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Selected Predictors of Academic Achievement for College Students in Remedial Mathematics Courses

Gregory Kyle McLeod

SELECTED PREDICTORS OF ACADEMIC ACHIEVEMENT FOR COLLEGE STUDENTS IN REMEDIAL MATHEMATICS COURSES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree of Doctor of Philosophy in
Leadership and Education in
the Adrian Dominican School of Education of

Barry University

by

Gregory Kyle McLeod, B.A.Ed., M.Ed.

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Barry University

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Area of Specialization: Higher Education Administration

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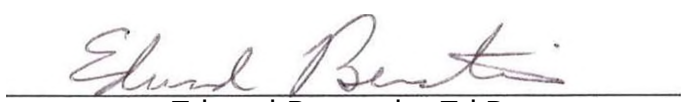
APPROVED BY:



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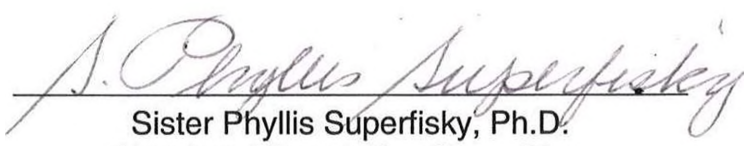

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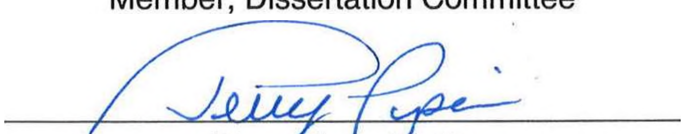

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Abstract

SELECTED PREDICTORS OF ACADEMIC ACHIEVEMENT FOR COLLEGE STUDENTS IN REMEDIAL MATHEMATICS COURSES

Gregory Kyle McLeod

Barry University, 2010

Dissertation Chairperson: Dr. Edward Bernstein

Purpose: The purpose of this quantitative study was to determine the multiple correlation between four predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and the outcome of academic achievement of college students enrolled in remedial mathematics at a 4-year college in the United States using standardized instruments validated in previous research. Recent studies show that the need for college remediation remains as strong as ever, and that the greatest area of need for it is in mathematics (Achieve, Inc., 2004; K. Dougherty, 2003; National Center for Education Statistics [NCES], 2004; National Scieruce Board, 2006; V. B. Olivares, 2000). Thus, continued efforts to address the need for college mathematics remediation and finding success in it are warranted. The dependent variable, academic achievement, was operationally defined as a score on the 30-question mathematics subtest of the Florida College Basic Skills Exit Test.

Method: This research study was conducted as a predictive research study using multiple regression to explore the possible relationships between the predictive variables of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability, with the dependent variable of academic achievement of college students enrolled in remedial mathematics. The sample from this population was derived from eight randomly selected Elementary Algebra classes offered in the Spring 2010 term at the selected college. Of the 162 students offered the opportunity to participate, 132 volunteered but only data on 88 students were complete and usable. To assure anonymity, the researcher did not have access to any identifying information.

Major Findings: Analysis of the data resulted in the calculation of a statistically significant multiple correlation coefficient (adjusted $R^2 = .363$, $p < .05$) to account for the variance in academic achievement by the predictor variables. As a result of the analysis of the data, the null hypothesis was rejected. Of the four independent variables, prior math ability and reading comprehension emerged as significant predictors within the regression equatk)n.

The results of this study generally supported results found in prior remedial math studies with some exceptions. Given the analysis of these specific predictors on academic achievement, unique qualities and implications were also found.

Acknowledgements

My deepest appreciation goes to Dr. Edward Bernstein, my dissertation chairperson. Your wisdom, guidance, and support throughout my studies and the dissertation were and continue to be invaluable. I am extremely grateful to my other dissertation committee members, Dr. Joe Maddox, Jr., and Dr. Phyllis Superfisky, whose insights, advice, and perspective were also invaluable.

Additionally, my sincerest appreciation goes to Dr. Terry Piper, Dr. Carmen McCrink, and the entire Leadership and Education Department in the Adrian Dominican School of Education at Barry University for affording me such an enriching experience and quality education. The professors, staff, and program as a whole reflect a high level of passion and care that is reflective of Dr. Piper and Dr. McCrink's leadership.

I thank God for my family and friends. I would not have made it this far had it not been for all of your love, support, and prayers. I love you all.

Finally, I thank my wife and best friend, Beverly. Your patience, support, encouragement, and understanding helped me see this journey to the end. I am eternally grateful.

Dedication

I dedicate this dissertation to my children, Jordan and Kyla, who inspired me to undertake and complete this journey. I am so proud and blessed to be your father. Strive always to be and do your best, and know that you can do all things through Christ, who strengthens you. I will always believe in you, just as you have believed in me.

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Chapter I

The Problem

This study explored the effects of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability on academic achievement of U.S. college students in remedial mathematics. This chapter provides an overview of the study including the statement of the problem, purpose of the study, background and significance, theoretical framework, research question, hypotheses, variable definitions, assumptions, and limitations.

Statement of the Problem

Today, more students are enrolling in U.S. colleges than ever before. Along with this, more are enrolling into college underprepared and, thus, are in need of some degree of remediation (Achieve, 2004; Dougherty, 2003; Parsad & Lewis, 2003). This is especially true in mathematics. The National Science Board (2006) found enrollment in remedial math courses gradually increased over the prior 20 years. Additionally, a 2006 national follow-up study of 14,200 former high school sophomores found that over half of the stgdents who never completed any high school math and nearly two-thirds of the students who completed only basic high school math were either attending or expecting to attend college (Bozick & Lauff, 2007). These high educational expectations, coupled with the apparent lack of adequate math preparation, present challenges for students and society in general.

For students, the need to take remedial coursework adds to their overall educational costs and lengthens the time it takes them to obtain a degree (Achieve, 2004; Levin & Calcagno, 2008; Manno, 1995; NCES, 2003). Adelman (1996) concluded that "the extent of a student's need for remediation is inversely related to his or her eventual completion of a degree" (p. 2). The resulting implication that remedial students have less of a chance to graduate when measured against non-remedial students was realized in a study by Bradburn (2002). In her study conducted at public 4-year institutions, she found that 24.3% of students needing any type of remediation dropped out with no degree and did not return within the 3-year time frame of the study versus 17.8% of students without any need for remediation. Additionally, Penny and White (1998) found that remedial math students have higher college dropout rates and subsequent math failure rates compared to students who do not need remediation in mathematics.

Society pays a heavy cost for the lack of success and persistence in college of remedial college students. The Alliance for Excellent Education in 2006 put the economic impact of the reduced earning potential of remedial college dropouts at nearly $2.3 billion based on lost government tax revenue and reduced consumer spending power. Similarly, a review of federal data by the Strong American Schools project in 2008 estimated the annual cost of remediation between $2.3 and $2.9 billion. In addition to these estimates are the costs associated with providing basic skills training to workers by their

employers, government agencies, and nonprofit organizations (Achieve, 2004; Alliance, 2006).

Lack of success and persistence in mathematics can be particularly limiting to students. Students who are unsuccessful in mathematics have limited choices in college majors available to them and, thus, fewer career options (Berenson, Carter, & Norwood, 1992; Stage, 2001; Stage & Kloosterman, 1995). Stage (2001) further argued that this has led to a lack of qualified workers in certain math-related fields in the United States.

Purpose of the Study

The purpose of this quantitative study was to focus on the predictive effects of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability on the academic achievement of college students in remedial mathematics using standardized instruments validated in previous research. No prior study was found that investigates this combination of predictors on remedial mathematics achievement. Most studies involving academic achievement and college remediation were found tP focus on the effect of high school preparation and demographic variables on the need for remediation, and others were found to focus on the effect of remediation on subsequent academic success. This has resulted in a significant gap in the literature on issues and concerns of the multiple effects of academic achievement of college students while undertaking remedial coursework.

With reports and findings suggesting increasing numbers of underprepared students going to college and the need for remediation negatively impacting persistence and success in college, continuous research in this area is warranted. Findings from this study may serve to support the relationship of college students' prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability. It is hoped that the results of this study add to the growing body of knowledge regarding college remediation, spur continued research in this field, and aid educational practitioners in improving academic achievement in this area.

Background and Significance

Students who must take coursework to remediate their deficiencies in undertaking college-level classes face a longer, steeper road to graduation than those who do not need remediation (Adelman, 1996). Yet, nearly a third of all freshmen enrolling in U.S. 4-year institutions enroll in at least one remedial course (Alliance, 2006; NCES, 2004). In both 2- and 4-year colleges, Achieve, Inc. (2004), found that 53% of entering college students take-at least a remedial English or math course.

Despite this longer, steeper road to graduation, studies have shown that students who managed to successfully complete remedial college coursework showed significantly higher subsequent success and persistence rates than similarly skilled students who did not take or complete remedial college coursework (Attewell, Lavin, Domina, & Levey, 2006; Batzer, 1997; Bettinger &

Long, 2009; Crane, McCay, & Poziemski, 2002; Lavin, Alba, & Silberstein, 1981). In their investigation, Bettinger and Long (2009) found that 4-year students who undertook remedial coursework were significantly more likely to persist and complete a degree than students who had placed in but chose not to take remedial coursework. In a community college study, Polk-Conley (2006) found that completing remedial math positively influenced the academic preparation for college-level math and subsequent graduation rates. In a large-scale study involving nearly 86,000 freshmen, Bahr (2008) realized that students who were able to successfully remediate their deficiencies in mathematics were just as successful in their long-term academic attainment as those math students who placed directly in college-level math courses without the need for remediation.

Given these prior study findings, it is hoped that this investigation of specific predictors of success in college remedial mathematics can guide institutional practices and curricular efforts focusing on improving the academic outcomes of those students entering college and placed in remedial mathematics courses.

