>
<td>3.80</td>
<td>3.470</td>
</tr>
<tr>
<td>Law, Public Safety, Corrections &amp; Security</td>
<td>95</td>
<td>2.78</td>
<td>3.166</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>18</td>
<td>2.72</td>
<td>3.304</td>
</tr>
<tr>
<td>Transportation, Distribution &amp; Logistics</td>
<td>94</td>
<td>3.19</td>
<td>3.345</td>
</tr>
<tr>
<td>General Studies</td>
<td>181</td>
<td>2.92</td>
<td>3.214</td>
</tr>
<tr>
<td>Total</td>
<td>992</td>
<td>3.30</td>
<td>3.335</td>
</tr>
</tbody>
</table>

Grades were coded as 0 = F or dropped, 1 = D-, 2 = D, 3 = D+, 4 = C-, 5 = C, 6 = C+, 7 = B-, 8 = B, 9 = B+, 10 = A-, and 11 = A.

Table 4.7

One-Way Analysis of Variance Summary Comparing Student Major, as Determined by Career Cluster, with Grade Earned in MAT 772

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student major</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>12</td>
<td>319.794</td>
<td>26.649</td>
<td>2.437</td>
<td>.004</td>
</tr>
<tr>
<td>Within groups</td>
<td>979</td>
<td>10704.665</td>
<td>10.934</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>991</td>
<td>11024.459</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A cross-tabulation analysis was conducted comparing actual counts and expected counts based on the major program of study, or Career Cluster, and the level of success in MAT 772. The results are provided in Table 4.8. Pearson chi-square tests were conducted to determine if there were statistically significant differences in the counts and expected counts between the variables. Assumptions were checked. Eighty percent of the expected counts were greater than five as required for the chi-square test (Morgan et al., 2007).

Students in the various Career Cluster groups differed on their level of success in MAT 772 – Applied Math, $\chi^2 = 33.38$, $df = 24$, $n = 992$, $p = .032$. Students in the Architecture & Construction; Law, Public Safety, Corrections & Security; Manufacturing;

Table 4.8

<table>
<thead>
<tr>
<th>Career Cluster</th>
<th>MAT 772 success level</th>
<th>$\chi^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail or drop</td>
<td>Borderline pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Agriculture, Food &amp; Natural Resources</td>
<td>11</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>Architecture &amp; Construction</td>
<td>37</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Arts, A/V Technology &amp; Communication</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Business Management &amp; Administration</td>
<td>28</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>Education &amp; Training</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Finance</td>
<td>0</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Health Science</td>
<td>81</td>
<td>56</td>
<td>106</td>
</tr>
<tr>
<td>Human Services</td>
<td>19</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>Information Technology</td>
<td>15</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>Law, Public Safety, Corrections &amp; Security</td>
<td>41</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Transportation, Distribution &amp; Logistics</td>
<td>37</td>
<td>17</td>
<td>40</td>
</tr>
<tr>
<td>General Studies</td>
<td>71</td>
<td>46</td>
<td>64</td>
</tr>
<tr>
<td>Totals</td>
<td>357</td>
<td>236</td>
<td>399</td>
</tr>
</tbody>
</table>
Transportation, Distribution & Logistics; and the General Studies Career Clusters under the null hypothesis were more likely than expected by chance to fail MAT 772 – Applied Math. Students in the Agriculture, Food & Natural Resources; Business Management & Administration; Finance; Health Science; Human Services; and Information Technology Career Clusters under the null hypothesis were more likely than expected by chance to pass MAT 772 – Applied Math. Phi, which indicates the strength of the association between the variables, was .197, and thus, the effect size was considered to be small.

Note that in looking at the cross-tabulation table, several groups had quite small numbers of observations. A consideration was given to recode Career Clusters into clusters of related industries (Maguire, 2009). In following this method, one could look at the Career Clusters as follows:

- General Studies;
- Health Sciences;
- Law, Public Safety, Corrections & Security;
- Transportation, Distribution & Logistics;
- Business Management & Administration; Arts A/V Technology & Communication; Education and Training; Finance; Human Services; Information Technology; and
- Agriculture, Food & Natural Resources; and Manufacturing.

However, in comparing the observed counts of students passing and failing in the career clusters that would be grouped together using Maguire’s (2009) method, there were drastic differences between the pass and fail rates in clusters in some of the groups. Therefore, a decision was made to keep them separate. However, because there were such
small numbers in these groups, the major program of study or Career Cluster was omitted from the fourth research question.

The fourth research question asked: *To what extent do student characteristics of age, gender, socioeconomic status, level of deficiency in math preparedness based on the entrance assessment arithmetic scores, along with the intervention variables of completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and consistently participating in support services predict academic success (as determined by the grade earned in the MAT 772 – Applied Math course) for the underprepared vocational math students in this study?* Academic success for this research question was based on the level of success in MAT 772 – Applied Math. The grade in MAT 772 – Applied Math was used to determine if the student failed or dropped the course, borderline passed with a grade of C– to D–, or successfully passed with a grade of a C or better. In order to address this research question, a multinomial logistic regression analysis was conducted.