Theoretical Framework

The theoretical framework upon which this study was based is Albert Bandura's (1986) social cognitive theory. This theory views human functioning as being uniquely determined by a dynamic, reciprocating interaction between individuals' behaviors, their personal thoughts and beliefs, and the environmental conditions that exist around them (Bandura, 1986; Pajares, 2002; Zimmerman,

1989). Bandura (1986) referred to this determination of human functioning as *triadic reciprocal determinism.* Although these three elements of behavior, personal factors, and environment interact and influence one another, they may differ in their degrees of interaction and influence given the situation (Bandura, 1986, 1989).

Social cognitive theory is differentiated from earlier social learning and behaviorist theories by its emphasis on the roles and importance of human agency and self-beliefs in human functioning (Bandura, 2001; Pajares, 2002). This theory promotes the perspective that people actively engage cognitively in their own personal development through exercising the fundamental capabilities of symbolizing, exercising forethought, vicarious learning, self-regulation, and self-reflection (Bandura, 1986, 1989; Pajares, 2002).

Central to Bandura's (1986) social cognitive theory is the type of self-reflection capability known as *self-efficacy.* He defined self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). He argued that these self-beliefs are more important than what is "objectively true" (p. 2), and that the higher the level of self-efficacy, the greater the effort, persistence, and resilience (Bandura, 1997). On the other hand, it is important to note that high self-efficacy alone will not lead to achievement outcomes if other determinants such as requisite skills, values, and expectations are lacking (Schunk, 1995).

Given this perspective of human functioning and the dynamic, reciprocating interaction of its determinants including self-efficacy, Bandura's social cognitive theory provided a useful framework for investigating and understanding academic achievement in college remedial mathematics.

Research Question

Fraenkel and Wallen (2009) stressed that research questions should be designed specifically to address the topic of a given study. In order to properly examine the topic of this study, which was the effect of selected predictors on college students' academic achievement in remedial mathematics, the following research question was designed to guide the study:

> What is the multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and the outcome, college students' academic achievement in remedial mathematics, as measured by a score on the Florida College Basic Skills Exit Test?

Null Hypothesis

The following null hypothesis was addressed in this study:

H_0: There is no multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test.

Research Hypothesis

Alternately, the following research hypothesis was addressed:

H_A:There is a multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test.

Operational Definitions of the Variables

This study required a consensual understanding of the terminology and definitions that were used for the purpose of this study.

Academic achievement in remedial mathematics - For the purpose of this study, academic achievement in remedial mathematics was operationally defined as a score on the 30-question mathematics subtest of the Florida College Basic Skills Exit Test. Students took this test as their final exam in Elementary Algebra at the selected college. Taking and passing this test with a score of 70% or better is a requirement of all remedial math college students attending Florida colleges and universities that are subject to Florida Statute 1008.30 (Florida Department of Education, 2009).

Academic self-efficacy - For the purpose of this study, academic self-efficacy was operationally defined as a score on the 33-item College Academic Self-Efficacy Scale (CASES) by Owen and Froman (1988). The term *academic self-efficacy* refers to the "personal judgments of one's capabilities to organize

and execute courses of action to attain designated types of educational performances" (Zimmerman, 1995, p. 203).

Attitude toward mathematics - For the purpose of this study, attitude toward mathematics was operationally defined as a score on the 30-item Indiana Mathematics Belief Scales by Kloosterman and Stage (1992). The phrase, *attitude toward mathematics,* refers to one's disposition toward mathematics and its perceived usefulness.

Prior math ability - For the purpose of this study, prior math ability was operationally defined as a score on the 17-question multiple-choice Accuplacer Arithmetic Placement Test by the College Board.

Reading comprehension ability - For the purpose of this study, reading comprehension ability was operationally defined as a score on the 20-question Accuplacer Reading Comprehension Placement Test by the College Board. The term *reading comprehension* refers to the strategic process in which readers simultaneously extract and construct meaning from text (Roe, Stoodt-Hill, & Burns, 2004).

Assumptions of the Study

Several assumptions existed in this study. The first assumption related to the participants' responses. It was assumed that all students who participated would understand and respond honestly to the questions on the survey instruments. A second assumption was that the remedial mathematics classes in which the participants were enrolled were consistent in instructional quality and

environment. A third assumption was that the four predictors of academic achievement in remedial mathematics could be measured by a score on the Florida College Basic Skills Exit Test. A final assumption was that the criteria for establishing correlation and multiple regression could be satisfied.

Limitations of the Study

Three primary limitations existed with regard to this study. The first limitation was that the study was limited to students enrolled in a specific remedial mathematics course (Elementary Algebra) during a limited time period at a single institution and, thus, it was not possible to make generalizations to populations in other institutions from the findings of this study. The second limitation was that participation was strictly voluntary and, thus, may have affected the sample size. Lastly, the data collected on attitude toward mathematics and academic self-efficacy were dependent upon self-reporting measures and, thus, were subject to human error and bias.

Chapter Summary

This chapter introduced the problem of increasing numbers of underprepared students going to college and the need for remediation negatively impacting persistence and success in college. As discussed in this chapter, the purpose of this quantitative study was to determine the multiple correlations between the four selected predictors of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability, and the outcome, academic achievement in remedial mathematics. This chapter

continued with the study's background and significance, theoretical framework, research question, hypotheses, variable definitions, assumptions, and limitations.

Chapter II

Review of the Literature

The purpose of this chapter is to provide a review and discussion of literature pertinent to this study. The review begins with the history of and current need for remediation in American higher education. This precedes a discussion of the literature on the role of prior math ability as measured by placement practices on academic achievement in remedial mathematics. Then, literature is reviewed linking student attitudes and academic self-efficacy to math achievement. Finally, the chapter concludes with a focus on literature relating reading comprehension ability to academic achievement in mathematics.

Remediation in American Higher Education

Remedial education in American higher education is as old as American higher education itself. In the early years of Harvard, the country's first institution of higher education, students who struggled with Latin and Greek were assigned tutors to help remediate their deficiencies (Breneman & Haarlow, 1998; Muse, 1999). Given expanding curricula and increased need for remediation across the United States, the *Yale Report of 1828* urged colleges to return to the classics and cease admitting students with "defective preparation" (Howe, 1828, p. 26). This increased need for remediation resulted in the establishment of America's first formal college preparatory department in 1849 at the University of Wisconsin, which offered remedial courses in reading, writing, and arithmetic (Boylan & White, 1987; Taylor, 2001). By 1915, no less than 315 such

departments or programs in higher education existed across the United States (Markus & Zeitlin, 1998).

This growth in college preparatory departments and programs can be partly attributed to the establishment of the Morrill Federal Land Grant Acts of 1862 and 1892. The aim of these acts was to "develop, at the college level, instruction relating to the practical realities of an agricultural and industrial society" (National Association of State Universities and Land Grant Colleges, 1995, p. 6). These acts provided more access to higher education and attracted working class people with education geared toward agriculture and mechanics (Bogue & Aper, 2000). However, many of these people were unprepared to handle the rigors of higher education, which further increased the need for remediation (Dempsey, 1985).

At the close of World War II, the Servicemen's Readjustment Act of 1944, also known as the G. I. Bill of Rights, provided funding to returning servicemen and women to go to college (Gladieux, King, & Corrigan, 2005; Markus & Zeitlin, 1998; McCabe & Day, 1998). This bill gave "unprecedented opportunity" (McCabe & Day, 1998, p. 3) to veterans of diverse backgrounds and educational experiences to attend college. Many of these veterans had been away from a classroom for a while and, thus, needed remediation (Levinson, 2005).

Soon after, the Presidential Commission on Higher Education, led by George F. Zook, produced a six-volume report, *Higher Education for Democracy,* between December 1947 and March 1948 recommending a number

of policies to greatly expand enrollment in America's college and universities (Reuben & Perkins, 2007). With this report, commonly referred to as *The Truman Report,* the commission's goal was to make higher education "available to all those who could possibly benefit from the experience" (Markus & Zeitlin, 1998, p. 169). To achieve this goal, the report called for expanding the reach of 2-year institutions, instituting a federal aid program for low-income students to attend public colleges and ending discriminating admissions practices based on religion and race (Reuben & Perkins, 2007).

From the 1960s to the 1970s, a number of federal acts were passed that further increased and ensured access to higher education. The Civil Rights Act of 1964 and Title IX of the Educational Amendments in 1972 forced institutions to cease discrimination practices on the basis of race and gender respectively (Reuben & Perkins, 2007). The Higher Education Act of 1965 was significant in promoting access to higher education through the authorization of a number of aid programs built on new and existing aid initiatives (Hannah, 1996). The Federal Work-Study program, begun during The Depression^was made permanent, and a federally subsidized loan program and Upward Bound, a program to attract and retain minorities with financial need, were created by the Higher Education Act (Gladieux & Wolanin, 1976; McAdam, 1989). The 1972 amendments to the Higher Education Act established the federally funded Basic Educational Opportunity Grants, also known as Pell Grants, to ensure the

availability of a certain amount of aid for all financially qualified students (Hannah, 1996; Levinson, 2005; Reuben & Perkins, 2007; Vaughan, 2006).

Several specific federal acts that focused on career and technical education increased the college-going interests and opportunities for special populations who had not traditionally pursued a college education. These acts include the 1963 Vocational Education Act, the 1984 Carl D. Perkins Vocational Education Act, the School-to-Work Opportunities Act of 1994, and the Workforce Investment Act of 1998. These federal acts, along with similar state-led initiatives, helped fuel the enrollment "growth in students with disabilities and part-time, women, disadvantaged, and older students" (Cohen & Brawer, 2008, p. 255) pursuing postsecondary education.

The need for remediation today remains strong, with findings signifying that the need has grown in recent decades (Achieve, Inc., 2004; Dougherty, 2003; National Science Board, 2006). Olivares (2000) went further to suggest that remedial education is the fastest growing curriculum in American higher education. In a review of national data, Achieve, Inc. (2004)^found that more than half (53%) of students took at least one remedial class in English or math during their college careers. In a separate study, Adelman (2004) estimated that 41% of all college students enroll in at least one remedial course during their college careers. In looking specifically at first-year patterns, NCES (2004) found that 28% of all college students enrolled in at least one remedial course during their freshman year. Similarly, a review of federal data conducted by the Strong

American Schools project in 2008 found that a combined 34% of all college students took at least one remedial course in their freshman year (43% for 2-year students and 29% for 4-year students).

The Need for and Outcomes of Mathematics Remediation

Looking into the significant numbers of students needing any type of remediation, studies show the greatest need is generally in mathematics. McCabe's 2000 study of remedial students at community colleges found that 62% of these students needed remediation in mathematics. This compares to 38% who needed remedial reading and nearly 45% who needed remedial writing. In another study involving 2-year colleges, the Community College Research Center found that over 70% of the students enrolled in 2002 at the 27 Achieving the Dream institutions needed remedial mathematics versus 34% who needed remedial English (Biswas, 2007). In a study conducted by ACT, Inc., Hetzner (2003) reported that, of the 40% of students found to need remediation, over three-fourths of them need remediation in mathematics. Parsad and Lewis (2003) found that, across all institution types, more freshmemenrolled in remedial mathematics (22%) than in remedial writing (14%) or reading (11%).

When looking at high school preparation, Hoyt and Sorensen (2001) found there was still a need for remediation among college-bound students who had completed college preparatory classes in mathematics. They found that over half of the students who were placed in remedial mathematics in college had already completed and passed intermediate algebra in high school. Surprisingly, over

one-quarter (27.4%) of the students who had already passed calculus in high school were required to take remedial mathematics or retake intermediate algebra, which at some institutions is considered a remedial mathematics course (Hoyt & Sorensen, 2001).

An NCES study of American high school seniors by Ingels, Planty, and Bozick published in 2005 found that a large percentage of students with intentions to go to college were not prepared. The study found that 63% of the students intending to pursue a 4-year degree had not mastered intermediate-level mathematics concepts. Furthermore, 32% of these students had not yet mastered "low-level mathematical concepts" (p. 6).

Although it may be challenging for institutions and governing bodies to deal with this large need for remediation, particularly in mathematics, success in remedial mathematics appears to be equally as challenging for most students. A study conducted by Roueche in 1968 found that 90% of students taking remedial mathematics failed or withdrew. A study by Penny and White (1998) supported Roueche's findings. They found remedial math students to have higher college dropout and subsequent math failure rates compared to students who did not need remediation in mathematics.

McCoy (1991) found that, of 120 entering students having a chance to move onto college-level math the following semester, only 15 students (12.5%) were able to do so in the first semester and the remainder of the students (87.5%) either failed or withdrew. Similarly, Hackett reported in 1985 that fewer

than half of students enrolled in remedial mathematics were successful on the first attempt.

Yet, successfully completing remedial mathematics has its benefits. Polk-Conley (2006) found in a study involving community college students that completing remedial math positively influenced their college-level math preparation and subsequent graduation rates. Similarly, Bahr (2008) found in an analysis of data involving 85,894 first-time college freshmen enrolled in 107 community colleges that math students who remediate successfully experience comparable outcomes to those students who place into college-level courses without the need for remediation. Although Bahr found this to be a "remarkable finding" (p. 442), he warned that a vast majority of the remedial math students (75.4%) did not successfully remediate. Thus, he concluded that remediation in math is extremely effective for those students who are able to remediate successfully, but that further research is needed to examine the barriers to and opportunities for success.

Prior Math Ability (Placement Scores) on Predicting MathuAchievement

Placement programs must be able to effectively assess the subject-area skills of students and, as a result, place them in the appropriate courses. Thus, college placement tests serving as reliable and valid measures of academic preparedness and course placement are dependent on the meaning and usefulness of the information conveyed in the test (Smittle, 1993).

Mathematics placement policies and practices should identify the best and highest initial mathematics course in which students can succeed with reasonable and appropriate effort (Dorner & Hutton, 2002). For this purpose, many studies have been conducted to measure the effectiveness of placement tests as predictors of success. Despite the common practice of placement testing, studies have not been able to mutually agree on the effectiveness of these tests.

Research conducted by Darbro in 2002 found that the COMPASS Math Placement Test by ACT, Inc. was not a reliable measure for determining course success in remedial mathematics. The results of his study, involving 358 freshmen at a state university, showed that course success was more closely related to student absences and instructor grading practices than placement test scores. Similarly, Long (2003) found no relationship between scores on the COMPASS Math Placement Test and success in any of the five remedial math courses at the community college investigated. In his study across three large-sized community colleges, Armstrong (2000) found that placement test scores were significant but too weakly correlated to final grades in remedial mathematics to be of any practical use, and that demographic variables, prior math success, and grade point average were found to be better predictors.

In a study conducted at East Tennessee State University, Stephens (2005) obtained mixed results. He found that, although scores on the COMPASS math test did not significantly correlate to final grades in elementary algebra, they

did correlate to final grades in intermediate algebra at the $p < .05$ level. Another set of mixed results was found in a study conducted by Shalyefu (2004) at a community college in New York. She found that, for a Fall 2003 cohort of 134 students, a diagnostic placement test was not significantly related to the final grades earned in a developmental elementary algebra course. However, this relationship was positive and significant for the Spring 2004 cohort of 214 students.

A study analyzing placement in college algebra at a private, urban university involving 657 students found that placement test scores and grades earned in college algebra were significantly correlated (Armstrong, 1999). Likewise, in a study involving 498 students at an urban community college in Texas, Little (2002) found a significant relationship between scores on an algebra achievement placement test and subsequent grades earned in introductory algebra. Day (1997) found that the Accuplacer Placement Test was the best predictor of elementary algebra grades as compared to the COMPASS and a locally developed paper-based assessment for underprepared students attending institutions in Tennessee. In a study involving 355 primarily ethnic and linguistic minorities at a 4-year institution, Olivares (2000) found that a math placement test was a significant predictor of overall college achievement and biographical characteristics and high school grades were not. Keleher (2005) conducted a study involving first-year students at a state university in 2004 and found that, although the Accuplacer Placement Test scores positively correlated to final

exam scores in elementary algebra, the placement test scores did not follow a normal distribution. This lack of a general consensus on the effectiveness of remedial placement as evidenced by these studies illustrates the need for continuous investigation in this area.

For this study, the Accuplacer Arithmetic Test was used to measure the prior math ability of the participants. The Accuplacer Placement Tests were designed by the College Board to facilitate the evaluation and placement of college students in appropriate courses. Introduced in 1985, the Accuplacer program—which consists of reading comprehension, sentence skills, arithmetic, and elementary algebra tests—was developed to place students in English and mathematics courses (College Board, 2003). Nationally, 199 high schools and 86 colleges participated in the initial development of the Accuplacer program to help establish the validity and reliability of the tests.

Attitudes on Predicting Math Achievement

Attitudes that are shaped through learning and experience are important in that they can predict behavior (Morris, 1996). Lefton (1997) added that attitudes are long-lasting patterns of feelings and beliefs based on past experiences that shape future behavior. This suggests that student attitudes toward mathematics are based on past math-related experiences and can predict future math achievement. A review of the literature finds a general consensus supporting the notion that student attitudes toward mathematics are a significant predictor of success in mathematics to differing degrees.

Gupta, Harris, Carrier, and Caron (2006) conducted a study on multiple predictors of student success in entry-level mathematics at the University of Southern Maine. The survey, involving 451 students, found that students with more positive attitudes toward mathematics earned higher grades. In this same study, they found that other significant predictors of success in entry-level mathematics included gender, age, frequency of class meetings, instructor rank, and number of missed classes.

In a study involving 115 students enrolled in an introductory undergraduate statistics course at a large, urban university, Evans (2007) found that significant correlations existed between student attitudes and achievement. He also realized that student attitudes remained consistent over the duration of the course when comparing pretest results to posttest results. However, Evans did find unexpected and significant differences in mean attitude score when scores were grouped by department (mathematics, psychology, and sociology).

Ma and Kishor (1997) conducted a meta-analysis of 143 primary studies and two quantitative syntheses dating from 1966 to 1993. Participants in the studies examined ranged from elementary school students to high school students. In their analysis, Ma and Kishor found that the separate attitude domains of self-concept about mathematics, perception of family support, and perception of mathematics as a male domain were each significantly related to mathematics achievement. Although gender was not found to be a significant factor in the relationship of each attitude domain to achievement, they did find

that the degree of relationship between attitude and achievement decreased significantly from junior high school to senior high school for each attitude domain.

In a study involving 280 students at a comprehensive high school in California, Abu-Hilal (2000) found evidence to suggest that “efforts should be made to foster positive attitudes towards school subjects in an educational programme” (p. 82). However, he warned that these efforts make little difference unless they are made in conjunction with efforts to help students set higher goals and intentions.

Singh, Granville, and Dika (2002) analyzed data from the National Education Longitudinal Study 1988 (NELS:88) to examine the effects of motivation, attitude, and academic engagement on junior high/middle school achievement in mathematics and science. They identified three questionnaire items from the NELS:88 related to attitude toward mathematics and compared them to their math grades earned in the sixth through eighth grades. These items asked the participants if they (a) looked forward to mathematics class, (b) thought mathematics would be useful in the future, and (c) were bored in school. In their analysis, Singh et al. found that attitude toward mathematics “exerted substantial direct effect on mathematics achievement” (pp. 327-328). The researchers also found that attitude toward mathematics directly influenced academic engagement (time spent on math homework per week and watching

television on weekdays), which was determined to be the strongest predictor of mathematics achievement overall.