Multinomial logistic regression is useful in situations when one wants to be able to classify subjects based on values of a set of predictor variables and the dependent variable is not restricted to two categories (IBM Corporation, 1989, 2012). In this study, it was presumed that all predictor variables were important and that this analysis would determine the highest possible multiple correlation of these variables with the dependent variable.

When the hierarchical multinomial logistic regression analysis was conducted, there were 451 (47.6%) cells with zero frequencies. Because there were so many missing cells, the deviance and chi-square distribution could no longer be used as an overall goodness-of-fit indicator. Academic success was then measured as pass or fail for MAT 772 – Applied
A hierarchical logistic regression analysis was then conducted. The dependent variable in this case was either pass or fail MAT 772 – Applied Math.

Multicollinearity can cause problems in regression analysis because it can make it difficult to identify the relationship between predictors and the dependent variable (Urdan, 2010). No variables were highly correlated. The logistic model was examined for goodness-of-fit using the Hosmer and Lemeshow test “where a good model produces a nonsignificant chi-square” (Tabachnick & Fidell, 2007, p. 459) and a value that is not significant at $p > .05$. Both phases of the logistic regression showed a good fit with the Hosmer and Lemeshow test with $p = .75$ for Model 1 and $p = .66$ for Model 2.

The first phase was to investigate whether the independent demographic variables differed on whether the participants passed or failed MAT 772 – Applied Math by utilizing chi-square statistics. Assumptions were evaluated for each of the independent variables: age, gender, race/ethnicity, socioeconomic status, and level of deficiency in math preparedness. The results are shown in Table 4.9.

The results indicated that age was statistically significant in passing or failing MAT 772 – Applied Math, $\chi^2 = 5.64, df = 1, N = 1,156, p = .018$; nontraditional students were more likely than expected under the null hypotheses to pass MAT772 – Applied Math. The results also showed that the MAT 772 – Applied Math pass/fail rates of White students were statistically significant, $\chi^2 = 3.69, df = 1, N = 1,156, p = .055$; White students were more likely than expected under the null hypotheses to pass MAT772 – Applied Math than were non-White students. The MAT 772 – Applied Math pass/fail rates of Asian and other race students also were statistically significant, $\chi^2 = 9.08, df = 1, N = 1,156, p = .003$; Asian and other race students were more likely than expected under the null hypotheses to pass
Table 4.9

*Correlations of Predictor Variables with MAT 772*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Correlation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.070</td>
<td>.018</td>
</tr>
<tr>
<td>Gender</td>
<td>.029</td>
<td>.331</td>
</tr>
<tr>
<td>Hispanic</td>
<td>−.017</td>
<td>.572</td>
</tr>
<tr>
<td>White</td>
<td>.056</td>
<td>.055</td>
</tr>
<tr>
<td>Black</td>
<td>−.015</td>
<td>.610</td>
</tr>
<tr>
<td>Asian and other</td>
<td>−.089</td>
<td>.003</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>.043</td>
<td>.148</td>
</tr>
<tr>
<td>Math preparedness</td>
<td>.077</td>
<td>.009</td>
</tr>
<tr>
<td>Developmental course</td>
<td>.084</td>
<td>.017</td>
</tr>
<tr>
<td>Tutoring</td>
<td>.016</td>
<td>.595</td>
</tr>
<tr>
<td>Computerized math software</td>
<td>.026</td>
<td>.380</td>
</tr>
<tr>
<td>Student support services</td>
<td>.069</td>
<td>.019</td>
</tr>
</tbody>
</table>

MAT772 – Applied Math than were non-Asian and other race students. The level of math preparedness was statistically significant in passing or failing MAT 772 – Applied Math, $\chi^2 = 6.88$, $df = 1$, $N = 1,156$, $p = .009$; moderately underprepared and slightly underprepared students were more likely than expected under the null hypotheses to pass MAT772 – Applied Math than severely underprepared students.

The next phase was to investigate, utilizing chi-square statistics, whether the independent intervention variables differed on whether the participants passed or failed MAT 772 – Applied Math. Assumptions were evaluated for each of the independent variables: successfully completing a developmental math course, utilizing tutoring services, utilizing computer-aided math software, and participating in consistent support services. The results also are shown in Table 4.9.
Successful completion of a developmental course MAT 041 – Basic Math was a statistically significant factor in passing or failing MAT 772 – Applied Math, $\chi^2 = 8.21, \text{df} = 1, N = 1,156, p = .017$; students who borderline passed or passed MAT 041 – Basic Math were more likely than expected under the null hypotheses to pass MAT 772 – Applied Math than were students who failed or didn’t complete MAT 041 – Basic Math. Participation in a consistent student support program was statistically significant in whether students passed or failed MAT 772 – Applied Math, $\chi^2 = 5.52, \text{df} = 1, N = 1,156, p = .019$; students who participated were more likely than expected under the null hypotheses to pass MAT 772 – Applied Math than were nonparticipating students. The remaining independent variables were not statistically significant (at the .05 significance level) in whether students passed or failed MAT 772 – Applied Math.

A hierarchical logistic regression analysis was conducted utilizing the demographic variables and the intervention variables. None of the variables were excluded. No cases had missing data.

Block 1 included demographic variables: age, gender, Hispanic, White, Black, Asian and other, socioeconomic status, and level of deficiency in math preparedness. These variables collectively were significant in predicting success in MAT 772 – Applied Math. The .030 Naglekerke $R^2$ value (with a maximum possible value of 1.0) indicates that success in MAT 772 – Applied Math could be accounted for only minimally by these demographic variables. The classification table indicated that the regression could predict only 3.2% of those that did not pass and 98.5% for those that did pass for an overall rate of 68.0%. The odds of estimating correctly who successfully completes MAT 772 – Applied Math improves by 68% if the student demographic characteristics are known. This model showed
statistically significant results in the passing or failing of MAT 772 – Applied Math, $\chi^2 = 24.638$, df = 9, $N = 1,156$, $p = .003$, indicating that the predictors, as a set, reliably distinguished between passing and failing MAT 772 – Applied Math.

Block 2 added the intervention variables of completing a developmental math course MAT 041 – Basic Math, utilizing tutoring services, utilizing computerized math software, and participating in consistent student support services. The combined effect of Blocks 1 and 2 showed statistically significant results in the passing or failing of MAT 772 – Applied Math, $\chi^2 = 39.728$, $df = 14$, $N = 1,156$, $p = <.001$. The Naglekerke $R^2$ value (with a maximum possible value of 1.0) improved to .047, which indicated that success in MAT 772 – Applied Math could be accounted for more adequately, but still minimally, by all demographic and intervention variables. The classification table for the hierarchical logistic regression when both demographic and intervention variables are considered is depicted in Table 4.10. The classification table for the block indicates correct classification of 5.7% of the nonpassers but only 97.1% of the passers. The odds of estimating correctly who successfully completes MAT 772 – Applied Math improves by 67.8% if the student demographic characteristics along with whether or not the student utilized the interventions are known. This was basically the same as Block 1 for which only the demographic characteristics were considered.

The full regression model is shown in Table 4.11. Upon examination of the regression model, under the null hypothesis, student’s age, race, socioeconomic status, level of preparedness, success in the developmental math course MAT 041 – Basic Math, and whether the student participated in a support services program (TRIO) were significant in predicting success.
Table 4.10  
*Classification Table for the Regression Model*

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted MAT 772 772 – Applied Math</th>
<th>Percentage Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fail</td>
<td>Pass</td>
</tr>
<tr>
<td>Step 1</td>
<td>MAT 772 772 – Applied Math</td>
<td></td>
</tr>
<tr>
<td>Fail</td>
<td>21</td>
<td>349</td>
</tr>
<tr>
<td>Pass</td>
<td>23</td>
<td>763</td>
</tr>
<tr>
<td>Overall Percentage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Cut value = .500.*

Table 4.11  
*Logistic Regression Predicting Student Success in MAT 772*

<table>
<thead>
<tr>
<th></th>
<th>Model 1 β</th>
<th>β</th>
<th>95% CI</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.632</td>
<td>5.460</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.702**</td>
<td>0.746*</td>
<td>0.570</td>
<td>0.976</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.913</td>
<td>0.956</td>
<td>0.736</td>
<td>1.241</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>0.780</td>
<td>0.744*</td>
<td>0.554</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.060</td>
<td>1.170</td>
<td>0.654</td>
<td>2.091</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>0.993</td>
<td>1.018</td>
<td>0.62</td>
<td>1.672</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>1.105</td>
<td>1.174</td>
<td>0.568</td>
<td>2.426</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian +</td>
<td>2.222*</td>
<td>2.345*</td>
<td>1.153</td>
<td>4.769</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately Underprepared</td>
<td>0.677*</td>
<td>0.656*</td>
<td>0.463</td>
<td>0.928</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly Underprepared</td>
<td>0.821</td>
<td>0.811</td>
<td>0.588</td>
<td>1.121</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borderline Passing MAT 041</td>
<td>0.762</td>
<td>0.565</td>
<td>1.027</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passing MAT 041 with C or higher</td>
<td>0.499*</td>
<td>0.286</td>
<td>0.868</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilizing Tutoring</td>
<td>0.967</td>
<td>0.584</td>
<td>1.603</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilizing Computerized Software</td>
<td>0.652</td>
<td>0.327</td>
<td>1.301</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilizing Student Support Services</td>
<td>0.455*</td>
<td>0.237</td>
<td>0.872</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.03</td>
<td>0.047</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>24.638*</td>
<td>39.73**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05. **p < .01.
As shown in Table 4.12, examination of a cross-tabulation of age by grade in MAT 772 – Applied Math revealed that nontraditional-age students were almost five times as likely as traditional students to pass MAT 772 – Applied Math. This indicates a proportionately much higher passage rate for nontraditional students. Students who were not considered low-income status were almost four times as likely as were low-income students to pass MAT 772 – Applied Math. Students who were Asian and other race were almost six times more likely to pass than were non-Asian and other race students. Moderately underprepared math students were almost six times more likely to pass than were severely underprepared math students. Student who completed MAT 041 – Basic math with a C– to D– were approximately three times more likely to pass, and students who earned a grade of C