Mason (2003) conducted a study involving 599 high school students in Italy to measure their beliefs about math and how those beliefs were related to their achievement in mathematics. She used Kloosterman and Stage's (1992) Indiana Mathematics Belief Scales as well as Fennema and Sherman's (1976) Fennema-Sherman Usefulness Scale to measure the students' attitudes toward mathematics. Fler findings showed that four of the six subscales in the questionnaire predicted achievement in mathematics. Starting in order of strongest predictor, the four subscales were (a) *I can solve time-consuming mathematics problems,* (b) *There are word problems that cannot be solved with simple, step-by-step procedures,* (c) *Math is useful for everyday life,* and (d) *Understanding concepts is important in mathematics.* To her surprise, the subscale used to measure the belief in the value of effort did not predict achievement. Also, the subscale used to measure the belief in the value of word problems had no internal consistency.

Bershinsky (1993) carried out a predictive study involving students enrolled in remedial math courses at Laramie County Community College. The selective predictors of course completion were demographic (age, race, gender, marital status, financial aid status, and employment status), achievement (years of high school math, high school grade point average, ACT math achievement test score, college credits completed, and current credits attempted), and

attitudinal (student feelings about school, self, and mathematics). The attitudinal variables along with marital status and years of high school math were found to be the most consistent predictor of course completion. On the other hand, ACT math achievement test scores were not found to be a good predictor of course completion. When Bershinsky went further to separate the participants into traditional and nontraditional groups, she found that attitudinal variables were stronger predictors of course completion for nontraditional students than for traditional students.

Similar results were found in a study that was conducted by Ironsmith, Marva, Harju, and Eppler (2003) at a large southeastern university involving students enrolled in remedial mathematics. Using a shortened version of the Fennema-Sherman Mathematics Attitudes Scales to measure math anxiety, confidence, usefulness, and effectance, the researchers found each of the measures to significantly correlate with math performance. As with Bershinsky's (1993) finding that attitude was a better predictor than math ACT scores, Ironsmith et al. found that each attitudinal measure was a better predictor of math performance than quantitative scores on the Scholastic Aptitude Test (SAT). The researchers further found differences between males and females. Their findings showed that attitudes toward mathematics were more strongly correlated with math performance for females than males.

Although Bassette (2004) realized similar results with a stronger correlation between attitudes and achievement for females over males, she

found that, overall, achievers and non-achievers at Prince George's Community College had the same attitude toward mathematics. Her study utilized the Aiken Mathematics Attitude Survey and also included the selected predictors of placement scores and demographic variables. The only predictors found to have a significant relationship to the final exam score in the basic arithmetic course were students' age, gender, and math placement scores.

Bassette's (2004) findings are also supported by Cox's (1993) earlier findings of remediated and non-remedial students enrolled in a first college-level mathematics class at a community college. He found that students' age, gender, and the select pretest scores of fractions, whole numbers, and numerical skills were significant predictors of achievement in the course. Math attitude scores along with ethnicity, attendance, educational goals, and the pretest scores of decimals, ratio and proportions, and percentages were not found to be significant predictors of achievement.

For the purpose of this study, the Indiana Mathematics Belief Scales by Kloosterman and Stage (1992) were used to measure students' attitudes toward mathematics. The instrument was developed and intended for high school and college-level mathematics students. The instrument contains 30 items evenly distributed across the following five different belief subscales: (a) *I can solve time-consuming mathematics problems,* (b) *There are word problems that cannot be solved with simple, step-by-step procedures,* (c) *Understanding concepts is important in mathematics,* (d) *Word problems are important in mathematics,* and

(e) *Effort can increase mathematical ability.* Sample beliefs included *In addition to getting a right answer in mathematics, it is important to understand why the answer is correct* and *Ability in math increases when one studies hard.*

The scales were combined into a single Likert-type instrument using the options of *strongly agree, agree, uncertain, disagree,* and *strongly disagree.* Using a sample of 517 college students with the majority enrolled in a remedial mathematics course and the remainder having completed two or three college-level mathematics courses, the internal consistency reliabilities for each of the five belief subscales were measured and found to be acceptable.

The Indiana Mathematics Belief Scales were determined to have content validity by six mathematics educators (professors, graduate students, and classroom teachers) who reviewed the statements to ensure they related to their intended constructs. Through the administration of the instrument to the 517 college students, construct validity was established. A supplemental administration of the *Understanding concepts is important in mathematics* subscale was completed with 88 students due to a substitution of an item to improve the subscale.

In a 1995 follow-up study, Stage and Kloosterman examined the role of gender in the beliefs and academic achievement of college students enrolled in remedial mathematics. They found that, for males, greater exposure to high school mathematics was related to arithmetic placement scores and final grade in remedial mathematics. On the other hand, exposure to high school

mathematics was not related to ability, beliefs, or achievement for females. The authors concluded that having a weak high school background in mathematics can be overcome in college remedial mathematics courses.

Self-Efficacy on Predicting Math Achievement

Central to this study's theoretical framework, Bandura's (1986) social cognitive theory, is the concept of self-efficacy. Bandura (1986) defined self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 391). Kerlinger and Lee (2000) described self-efficacy concisely as the "self-perception of competence" (p. 730) and stated that perceived self-efficacy "affects the competence of a person's actual performance" (p. 730). Bandura (1993) added that efficacy beliefs contribute to human functioning by influencing "how people feel, think, motivate themselves, and behave" (p. 118).

Self-efficacy beliefs are influenced by four primary sources. The four sources are mastery experiences, vicarious experiences, social or verbal persuasion, and physiological and emotional states (Alderman, 2004; Bandura, 1986; Pajares, 2002; Pintrich & Schunk, 2002; Zimmerman, 2000). Mastery experiences are based on interpretations of previous successes and are considered the most influential of the four sources (Pajares, 2002). Bandura (1977) explained the importance of mastery experiences in the formation of self-efficacy beliefs:

> Successes raise mastery expectations; repeated failures lower them, particularly if the mishaps occur early in the course of events. After strong efficacy expectations are developed through repeated success, the negative impact of occasional failures is likely to be reduced. Indeed, occasional failures that are later overcome by determined effort can strengthen self-motivated persistence if one finds through experience that even the most difficult obstacles can be mastered by sustained effort. The effects of failure on personal efficacy, therefore, partly depend on the timing and the total pattern of experiences in which the failures occur, (p. 195)

Vicarious experiences, which are gained by watching other people perform certain tasks, also influence self-efficacy beliefs. Although Bandura (1977) considered this source to be weaker than mastery experiences in influencing self-efficacy beliefs, it is particularly important for people with few previous successes of their own to draw upon (Pajares, 2002). The stronger the similarities between the observer and the observed, the more influential the vicarious experience is on the formation of the observer's self-efficacy beliefs.

The third source that influences self-efficacy beliefs is verbal or social persuasion. These verbal or social persuasions involve exposure to verbal judgments or feedback received by others. Positive judgments and feedback build self-efficacy. However, according to Pajares (2002), this positive feedback

alone is not enough. Those who give these positive judgments and feedback must also relay a realistic and attainable goal in which the person can succeed.

Somatic and emotional states are the fourth source of self-efficacy development. These somatic and emotional states, which include anxiety, arousal, and stress, refer to how people feel "before, during, and after engaging in a task" (Margolis & McCabe, 2006, p. 220). Explaining how these states influence self-efficacy, Bandura (1977) said, "Stressful and taxing situations generally elicit emotional arousal that, depending on the circumstances, might have informative value concerning personal competency" (p. 198). Although specific situations may elicit certain emotional states, Bandura also argued that the influence these states have on self-efficacy is not necessarily task- or domain-specific. For example, stress and anxiety generated from caring for a sick family member may affect a person's academic self-efficacy.

Self-efficacy itself is not considered a global construct but is considered dependent upon and specific to domain and context. Within the domain of education, the construct of academic self-efficacy has been studied. Zimmerman (1995) defined academic self-efficacy as the "personal judgments of one's capabilities to organize and execute courses of action to attain designated types of educational performances" (p. 203). Within the context of education, Pascarella and Terenzini (2005) described self-efficacy as "a product of multiple personal and comparative factors, including students' conceptions of their

intellectual and social abilities and their successes and failures in previous academic setting, all tempered by comparisons with others" (p. 223).

Achievement is found to be a prominent focus of most studies of academic self-efficacy, with findings generally supporting the positive relationship between students' academic self-efficacy beliefs and their academic achievement (Bandalos, Yates, & Thorndike-Christ, 1995; Bandura, 1997; Bong, 1996; Brown, Lent, & Larkin, 1989; Chemers, Hu, & Garcia, 2001; Collins, 1985; Eccles, Wigfield, & Schiefele, 1998; Hackett, 1985; Hackett & Betz, 1981; Hall & Ponton, 2005; Linnenbrink & Pintrich, 2003; Lopez, Lent, Brown, & Gore, 1997; Lyman, Prentice-Dunn, Wilson, & Bonfilio, 1984; Multon, Brown, & Lent, 1991; Pajares & Kranzler, 1995; Pintrich, 2000; Pintrich & Schunk, 2002; Schunk, 1989; Schunk & Pajares, 2002; Zimmerman, 2000).

In the specific academic area of mathematics, research has shown that perceived self-efficacy contributes to academic achievement (Collins, 1985; Hall & Ponton, 2005; Lopez, Lent, Brown, & Gore, 1997; Pajares & Graham, 1999; Pajares & Miller, 1994; Sizoo, Jozkowskia, Malhotra, & Shapero, 2008; Stevens, Olivarez, Lan, & Tallent-Runnels, 2004; Wadsworth, Husman, Duggan, & Pennington, 2007). Pajares and Miller (1994) conducted a study involving the effects of self-efficacy, perceived usefulness of math, math anxiety, math self-concept, and prior experience on performance in mathematics. Three hundred and fifty undergraduate students attending a large, public university in the South participated in the study. The researchers found that self-efficacy, math self-

concept, and prior high school-level experience were significantly related to performance, with self-efficacy having the strongest direct and total effects on performance of the independent variables. The researchers also realized that the effects of gender and prior experience on performance were largely indirect and mediated by self-efficacy.