<table>
<thead>
<tr>
<th>Variables</th>
<th>p</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.032</td>
<td>4.576</td>
</tr>
<tr>
<td>Gender</td>
<td>.733</td>
<td>0.116</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>.050</td>
<td>3.835</td>
</tr>
<tr>
<td>Hispanic</td>
<td>.597</td>
<td>0.279</td>
</tr>
<tr>
<td>White</td>
<td>.943</td>
<td>0.005</td>
</tr>
<tr>
<td>Black</td>
<td>.665</td>
<td>0.188</td>
</tr>
<tr>
<td>Asian +</td>
<td>.019</td>
<td>5.541</td>
</tr>
<tr>
<td>Moderately underprepared</td>
<td>.017</td>
<td>5.678</td>
</tr>
<tr>
<td>Slightly underprepared</td>
<td>.204</td>
<td>1.611</td>
</tr>
<tr>
<td>Intervention variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Borderline passing MAT 041</td>
<td>.074</td>
<td>3.183</td>
</tr>
<tr>
<td>Passing MAT 041 with C or higher</td>
<td>.014</td>
<td>6.051</td>
</tr>
<tr>
<td>Utilizing tutoring</td>
<td>.897</td>
<td>0.017</td>
</tr>
<tr>
<td>Utilizing computerized software</td>
<td>.225</td>
<td>1.470</td>
</tr>
<tr>
<td>Utilizing student support services</td>
<td>.018</td>
<td>5.632</td>
</tr>
</tbody>
</table>
or better were over six times more likely to pass. Students participating in consistent student support services were almost six times as likely to pass as well.

**Summary**

Following a review of the 1,156 student records, descriptive statistics were used to describe the underprepared vocational math students at the Midwestern community college in this study. Chi-square tests and cross-tabulation analyses were used to determine if there were significant differences between the counts and expected counts of the level of success in MAT 772 – Applied Math for those students based on the demographic characteristics.

A one-way ANOVA procedure was conducted to determine if there were differences in the success of underprepared vocational math students based on their level of math preparedness. Chi-square tests and cross-tabulation analysis also were used to determine if there were significant differences in the counts and expected counts of the level of success in MAT 772 – Applied Math for those students based on the demographic characteristics.

A one-way ANOVA procedure was conducted to determine if there were differences in the success of underprepared vocational math students based on their major program of study as classified by Career Cluster. Chi-square tests and cross-tabulation analysis also were used to determine if there were significant differences in the counts and expected counts of the level of success in MAT 772 – Applied Math for those students based on Career Cluster.

A multinomial logistic regression revealed that there was not a large enough sample to accurately provide results. Therefore, a hierarchical logistic regression analysis was conducted to determine the extent to which a prediction could be made on the success of passing MAT 772 based on demographic characteristics as well as the demographic characteristics and interventions.
CHAPTER 5. DISCUSSION AND CONCLUSIONS

This study attempted to provide guidance to community college administrators and advisors to assist underprepared vocational math students to become successful and complete their degree. This chapter provides a summary and discussion of the findings reported in Chapter 4. It then provides implications for practice and concludes with recommendations for further research and final thoughts.

Summary of Findings

In this *ex post facto* study, records of students who were admitted to this midwestern community college and registered for a vocational math course during the 2007–2012 academic years were examined. Of the vocational math students, this study focused on those students that were underprepared in math \((N = 1,156)\) based on their arithmetic entrance exam score. Data were collected on date of birth, gender, race/ethnicity, socioeconomic status as determined by Pell grant eligibility, arithmetic entrance exam scores, grades received in a developmental math course MAT 041 – Basic Math, tutoring records, computerized math software usage, and participation records for a student support service (TRIO). All were used as independent variables. Data on the final grade in MAT 772 – Applied Math (the minimum level vocational math course required for graduation) were used as dependent variables.

Descriptive statistical analyses were conducted to describe and summarize the data and to explore the nature of the underprepared vocational math students in this study. In this study, the majority (56.6%) of the underprepared vocational math students were traditional age (age 24 or younger). There were more females (at 56.7%) than there were males. The majority of the students were White (68.9%) and low income or Pell grant eligible (71.8%).
All of these demographic characteristics are typical of the entire student body at the community college in this study.

The largest percentage of the underprepared vocational math students in this study had a declared major in the Health Science Career Cluster. Health Science students comprised 21.0% of the students; students with a General Studies major were 15.7%; Law, Public Safety, Corrections & Security were 8.2%; Transportation, Distribution & Logistics were 8.1%; Business Management & Administration were 7.8%; Architecture & Construction were 6.3%; Human Services were 5.4%; Information Technology were 4.3%; Arts, A/V Technology & Communication and Manufacturing were both 1.6%; and Education & Training along with Finance were both 1.0% of the sample.