A similar study by Sizoo, Jozkowskia, Malhotra, and Shapero (2008) focused on the effects of math anxiety and general self-efficacy on 501 students enrolled in finance classes at the undergraduate and graduate levels. Their scores on a 25-item math anxiety scale and a 17-item general self-efficacy scale were compared to one another. The researchers found a significant negative correlation between the students' self-efficacy and math anxiety scores. Grouping the students by age, they concluded that low self-efficacy was a greater barrier to success than having high math anxiety, particularly for undergraduate, under-25-year-old students.

Hall and Ponton (2005) compared math self-efficacy between 105 college freshmen enrolled in Intermediate Algebra and 80 enrolled in-Calculus I at a medium-sized, rural, public university in the Southeast for the Fall 2001 semester. They administered the Betz and Hackett Mathematics Self-Efficacy Scale to measure the students' confidence in their ability to perform everyday mathematics tasks and their ability to earn a B grade or better in a college course that requires mathematical skills. The results showed a significant difference in the level of self-efficacy between the two groups, with the students enrolled in

Calculus I exhibiting a higher mean mathematics self-efficacy than the Intermediate Algebra students.

In a study involving undergraduate students enrolled in an online basic algebra course at a large Southeastern public university, Wadsworth, Husman, Duggan, and Pennington (2007) sought to investigate the effects of learning strategies and self-efficacy on online mathematics achievement. Self-efficacy, motivation, concentration, and information processing were found to be positively correlated to achievement, whereas self-testing strategies by students were found to be negatively correlated with achievement. When the authors grouped the students by final grade earned (A, B, C, and no credit), they found significant differences in the mean scores of their self-efficacy, motivation, and concentration. Although these findings are similar to other findings, it is worth noting that the authors found the sample size and online delivery mode to be limitations of the study.

Lopez, Lent, Brown, and Gore (1997) undertook a self-efficacy study involving students enrolled in geometry and advanced algebra classes at a high school located in the Midwest. One hundred and fifty-one geometry and 145 advanced algebra students participated in the study and completed surveys designed to measure their demographic characteristics, self-efficacy, outcome expectations, perceived sources of self-efficacy, and mathematics-related interests. The results of these surveys were compared with one another as well as their math ability and end-of-course grades. The researchers' primary

findings were that math ability and self-efficacy were significantly related to end-of-course grades. For the advanced algebra students, ability and self-efficacy accounted for 20% of the end-of-course grade variation. For geometry students, they accounted for 33% of the grade variation. The researchers also found significant gender differences for end-of-course grades and perceived sources of self-efficacy in advanced algebra students. The female students enrolled in advanced algebra earned higher end-of-course grades and reported higher math-related social persuasion and vicarious influence than the male students. This difference was not found in the geometry group.

In another self-efficacy study involving high school math students, Stevens, Olivarez, Lan, and Tallent-Runnels (2004) investigated differences between Hispanic and Caucasian students enrolled in an algebra course at a public high school in west Texas. Three hundred fifty-eight students in the 9th- and 10th-grades completed tests and surveys to measure their general mental ability, mathematics self-efficacy, motivational orientation, and prior mathematics achievement. This data were compared to their performance*on a subsequent mathematics test and their reported intention to take additional math courses. The results showed that each variable significantly influenced performance, with general mental ability being the strongest, followed closely by mathematics self-efficacy and prior mathematics achievement. These three variables accounted for 29% of the variance in mathematics performance for the Hispanic students and 50% of the variance for Caucasian students.

Collins (1985) conducted a study examining self-efficacy and ability to mathematics performance of fifth-grade students. The 148 students who participated in the study were divided into high-, average-, and low-ability groups, with each ability group further divided into subgroups of high, average, and low self-efficacy. Her findings showed that students with high self-efficacy performed significantly better in math and chose to rework more missed problems than students with low self-efficacy. This was found to be consistent regardless of ability group, but more prominent within the average-ability group. Collins (1985) also found that attributions of failure differed markedly between students of low and high self-efficacy. Low self-efficacy students were more likely to attribute their failure to things they had little control over such as lack of ability, whereas high self-efficacy students attributed failure to things they had more immediate control over such as lack of effort.

In another study involving similarly aged students, Pajares and Graham (1999) conducted a study of the effects of certain motivational variables on the mathematics performance of sixth-grade students. The 273 participants were enrolled in regular or gifted math classes at a suburban, public middle school in the South. Of the motivation variables in the study (self-efficacy, math anxiety, math self-concept, perceived value, and academic engagement), self-efficacy was the only one to predict mathematics performance. The researchers found no significant effect with gender on performance but found that gifted students reported higher levels of perceived self-efficacy, were more accurate in their self-

efficacy assessments, and had a higher mean score on mathematics performance than other students.

For the purpose of this study, the instrument used to measure self-efficacy was the College Academic Self-Efficacy Scale (CASES). This 33 item, five-point Likert-type scale was developed by Owen and Froman (1988) with the assistance of three university instructors and seven graduate teaching assistants who developed a group of frequent, routine academic behaviors considered typical for college students. The scale was originally piloted by 93 undergraduate students majoring in education and psychology. Each statement on the instrument is scored based on the participants' response of how much confidence they have in performing the behavior described. Sample behaviors include *Studying enough to understand content thoroughly* and *Explaining a concept to another student.* The point values range from 1 to 5, with 1 being assigned to *very little confidence* up to 5 being assigned to *quite a lot of confidence* for each statement. The overall level of academic self-efficacy is determined by the mean score of the responses given. A higher mean score indicates a greater sense of academic self-efficacy, and a lower mean score indicates a lower sense of academic self-efficacy.

A test-retest method was employed to determine the reliability of the CASES instrument. It was administered twice over an eight-week period to 88 education and psychology students. Owen and Froman (1988) measured the internal consistency reliability by utilizing Cronbach's alpha. This method yielded

reliability coefficients of .90 and .92. The stability estimate over the eight-week period was measured at .85.

Validity of the CASES instrument was determined through several analyses. Using criteria based on Bandura's (1997) self-efficacy theory (frequency of performing each task and enjoyment of each task), Owen and Froman (1988) used regression techniques to determine that the instrument showed "very strong incremental validity beyond that explained by GPA alone" (p. 5).

Factorial validity was also estimated. This was computed via the exploratory principal factor analysis. From this analysis, three factors emerged: overt, social situations; cognitive operations; and technical skills. Together, these factors were able to explain 78% of the systematic item variance. Additionally, 122 students were asked to rate the difficulty of performing each behavior listed in CASES. The least difficult behaviors were determined to be ones with which the students had the most experience and success, and those marked most difficult were behaviors rarely attempted. These findings were determined to be in alignment with Bandura's (1986) self-efficacy theory.

Reading Comprehension on Predicting Math Achievement

Although many studies have shown that the greatest need for remediation is generally in mathematics, inadequate reading skills have been found to be severely limiting to students. In analyzing national data regarding remediation obtained from the NCES, Adelman (1998) found that "when reading is at the core

of the problem, the odds of success in college environments are so low that other approaches are called for" (p. 11). This finding was based on the low degree-completion percentages found for students who needed reading remediation and the correlations that showed that those who needed reading remediation were more likely to need remediation in other areas as well. These correlations led him to the conclusion that "if you can't read, you can't read the math problem, either (let alone the chemistry textbook, the historical documents, or the business law cases)" (p. 11). Fite (2002) agreed with this conclusion by arguing that "student(s) must be able to read before they can be successful at any other academic endeavor" and that "trying to improve math performance for a student who cannot read will be ineffective" (p. 11).

Despite the need to be able to read and comprehend text in general, the unique nature of mathematics presents its own reading challenges to students. According to Schell (as cited in Beliveau, 2001), "mathematics is arguably the most difficult content area material to read; it presents more concepts per word, sentence, and paragraph than any other subject" (p. 2). Beliveau (2001) added that "the language of math is comparable to a foreign language; math is a combination of symbols, numbers, and words" (p. 2). Fite (2002) supports these arguments by sharing the perspective that "the math teacher is a reading teacher . . . a reading teacher that teaches the student to read math" (p. 9). Siegel, Borasi, and Smith (1989) found reading to be so vital to learning math that they

called for “a new relationship between reading and math educators as well as a new agenda for research and practice” (p. 12).

Several studies have been found that show a connection between reading and math success. An examination of international student data conducted by NCES (2007) showed a strong connection between reading and math for 15-year-olds. Focusing specifically on the reading performance of the lowest math performers and the math performance of the lowest reading performers, the results showed that students who scored low in one subject were likely to score low in the other subject as well. This relationship was found to be strong and consistent across the seven countries examined. Of these seven countries, the United States was found to have the highest percentage of students (82%) at the lowest level of reading proficiency who were also at the lowest level of mathematics proficiency.

The National Endowment for the Arts (2007) published a research report based on an analysis of reading trends of 12th-grade students. Comparing the reported number of books at home to scores on a national math test, the research reported a significant, positive relationship between the two measures. When controlling for parents’ level of education, the number of books at home remained a significant predictor of test scores.

Campbell, Schlumberger, and Pate (1998) conducted a study examining reading strategies designed to improve community college students’ abilities to effectively read and study math concepts. These remedial math students, most

of whom were minority students, reported high ratings for the perceived usefulness of specific reading strategies toward their success in math. The highest rated reading strategies were the preview, predict, read, and review strategy and the concept cards strategy.