The percentage of students declaring a major in the General Studies category (15.7%) was of some concern, as it raised questions about the appropriateness of students enrolling in MAT 772 – Applied Math (a math course for vocational programs). The vocational math course, MAT 772 – Applied Math, is not the correct math course for students to complete if their intent is to transfer or earn an Associate of Arts degree. The General Studies degree is designed for students who are not pursuing a specific vocational degree. The practice of advising students with a General Studies major to take MAT 772 – Applied Math needs to be revisited. If a student selects General Studies as their major, the question of transferability needs to be discussed so that students are placed in the appropriate math course. A more appropriate math course would be one that is designed to provide students with an introduction to basic algebra and includes topics such as signed numbers, exponents, algebraic expressions, polynomials, roots and radicals, factoring, linear equations and inequalities, systems of equations, and graphing. Students need to be made aware that MAT
772 – Applied Math was not designed to prepare students to take upper level math courses. It is a terminal math course.

Based on the arithmetic entrance exam, the majority of the students were moderately underprepared (47.1%). Nearly one third (30.1%) were severely underprepared. Only 22.8% of the students were slightly underprepared.

A cross-tabulation analysis and chi-square tests were conducted to determine if there were significant differences in the actual counts and expected counts in the level of success in MAT 772 – Applied Math (based on failed, borderline passed with a C– to D–, or passed with a C or better) for each variable. Traditional students were, under the null hypothesis, more likely than expected to fail and less likely to pass MAT 772 – Applied Math. Nontraditional students were less likely than expected to fail and more likely to pass than expected. However, the strength of the association was small.

Male students, under the null hypothesis, were more likely than expected to fail and less likely to pass MAT 772 – Applied Math. Female students were less likely than expected to fail and more likely to pass. The strength of the associations also small.

White students, under the null hypothesis, were less likely to fail and more likely to pass MAT 772 – Applied Math. Asian and other race students were less likely to pass and more likely to fail than expected. The strength of theses associations was also small.

A one-way ANOVA was conducted to determine if there was a relationship between the size of the gap of the deficiency in math preparedness and academic success of underprepared vocational math students. The null hypotheses was that there were no differences in the mean academic success (as determined by the grade in the minimum required vocational math course) of underprepared vocational math students based on the
size of the gap of the deficiency on their level of math preparedness (slightly underprepared, moderately underprepared, and severely underprepared), based on their arithmetic CPT scaled score. A statistically significant difference in grade in MAT 772 – Applied Math was found among the three levels of preparedness. The mean grade score earned in MAT 772 – Applied Math (where 0 = F or dropped, 1 = D−, 2 = D, 3 = D+, 4 = C−, 5 = C, 6 = C+, 7 = B−, 8 = B, 9 = B+, 10 = A−, and 11 = A) was 3.07 for students who were classified as severely underprepared, 3.67 for students that were classified as moderately underprepared, and 3.68 for students who were classified as severely underprepared. The mean scores converted to approximately a D+ or C−. Even though a statistically significant difference was found in academic success among students in the three levels of preparedness, it was a very small effect size according to Cohen (1988). In this case, the difference was less than the difference between a grade of C− or D+, which is not considered a practical significance. Thus, the academic success between the students in the three levels of preparedness was not very different in terms of academic success based on grade.

A cross-tabulation analysis and chi-square tests were conducted to determine if there were significant differences in the actual counts and expected counts based on the level of math preparedness and the level of success in MAT 772 – Applied Math (based on failed, borderline passed with a C− to D−, or passed with a C or better). Severely underprepared students, under the null hypothesis, were more likely to fail and less likely to pass MAT 772 – Applied Math. Moderately underprepared and slightly underprepared students were less likely to fail and more likely to pass. Even though a statistically significant difference was found in academic success among students in the three levels of preparedness, it was a very small effect size according to Cohen (1988). In this case, however, the difference was
meaningful in that the difference of passing or failing the course results in success or failure in terms of academic credit and matters when completing a degree.

Research has shown a statistically significant difference in success based on the level of preparedness. Bahr’s (2012) research, which focused on community college students in California, revealed sizeable gaps in achievement between low-skilled and high-skilled students in remedial math and writing students. The Community College Research Center (Bailey et al., 2010) analyzed Achieving the Dream data and reported 31% of students referred to developmental math courses completed the recommended sequence of courses within three years, yet only 16% of the lowest level of developmental math students completed remediation. The findings of the present study was consistent with Bahr’s and Bailey et al.’s research that there is a significant difference in the academic success.

A one-way ANOVA was conducted to determine if there was a relationship between the students’ major (as categorized by the 16 Career Cluster areas) and academic success. The null hypothesis was that there were no differences in the mean academic success (as determined by the grade in the minimum required vocational math course) of underprepared vocational math students based on their major (as categorized according to the 16 Career Cluster areas).