A study involving community college students conducted by Preast (1998) showed a relationship between scores on the Texas Academic Skills Program (TASP) Reading Test with the TASP Elementary Algebra Test. The study sought to examine the appropriateness of the TASP Reading Test for placement purposes in math classes at a community college in Texas. The 830 participants were enrolled in developmental mathematics or college algebra during the Fall 1996 term. Findings showed a significant relationship ($p < .05$) between the TASP reading scores and TASP mathematics scores for students enrolled in elementary algebra but not in the other math courses (pre-algebra, intermediate algebra, and college algebra).

Stephens (2005) analyzed results compiled from surveys collected from 994 university students enrolled in elementary algebra, intermediate algebra, or probability and statistics. The study consisted of comparing a variety of factors including ACT and COMPASS reading scores with end-of-semester grades in these math courses. Of the two reading assessment tests, he found a significant correlation between ACT reading scores and end-of-course grades in intermediate algebra and a stronger one for probability and statistics but not in elementary algebra. Although a positive relationship was seen between

COMPASS reading scores and end-of-semester grades, this relationship was not strong enough to be significant beyond chance.

In an investigation of the correlations between reading and mathematics performance of Texas students in grades 3 through 11, Das (2008) found "strong and positive correlations" (p. 54) exist in all grades for all students. When separated by ethnicity and native language, Das found that the connection between reading and mathematics performance remained strong for Caucasian and non-English language learner (ELL) students across all grades but was "at most moderate" (p. 53) for Hispanic and ELL students.

Hunsader (2005) conducted a study on how gender, reading ability, and mathematics ability are related to children's problem-solving processes, their proficiency in providing a linguistic explanation of those solution processes, the accuracy of their feelings of self-efficacy, and their ability to assess their own work. The study involved 286 fifth-grade students in west central Florida who took the prior year's Florida Comprehensive Assessment Test. Among her findings, reading ability was found to be a significant predictor of math performance. Additionally, she found an interactive effect between gender and reading ability, with the effect being significant only for students having a mid-level reading ability.

For this study, the Accuplacer Reading Comprehension Test was used to measure the reading comprehension ability of the participants. The Accuplacer Placement Test was designed by the College Board to facilitate the evaluation

and placement of college students in appropriate courses. Introduced in 1985, the Accuplacer program, which consists of reading comprehension, sentence skills, arithmetic, and elementary algebra tests, was developed to place students in English and mathematics courses (College Board, 2003). Nationally, 199 high schools and 86 colleges participated in the initial development of the Accuplacer program to help establish the validity and reliability of the tests.

Chapter Summary

The review of the literature contained in this chapter provided an appropriate and pertinent contextual background for this study. The review began with the history and current trends of remediation in American higher education and continued with a review of the literature on the effect of prior math ability on academic achievement in remedial mathematics. Following this, literature linking student attitudes and academic self-efficacy to math achievement was reviewed. Finally, the chapter concluded with a focus on literature relating reading comprehension ability to academic achievement in mathematics.

Chapter III

Methodology and Procedures

This chapter details the method and procedures that were used in addressing the research question posed in this study. This chapter begins with a discussion of the research design, setting, participants, data collection, research question and hypotheses, variables of the study, and instrumentation. The last sections of this chapter include an overview of the data analysis methods and chapter summary.

Research Design

Research designs function as "templates" for researchers by helping to "facilitate the planning of their studies" (Gall, Gall, & Borg, 2003, p. 289). For studies that involve prediction, correlational research designs are used (Gall et al., 2003). This predictive study sought to address the significance of multiple, pre-identified predictors on the academic achievement of college students enrolled in remedial mathematics. The particular correlational technique that was utilized in this study involving four predictor variables was multiple regression. Multiple regression is a correlational technique that allows researchers to measure the degree of relationship between a criterion variable and a combination of two or more predictor variables (Fraenkel & Wallen, 2009; Gall et al., 2003). In addition to measuring the degree of relationship, multiple regression can measure (a) which variable is the best predictor, (b) if each variable contributes to the predictive ability of the model despite the other

predictor variables in the model, and (c) whether or not a predictor variable is able to predict the outcome when the predictive contributions of the other variables are controlled (Pallant, 2007, p. 147).

Population and Sample

The population for this study consisted of students enrolled in Elementary Algebra at the selected college. The sample from this population was derived from eight randomly selected classes from approximately 50 overall Elementary Algebra sections offered in the selected term. These classes were taught at various campus sites throughout the county, with classes offered at a variety of times and days. Enrollment in any of these Elementary Algebra classes was open to any student who met the course requisites.

All students enrolled in any of the eight randomly chosen classes and present on the day the surveys were distributed were offered an opportunity to participate in the study. Participation was strictly voluntary. Students who chose not to participate did not suffer any adverse consequences. Those willing to participate in the study were asked to complete an assessment packet containing a consent form and the survey instruments. Students were asked for their permission to access their arithmetic and reading comprehension scores from the college's student information database and their remedial math exit exam scores from the Office of the Dean of Mathematics. The remedial math exit exam scores and surveys of the participants were gathered and collated at the conclusion of the class. The offer to participate, administration of the

assessment packets, and compilation of the data were conducted by a third-party individual to ensure that I did not have access to any identifiable information of the participants. Only data from those willing participants who took the arithmetic and reading comprehension tests, completed the assessment packet, and took the remedial math exit exam were included in the study.

Data Collection Procedures

In studies involving multiple regression, Gall et al. (2003) stressed the need to maintain a reasonable balance between sample size and the number of predictor variables using a proportion of 15 subjects per variable (p. 347). Given this rule of thumb and the four predictor variables in the study, a minimum of 60 participants was needed among the eight randomly chosen classes.

A third-party administrator was responsible for collecting all of the data and providing the scores with no names to ensure anonymity. The third-party administrator and dean of mathematics received third-party confidentiality agreements (Appendix A) for their signatures, which were required for their participation in this study.

The list of classes available was obtained from the dean of mathematics, and the selected classes were chosen at random. Once the classes were chosen, selection of the day and time to administer the assessment packet by the third-party administrator was sought in advance from the instructors of the randomly selected classes and the dean of mathematics.

At the day and time selected for each class, the third-party administrator distributed the assessment packets to all of the students who were present. The third-party administrator explained that participation was completely voluntary, confidential, and free of benefits or penalties. The third-party administrator read the following statement from the research participant cover letter (Appendix B):

> Your consent to be a research participant is strictly voluntary and should you decline to participate or should you choose to drop out at any time during the study, there will be no adverse effects on your performance. Any risk of identifying individual students by the researcher is minimized by the following procedures: the survey can only be identified by the student number which is self-disclosed. Your prior math ability and reading comprehension is based on your placement test scores which will be retrieved by the third party administrator, and this researcher will not have access to any student names or numbers to ensure anonymity. Although there are no direct benefits to you, your participation in this research project furthers our understanding of the effects of prior math ability, attitudes toward math, self-efficacy, and reading comprehension on academic achievement in mathematics.

The assessment packets contained a participant cover letter (Appendix B), informed consent (Appendix C), the Indiana Mathematics Belief Scales (Appendix D), and the College Academic Self-Efficacy Scale (CASES; Appendix E). Students who desired to participate signed the consent form and completed

the survey instruments. Upon completion, the participants were asked to place the consent form and survey instruments back into their respective envelopes. Participants then were asked to seal their envelopes and return them to the third-party administrator. Upon the return of all assessment packets, the third-party administrator reviewed the packets for consent and compiled the results with the arithmetic and reading comprehension scores retrieved from the student records database and the Florida College Basic Skills Exit Test scores provided by the dean of mathematics. Once the data were compiled and all identifiable information removed, the third-party administrator then provided the dataset to the researcher for data analysis. Once the data were received, the researcher began to analyze the data.

The researcher did not have access to any student names or identifying information during any portion of the study in order to ensure anonymity of the participants. The cover letter to the participants contained an explanation of how the data would be maintained and safeguarded in a locked file cabinet. The data would be maintained for the appropriate five-year period according to the Barry University Institutional Review Board, after which time the data would be destroyed.

Research Question and Hypotheses

The following research question was designed to guide the study: What is the multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading

comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test?

The following hypotheses were addressed in this study:

Null hypothesis. There is no multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test.

Research hypothesis. There is a multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test.

Variables of the Study

The dependent or criterion variable in this study was academic achievement as measured by the score on the mathematics subtest of the Florida College Basic Skills Exit Test. There were four independent or predictor variables in this study. These independent variables were scores indicating prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability.

Instrumentation

Prior math ability and reading comprehension. For the purpose of this study, prior math ability for each participant was determined by the score earned on the 17-question Accuplacer Arithmetic Placement Test, and the level of reading comprehension was determined by the score earned on the 20-question Accuplacer Reading Comprehension Placement Test. These tests are scored electronically by the Accuplacer computer program, with possible scores ranging from 20 to 120. Score calculations are based on the number of problems correctly answered as well as the quality of the answer chosen from the multiple choices available per question. Thus, high scores indicate high levels of ability in the respective academic areas. Conversely, low scores indicate low levels of ability in the respective academic areas. The Accuplacer Placement Tests by the College Board are currently used to determine academic placement for first-time-in-college, degree-seeking students applying to public colleges and universities in Florida unless exempted by certain minimum SAT or ACT achievement test scores. The requirement to administer an entry-level placement test to first-time-in-college, degree-seeking applicants of Florida public colleges is enforced through Florida Administrative Code Rule 6A-10.0315 by the Florida Department of Education.

For tests such as Accuplacer used to identify the proper placement of students in remedial coursework, it is essential that the test content is relevant to the corresponding subject matter. To address this, the College Board (2003) has

conducted many analyses on Accuplacer test items to determine that they are relevant to the subject matter assessed, thereby establishing content validity.