The NADCTEc (2012) was established to support an innovative system to prepare students to succeed in their education and their careers. The consortium found one of the keys to improving student achievement was to provide students with relevant contexts for studying and learning. Career Clusters were developed as an important organizing tool for schools to develop more effective curriculum.
A difference was found in this study between students’ declared major (as categorized by Career Cluster) and grade earned in MAT 772 – Applied Math. With grade scores coded as $0 = F$ or dropped, $1 = D–$, $2 = D$, $3 = D+$, $4 = C–$, $5 = C$, $6 = C+$, $7 = B–$, $8 = B$, $9 = B+$, $10 = A–$, and $11 = A$, the mean grade score in MAT 772 – Applied Math was 2.18 (or D) for students in the Architecture & Construction Career Cluster and 5.91 (or C+) for students in the Finance Career Cluster. According to Cohen (1988), this is a much larger effect than usual. This has practical significance in that a grade of D and a grade of a C+ have different meanings in terms of academic success. A grade of C or better at this midwestern community college represents average achievement and a passing grade.

A cross-tabulation analysis and chi-square tests were conducted to determine if there were significant differences in the actual counts and expected counts based on the major program of study or Career Cluster and the level of success in MAT 772 – Applied Math (based on failed, borderline passed with a C– to D–, or passed with a C or better). Under the null hypothesis, students in the Architecture & Construction; Law, Public Safety, Corrections & Security; Manufacturing, Transportation, Distribution & Logistics; and General Studies Career Clusters were more likely to fail MAT 772 – Applied Math than would be expected by chance. Also under the null hypothesis, students in the Agriculture, Food & Natural Resources; Business Management & Administration; Finance; Health Science; Human Services; and Information Technology Career Clusters were more likely to pass MAT 772 – Applied Math than would be expected by chance. However, the effect size was considered to be small. In any event, because differences were observed, providing students with relevant contexts for studying and learning should be considered.
Washington State’s I-BEST program has shown a way to make course material more meaningful to students by linking the information covered in one class to the discussions and assignments of another class. This method integrated basic math skills into college-level career or technical training. Jenkins et al. (2009) found that I-BEST students had higher persistence rates, earned more occupational credits toward a college credential, and showed greater increases on remedial education tests.

A hierarchical logistic regression analysis was conducted in order to determine if one could predict academic success well from a combination of variables regarding underprepared vocational math students. The demographic variables included age, gender, socioeconomic status, and level of math preparedness. Intervention variables included level of success in a developmental math course (MAT 041 – Basic Math), utilization of tutoring services, utilization in computer-aided math software, and participation in consistent support services (TRIO).

The hierarchical logistic regression analysis in this study suggested that approximately 68% of the variance in academic success could be predicted with the combination of demographic variables of age, gender, socioeconomic status based on Pell grant eligibility, and level of math preparedness. The hierarchical logistic regression analysis in this study also suggested that approximately 68% of the variance in academic success could be predicted with the combination of demographic variables of age, gender, socioeconomic status based on Pell grant eligibility, and level of math preparedness as well as the intervention variables of level of success in a developmental math course (MAT – 041 – Basic Math), utilizing tutoring services, utilizing computerized math software, and participating in consistent student support services (TRIO).
The best predictors of success in MAT 772 – Applied Math, in order, were:

1. Successful completion of the developmental math course (MAT 041 – Basic Math) with a grade of C or better. Prior research also supported students taking developmental courses to assist them in raising their skills to improve academic success. Lavin et al.’s (1981) analysis of 2-year college students concluded that success in remedial courses did make a difference on academic success.

2. Classified as moderately underprepared. Bahr’s (2012) analysis also concluded that sizeable gaps in achievement were evident between low-skill and high-skill remedial math students.

3. Utilizing consistent student support services (TRIO). Pascarella and Terenzini (1991, 2005) suggested that institutions can aid the academic adjustment of poorly prepared students by providing extensive instruction in academic skills, advising, counseling, and comprehensive support services.

4. Asian and other race students. However, great caution should be used in interpreting this result due to the coding of this variable.

5. Nontraditional-age student.

6. Nonqualified for Pell benefits. Both Bailey et al.’s (2010) and Bahr’s (2012) research concluded that socioeconomic status has an effect on academic success. Bailey et al.’s analysis of the Achieving the Dream student data concluded that students at institutions serving disadvantaged students have lower odds of passing to a higher level of remediation than do their peers at colleges serving low proportions of this population. Bahr’s (2012) analysis of community college students concluded: “Community college students of historically disadvantaged
groups disproportionately begin college at the lower end of the remedial hierarchy, where the chances of attaining college-level competency are also the lowest” (p. 685).

7. Passing the developmental math course with grade of C– to D–. Schiel and Sawyer (2002) also studied the effectiveness of taking developmental courses and found them effective for those who completed them.

In this study, participating in tutoring services was not a significant predictor of success. Gallard et al.’s (2010) study at a community college in Florida found a significantly higher developmental course completion rate with an enhanced tutoring program. Boylan et al.’s (1992) study concluded that developmental programs with the highest rates of student retention regularly used supplemental instruction and tutoring to support students enrolled in difficult courses.