As for the predictive validity of the Accuplacer Placement Tests, the College Board (2003) conducted a large-scale study from 1990 to 1992 to establish the predictive validity for the tests. This study involved the participation of 50 educational institutions, of which 38 were two-year colleges and the remaining were four-year colleges (College Board, 2003). According to the College Board (2003), the norm group for the arithmetic section numbered 6,114 students and the norm group for the reading comprehension section numbered 9,081 students. Study results revealed correlations between arithmetic test scores and grades earned in general mathematics, arithmetic, elementary algebra, and intermediate algebra arithmetic courses ranging between .31 and .38 for the participating institutions. The internal consistency reliability of the arithmetic test was found to be .92. These correlation coefficients revealed that the Accuplacer Arithmetic Placement Test accounts for 10% to 14% of the variation in predicting course grades.

For reading comprehension, the mean correlation found across the 15 reporting institutions of reading comprehension scores with grades earned in developmental reading was .18. The median correlation was .19. The highest correlation between the scores and course grades in developmental reading was .38. The internal consistency reliability of the Accuplacer Reading

Comprehension Placement Test was found to be .87. Overall, these findings were found to be consistent with other validity studies reported in the study.

In a follow-up validity study published in 2009, Mattern and Packman examined the data from 47 placement validity studies conducted from 2001 to 2006 at 17 separate institutions. With effort made to correct for statistical artifacts such as sampling error, range restriction, and unreliability, moderate-to-strong relationships were found between test scores and course performance. Population estimates of the true score validity ranged from .37 to .46 for the arithmetic test and .22 to .36 for the reading comprehension test. As a result, the percentages of students correctly placed were found to range from 66.4% to 83.7% for the arithmetic test-takers and 62.4% to 80.3% for the reading comprehension test-takers. These findings strengthened the support for the predictive validity of the Accuplacer Arithmetic and Reading Comprehension Tests.

Additionally, the College Board carried out a validation study authorized by the North Carolina Community College System (Michaelides^2005). Placement score and final-course grade data were collected from 19 North Carolina community colleges from January 2000 to May 2003 and analyzed for validation. The findings from the study established the predictive validity of the Accuplacer Placement Tests, including the Arithmetic and Reading Comprehension Placement Tests, for performance in related courses in which students were placed in their first semester of college.

Attitude toward mathematics. The instrument used for measuring the participants' attitudes toward mathematics was Kloosterman and Stage's (1992) Indiana Mathematics Belief Scales (IMBS). The instrument was developed and intended for high school and college-level mathematics students. The instrument contains 30 items evenly distributed across the following five different belief subscales:

1. I can solve time-consuming mathematics problems
2. There are word problems that cannot be solved with simple, step-by-step procedures
3. Understanding concepts is important in mathematics
4. Word problems are important in mathematics
5. Effort can increase mathematical ability

Responses to each statement in the Likert-type instrument are chosen from the options of *strongly agree*, *agree*, *uncertain*, *disagree*, and *strongly disagree*. Each statement on the instrument is scored by assigning point values to each choice. The point values ranges from 1 to 5, with 1 being assigned to *strongly disagree* up to 5 being assigned to *strongly agree* for each positively worded statement. For negatively worded statements, a point value of 5 is assigned to the *strongly disagree* choice down to the point value of 1 assigned to the *strongly agree* choice. Thus, high overall scores indicate positive attitudes toward mathematics, and low overall scores indicate negative attitudes toward mathematics. With each statement ranging in point value from 1 to 5, each belief

subscale score ranges from 6 to 30. According to Kloosterman and Stage (1992), these belief subscales can be used separately or in any combination together.

Using a sample of 517 college students with the majority enrolled in a remedial mathematics course and the remainder having completed two or three college-level mathematics courses, reliability for each of the five belief subscales was measured. The internal consistency reliability (Cronbach's a) for each of the five subscales is presented in Table 1. Kloosterman and Stage (1992) cautioned researchers in their use of the *Word problems are important in mathematics* subscale due to its low internal consistency reliability and, thus, for the purpose of this study, two subscales were combined *(Understanding concepts is important in mathematics* and *Effort can increase mathematical ability)* to measure students' attitudes toward math.

Table 1
Internal Consistency Reliabilities of the Indiana Mathematics Belief Scales (IMBS)

Subscale	Cronbach's a
I can solve time-consuming mathematics problems	.77
There are word problems that cannot be solved with simple step-by-step procedures	.67
Understanding concepts is important in mathematics	.76
Word problems are important in mathematics	.54
Effort can increase mathematical ability	.84

The IMBS were determined to have content validity by six mathematics educators (professors, graduate students, and classroom teachers) who reviewed the statements to ensure they related to their intended constructs. Further, construct validity was established through an administration of the instrument to 517 college students. A supplemental administration of the *Understanding concepts is important in mathematics* subscale was done with 88 students due to a substitution of an item to improve the subscale.

Academic self-efficacy. To measure academic self-efficacy, the instrument used in the study was the College Academic Self-Efficacy Scale (CASES). This 33-item, five-point Likert-type scale, calculated to take approximately 5 minutes, was developed by Owen and Froman (1988) with the assistance of three university instructors and seven graduate teaching assistants who developed a group of frequent, routine academic behaviors considered typical for college students. The scale was originally piloted by 93 undergraduate students majoring in education and psychology.

Each statement on the instrument is scored based on the participants' response of how much confidence they have in performing the behavior described. Sample behaviors include *Studying enough to understand content thoroughly* and *Explaining a concept to another student.* The point values range from 1 to 5, with 1 being assigned to *very little confidence* up to 5 being assigned to *quite a lot of confidence* for each statement. The overall level of academic self-efficacy is determined by the mean score of the responses given. A higher

mean score indicates a greater sense of academic self-efficacy, and a lower mean score indicates a lower sense of academic self-efficacy. The benefit of calculating a mean score, as explained by Owen and Froman (1988), is that unanswered statements would not jeopardize the use of a participant's survey or unfairly penalize their overall academic self-efficacy score.

A test-retest method was employed to determine the reliability of the self-efficacy instrument. It was administered twice over an eight-week period to 88 education and psychology students. Owen and Froman (1988) measured the internal consistency reliability by utilizing Cronbach's alpha. This method yielded reliability coefficients of .90 and .92. The stability estimate over the eight-week period was measured at .85.

Validity of the CASES instrument was determined through several analyses. Using criteria based on Bandura's (1997) self-efficacy theory (frequency of performing each task and enjoyment of each task), Owen and Froman (1988) used regression techniques to determine that the instrument showed "very strong incremental validity beyond that explained by GPA alone" (p. 5).

Factorial validity was also estimated. This was computed via the exploratory principal factor analysis. From this analysis, three factors emerged: overt, social situations; cognitive operations; and technical skills. Together, these factors were able to explain 78% of the systematic item variance. Additionally, 122 students were asked to rate the difficulty of performing each

behavior listed in CASES. The least difficult behaviors were determined to be ones that students had the most experience and success with, and those marked most difficult were behaviors rarely attempted. These findings were determined to be in alignment with Bandura's self-efficacy theory.

Data Analysis Methods

The data collected from the study institution and surveys were analyzed using the IBM SPSS Statistics 18 by IBM, Inc. The statistical procedure of multiple regression was used to analyze the combined relationship (expressed by the correlation coefficient *R)* that was determined to exist between the four independent variables (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension) and the dependent variable, academic achievement. Creswell (2005) defined multiple regression as

> A statistical procedure for examining the combined relationship of multiple independent variables with a single dependent variable. In regression, the variation in the dependent variable is explained by the variance of each independent variable (the relative importance of each predictor), as well as the combined effect of all the independent variables, (p. 336)

Pearson product-moment correlation coefficients *(r)* were calculated separately between each independent variable and the dependent variable. This indicated the degree of association, if any, between each independent variable and the dependent variable as well as the direction of each separate relationship

(Creswell, 2005). For all statistical analyses, a significance level of .05 was used.

Chapter Summary

This chapter detailed the method and procedures that were used in determining the effect of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension on the academic achievement of college students enrolled in remedial mathematics. This chapter began with a discussion of the research design, setting, participants, data collection, research question and hypotheses, variables of the study, and instrumentation. The last sections of the chapter included an overview of the data analysis methods and chapter summary.

Chapter IV

Results

The purpose of this study was to determine the multiple correlation between four predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and the outcome of academic achievement of college students enrolled in remedial mathematics at a 4-year college using standardized instruments validated in previous research. The study was designed to test the hypothesis, as stated in the null, that there is no multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and the outcome of academic achievement of college students enrolled in remedial mathematics. For the purpose of the study, the dependent variable, academic achievement, was operationally defined as a score on the 30-question mathematics subtest of the Florida College Basic Skills Exit Test.

During the Spring 2010 semester, 162 students enrolled in the Elementary Algebra course were offered the opportunity to participate in the study. These students were given assessment packets containing a participant cover letter (Appendix B), informed consent (Appendix C), the Indiana Mathematics Belief Scales (Appendix D), and the College Academic Self-Efficacy Scale (CASES; Appendix E). The Indiana Mathematics Belief Scales consist of 30 Likert-type items, and CASES consists of 33 Likert-type items. Overall, 132 of the 162

students volunteered to participate in the study by signing the consent form and completing the assessment packet.

This chapter reports results found from the statistical analyses that were described in chapter 3. It first discusses the target population and sample, response rates, and descriptive statistics for each variable. Second, the chapter addresses the survey instruments, the hypothesis, and whether the null hypothesis was rejected based on the findings.

Sample Characteristics

The target population for this study was college students enrolled in the remedial mathematics course, Elementary Algebra, at the selected 4-year college located in the southeastern region of the United States. The selected college offered this course to qualified students at various campus sites throughout the county service area, with classes offered at a variety of times and days. Enrollment in this Elementary Algebra course was open to any student who met the course requisites.