In this study, utilizing computerized math software was not a significant predictor of success. One of the emerging practices for academic success for community college students was suggested by Golfin et al. (2005), who recommended technology as a supplement to classroom instruction. However, Boylan (2002) discovered an inverse relationship between the amount of computer technology used in a developmental course and pass rates in the course.

Implications for Practice

Based on the findings of this study, implications for practice are posed and recommendations for policy changes are suggested below within the context of this midwestern community college. This model may be generally applicable in the context of
other community colleges, although adaptations may have to be made in terms of measurements and specific needs.

1. The findings of this study showed students in specific Career Cluster areas did better or worse than did students in other Career Clusters. It is recommended that students in the required vocational math course be separated by Career Cluster. This way, the instructor can focus on application of the mathematical concepts as they relate to real-world situations in the student’s specific content areas. This would especially be important for students in the Architecture & Construction; Manufacturing; and Law, Public Safety, Corrections & Security Career Cluster areas. It would not be as critical for students in the Finance and Agriculture, Food & Natural Resources Career Clusters.

2. This study also showed approximately 15.7% of the students had declared General Studies as their major. The MAT 772 – Applied Math course is not the correct course for students to complete if their belief is that it applies toward all programs’ requirements or they are planning to earn an Associate of Arts degree. The practice of advising students with a General Studies major to take MAT 772 – Applied Math needs to be revisited. If students select General Studies as their major, the question of transferability needs to be discussed so that students are placed in the appropriate math course. A more appropriate math course would be one that is designed to provide students with an introduction to basic algebra and includes topics such as signed numbers, exponents, algebraic expressions, polynomials, roots and radicals, factoring, linear equations and inequalities, systems of equations, and graphing. Students need to be aware that MAT 772 –
Applied Math was not designed to prepare students to take upper level math courses.

3. Analysis of the data from this study showed the differences in the mean academic success of underprepared vocational math students were statistically significantly when comparing them with the success of students based on the level of math preparedness. In this study, even though a significant relationship was found, the difference was less than the difference between a grade of C– and D+ and, thus, not a practical significance. However, severely underprepared students, under the null hypothesis, were more likely to fail and less likely to pass MAT 772 – Applied Math. Moderately underprepared and slightly underprepared students were less likely to fail and more likely to pass. In this case, however, the difference was meaningful in that the difference of passing or failing the course results in success or failure in terms of academic credit and completing a degree. This researcher would recommend that severely underprepared math students be required to take the developmental math course (MAT 041 – Basic Math) and that the students be provided consistent student support services.

4. If students are not required to take an arithmetic entrance exam, this researcher would recommend that students take math courses based on Career Cluster as recommended in Implication #1. An arithmetic examination should be given the first week of the term in order to determine the level of preparedness. The results of this study showed that severely underprepared students have significantly lower academic success. This researcher also recommends initiating an ALP model such as was initiated at the Community College of Baltimore (Jenkins et al., 2010).
With this model, students are mainstreamed into the required college level course and simultaneously enrolled in an ALP course (taught by the same instructor), which meets immediately following the required course. The underprepared vocational math students then take the math course required for graduation with the instructor teaching relevant content and with additional instructional support immediately following each class session.

5. Supplemental instruction peer tutors should be utilized to assist in reinforcing important concepts in the MAT 772 – Applied Math courses. These tutors would then be familiar with how the instructor presented the material and could reinforce the same methods as they tutor the students. Boylan et al. (1992) found developmental programs with the highest rates of student retention regularly used supplemental instruction to support students enrolled in difficult courses.

6. Instructors teaching the MAT 772 – Applied Math course need to re-examine how they teach the course and how they utilize the computer-aided software that is sold with the textbook. The analysis of the data in this study did not show a significant improvement of success based on the usage of the software. Golfin et al. (2005) provided emerging practices that included greater use of technology as a supplement to classroom instruction as well as integration of classroom and lab instruction. If instructors continue to require the purchase of computer-aided math software along with the math textbook, they should integrate the software into the classroom and lab instruction and the software should not be used to provide the majority of the classroom instruction. Providing face-to-face support for the software could enhance the effectiveness of the software.
7. In this study the variables of level of preparedness, grade in the developmental math course, and consistent participation in student services program were all predictors of the grade students earned in MAT 772 – Applied Math. These predictor variables were positively associated with the level of success in MAT 772 – Applied Math. Based on the coding of these variables, the findings showed that higher level of math preparedness, higher grade in the developmental math course, and consistent participation in student support services were significant predictors of success. However, when considering all the factors together, they accounted for only a small percentage of the variance. This researcher recommends community college advisors be aware that those factors have an effect but also be cognizant it is a very small effect.

8. Utilizing consistent student support services was a significant predictor of success in this study. Administrators need to provide funding for student support services. This researcher would recommend a pilot program to hire mentors to support students. If resources at community colleges are too scarce, volunteers could be recruited throughout the community college to take on a case load and assist these students. Since resources probably will be an issue, the resources should be used to benefit the students with the greatest need. Based on this study, of all the MAT 772 – Applied Math underprepared students; the following students wouldn’t have the greatest need: non-Pell grant eligible students, students who completed MAT 041 – Basic Math with a C or better, slightly underprepared and moderately underprepared students, and students participating in a student support program.
such as TRIO. This would provide resources to students that would be most in need.

9. With only 26% of the 12th grade students scored as demonstrating competency or above (NCES, 2013), there is a definite need for math remediation in order to assist students in completing their degrees. The U. S. Department of Labor (2013) recently awarded a grant to the Iowa-Advanced Manufacturing (I-AM) consortium. This grant was awarded in response to a documented shortage of skilled workers in Iowa’s advanced manufacturing sector. Through this grant, funds are available to the consortium to secure software and develop additional resources to accelerate remediation experiences. Grant funding that includes additional funds to be used in this manner will greatly benefit underprepared vocational math students.

**Implications for Policy**

1. Comprehensive support and retention programs offer a wide variety of services and programs that are intended to promote academic adjustment, persistence, and degree completion. These programs often have been supported by federal and state agencies. The federal Student Support Services (SSS) program, one of the clusters of the TRIO programs, is a great example of this. In this study, student support services were a significant predictor of academic success for the underprepared vocational math students. Federal funding for student support services, such as the TRIO program, should be continued and increased. The current funds are providing valuable resources to provide student support services, which been shown to have a significant difference in academic success.
2. Community colleges fill a great need and provide access within commuting distance for students who otherwise may not have access. Community colleges are able to serve the underprepared and underserved. Low-income students need federal assistance to assist in paying for their education. Federal financial aid needs to be a priority for legislators so that low-income students will continue to have access to postsecondary education. If sufficiently trained workers are not available, the nation will not succeed in the 21st century. Federal assistance is the only way low-income students can afford to continue their education and become part of a skilled workforce.

3. Federal guidelines and regulations in math education need to be re-evaluated. Due to recent immigration, math content in testing material needs to be modified so that it can be easily understood by migrant populations. Vocabulary that is easily misinterpreted due to slang or multiple interpretations should be avoided. Current testing can be biased and present unfair advantages to migrant students.

4. Student needs should be studied using a holistic approach. Data sharing is important to relevant research. Acquiring access to desired data is very difficult. Regulations need to be re-evaluated regarding the sharing of information. Easier access to data would benefit researchers and lead to more comprehensive studies.

**Recommendations for Future Research**

With a large majority of students entering 2-year public institutions underprepared in mathematics, the need for continued study of factors related to remedial education and ways to increase student success for underprepared vocational math students is necessary. These factors include the variables in this study as well as whether or not students have disabilities,
the number of math courses taken in high school, the grades in previous math courses, 
overall grade point average, parent’s education, number of hours worked, and dependency 
status. This study provided evidence that specific factors have an effect on the academic 
success of underprepared vocational math students. More research needs to be conducted on 
these and the other factors listed above. A larger sample from a national database should be 
included.

Qualitative data also, such as attitudes and beliefs of students and their parents, 
should be analyzed. This could provide useful information for underprepared vocational 
math students.

A study of multiple cohorts would add to this study. Data collected annually from a 
national study would be recommended. Therefore, longitudinal data could be analyzed. 
Other longitudinal data, including graduation data, also should be explored.

**Final Thoughts**

In order to be prepared for many of the jobs of the 21st century, candidates for these 
jobs need to have workforce training or higher education that extends beyond high school. In 
order to compete globally, the future of the nation depends on a trained workforce.
Community colleges provide access to much of that training. It is important for community 
college administrators, advisors, and instructors to assist students in completing that training 
and ensuring the graduates are ready for a career.

With nearly 75% of students entering 2-year colleges with low math skills (Noel-
Levitz, 2006), many students are underprepared for college-level work. Community colleges 
need to retain and graduate underprepared vocational math students. Community colleges 
often offer interventions to assist underprepared vocational math students become successful.
However, offering interventions is not enough. Interventions alone cannot accurately predict success. Community colleges need to offer courses with relevant content along with instructional support to assist students in becoming successful.

As Roueche, Ely, and Roueche (2001) stated: “Commitment to success requires an enormous curiosity about improving performance, an enthusiasm for identifying better approaches to everything, and a promise to leave behind what no longer works. It is a potent catalyst for innovation” (p. 110). All community college administrators, staff, and faculty need to be a catalyst for innovation.
APPENDIX. INSTITUTIONAL REVIEW BOARD APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 8/2/2012
To: Diane Hargens
444 Forest View Ave
Sioux City, IA 51103

CC: Dr. Larry Ebbers
N256 Lagomarcino Hall

From: Office for Responsible Research

Title: Underprepared Vocational Math Students and Academic Success: A Case Study

IRB ID: 12-368

Approval Date: 8/1/2012
Date for Continuing Review: 7/31/2014

Submission Type: New
Review Type: Expedited

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.
- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.
- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.
- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 1138 Pearson Hall, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.
REFERENCES


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LeCompte, M. D., & Preissle-Goetz, J. (1994) Qualitative research: What it is, what it isn’t, and how it’s done. *Advances in Social Science Methodology, 3*, 141–163.