The sample from this population was derived from eight randomly selected Elementary Algebra classes taught during the Spring 2010 semester. All enrolled students present on the day the surveys were distributed by a third-party administrator were offered the opportunity to participate in the study. Participation was strictly voluntary. Students who chose not to participate did not suffer any adverse consequences. Those willing to participate in the study were asked to complete an assessment packet containing a consent form and the

survey instruments. Students were asked for their permission to access their arithmetic and reading comprehension scores from the college's student information database and their Florida College Basic Skills Exit Test scores from the Office of the Dean of Mathematics. The exit test scores and surveys of the participants were gathered by the third-party administrator at the conclusion of the classes. The administration, collection, and compilation of the data by the third-party administrator ensured that the researcher did not have access to any identifiable information of the participants. Only the data from those willing participants who took the arithmetic and reading comprehension tests, completed the assessment packet, and took the remedial math exit exam were included in the study.

Response Rates

Of the 162 students present on the day the third-party administrator visited each class, 132 voluntarily participated in the study as indicated by their signature on the consent form. However, due to incomplete responses on the survey instruments, the responses of 14 of the 132 participants were omitted. Additionally, the data for 30 of the remaining participants were omitted due to missing reading comprehension or remedial math exit exam scores. Thus, the sample utilized for this study consisted of 88 participants, resulting in an overall response rate of 54.3% (Table 2). With Gall et al. (2003) calling for a minimum of 15 subjects per predictor variable in multiple regression analyses, the minimum of 60 participants needed based on four predictor variables was achieved.

Table 2
Participants' Response Rates

	Frequency (A/)	Percent
Total packets distributed	162	100%
Total packets returned with consent signed	132	81.5%
Consented packets missing information	44	27.2%
Consented packets eligible to be used	88	66.7%
Eligible packets out of total packets distributed	88	54.3%

Table 3 shows the frequency distribution of the participants' prior math ability scores. The level of each participant's prior math ability was determined by the score earned on the Accuplacer Arithmetic Placement Test. These scores were retrieved by the third-party administrator from the student records database. A high level of prior math ability was indicated by a high score earned on the Accuplacer Arithmetic Placement Test, and a low level of prior math ability was indicated by a low score earned on the Accuplacer Arithmetic Placement Test. Of the 88 participants in the study, 11 (12.5%) earned less than or equal to 45 points, 41 (46.6%) earned greater than 45 but less than or equal to 70 points, 32 (36.4%) earned greater than 70 but less than or equal to 95 points, and four (4.5%) earned greater than 95 points on the arithmetic placement test. The lowest possible score that could be earned on the Accuplacer Arithmetic Placement Test was 20, and the highest possible score was 120.

Table 3
Prior Math Ability Score Frequency Distribution

	Frequency (A/)	Percent	Cumulative percent
<45	11	12.5%	12.5%
> 45 but < 70	41	46.6%	59.1%
> 70 but < 95	32	36.4%	95.5%
> 95	4	4.5%	100.0%
Total	88	100.0%	

Table 4 shows the frequency distribution of the participants' attitude toward math scores. The level of each participant's attitude toward math was determined by the summed score calculated on two subscales of the Indiana Mathematics Belief Scales. This instrument was scored manually by the researcher. A high score calculated on the belief scales indicated a more positive attitude toward math, and a low score indicated a less positive attitude toward math. Of the 88 participants in the study, five participants (5.7%) scored less than or equal to 40 points, 31 (35.2%) scored greater thaji 40 but less than or equal to 50 points, and 52 (59.1%) scored greater than 50 but less than or equal to 60 points. The lowest possible point value was 12, and the highest possible point value was 60.

Table 4
Attitude Toward Math Score Frequency Distribution

	Frequency (A/)	Percent	Cumulative percent
<40	5	5.7%	5.7%
> 40 but < 50	31	35.2%	40.9%
> 50 but < 60	52	59.1%	100.0%
Total	88	100.0%	

Table 5 shows the frequency distribution of the participants' academic self-efficacy. The level of each participant's academic self-efficacy was determined by the mean score calculated on CASES. This instrument was scored manually by the researcher. A high mean score calculated on CASES indicated a greater sense of academic self-efficacy, and a low mean score indicated a lower sense of academic self-efficacy. Of the 88 participants in the study, 17 participants (19.3%) had less than or equal to a 3.0 mean score, 39 (44.3%) had greater than a 3.0 but less than or equal to a 4.0 mean score, and 32 (36.4%) had greater than a 4.0 but less than or equal to a-5.0 mean score. The lowest possible mean score value was 1.0, and the highest possible mean score value was 5.0.

Table 5
Academic Self-Efficacy Score Frequency Distribution

	Frequency (*N*)	Percent	Cumulative percent
<3.0	17	19.3%	19.3%
>3.0 but <4.0	39	44.3%	63.6%
> 4.0 but < 5.0	32	36.4%	100.0%
Total	88	100.0%	

Table 6 shows the frequency distribution of the participants' reading comprehension scores. The level of each participant's reading comprehension ability was determined by the score earned on the Accuplacer Reading Comprehension Placement Test. These scores were retrieved by the third-party administrator from the student records database. A high level of reading comprehension ability was indicated by a high score earned on the Accuplacer Reading Comprehension Placement Test, and a low level of reading comprehension ability was indicated by a low score earned on the Accuplacer Reading Comprehension Test. Of the 88 participants in the Study, none (0.0%) earned less than or equal to 45 points, 28 (31.8%) earned greater than 45 but less than or equal to 70 points, 50 (56.8%) earned greater than 70 but less than or equal to 95 points, and 10 (11.4%) participants earned greater than 95 points on the Accuplacer Reading Comprehension Placement Test. The lowest possible score that could be earned on the Accuplacer Reading Comprehension Placement Test was 20, and the highest possible score was 120.

Table 6
Reading Comprehension Score Frequency Distribution

	Frequency (A/)	Percent	Cumulative percent
<45	0	0.0%	0.0%
> 45 but < 70	28	31.8%	31.8%
> 70 but < 95	50	56.8%	88.6%
> 95	10	11.4%	100.0%
Total	88	100.0%	

Table 7 shows the frequency distribution of the participants' academic achievement scores. The level of each participant's academic achievement was determined by the score earned on the mathematics subtest of the Florida College Basic Skills Exit Test. These test scores were retrieved by the third-party administrator from each instructor. A high level of academic achievement was indicated by a high score earned on the mathematics subtest of the Florida College Basic Skills Exit Test, and a low level of academic achievement was indicated by a low score earned on the mathematics subtest of the Florida College Basic Skills Exit Test. Of the 88 participants in the study, 6 (6.8%) scored less than or equal to 15 points, 15 (17.0%) scored greater than 15 but less than or equal to 20 points, 36 (40.9%) scored greater than 20 but less than or equal to 25 points, and 31 (35.2%) participants scored greater than 25 points on the Accuplacer Arithmetic Placement Test. The lowest possible score that

could be earned on the Accuplacer Arithmetic Placement Test was zero and the highest possible score was 30.

Table 7
Academic Achievement Score Frequency Distribution

	Frequency (A/)	Percent	Cumulative percent
< 15	6	6.8%	6.8%
> 15 but <20	25	28.4%	35.2%
> 20 but < 25	38	43.2%	78.4%
>25	19	21.6%	100.0%
Total	88	100.0%	

Data Analysis Overview

Descriptive and inferential statistics were used to analyze the data collected in this study. Descriptive statistics included means, medians, modes, minimums, maximums, and standard deviations. Inferential statistics analyzed in this study included multiple regression and Pearson product-moment correlation coefficients *(r).* All statistical analyses were conducted using a significance level of .05.

The data were analyzed using IBM SPSS Statistics 18 by IBM, Inc. The statistical procedure of multiple regression was used to analyze the combined relationship (expressed by the correlation coefficient *R)* of the independent variables on a single dependent variable. In regression, "the variation in the

dependent variable is explained by the variance of each independent variable (the relative importance of each predictor), as well as the combined effect of all the independent variables" (Creswell, 2005, p. 336).

Descriptive Statistics

Descriptive statistics were calculated for each of the variables in the study and are presented in Table 8. For prior math ability, the mean score calculated for the 88 participants was 66.7, with scores ranging from 24 to 109 and a standard deviation of 17.37. For attitude toward math, scores ranged from 30 to 60, with a mean score of 51.0 and a standard deviation of 5.65. The academic self-efficacy scores of the 88 participants ranged from 2.42 to 5.00, with a mean score of 3.72 and a standard deviation of 0.63. Participants' scores for reading comprehension ranged from 47 to 106, with a mean score of 78.1 and a standard deviation of 14.02. Lastly, scores for the dependent variable, academic achievement, as measured by the score on the mathematics subtest of the Florida College Basic Skills Exit Test, ranged from 14 to 30, with a mean of 22.0 and a standard deviation of 3.82.

Table 8

Descriptive Statistics for Variables

	N	Mean	Minimum score	Maximum score	Standard Deviation
Prior math ability	88	66.7	24	109	17.37
Attitude toward mathematics	88	51.0	30	60	5.65
Academic self-efficacy	88	3.72	2.42	5.00	0.63
Reading comprehension	88	78.1	47	106	14.02
Academic achievement	88	22.0	14	30	3.82

Instrument Reliability

This study utilized two instruments scored manually by the researcher. The 30-item Indiana Mathematics Belief Scales (Appendix D) was used to measure the independent variable, attitude toward math, and the 33-item CASES (Appendix E) was used to measure the independent variable, academic self-efficacy. Each instrument has been used frequently in previous research studies, with each demonstrating sound psychometric properties. Developed by Kloosterman and Stage (1992), the Indiana Mathematics Belief Scales contains five separate subscales designed to assess different dimensions of students' attitudes toward mathematics. Responses to each statement in the Likert-type instrument are chosen from the options of *strongly agree, agree, uncertain, disagree,* and *strongly disagree.* Each statement on the instrument is scored by assigning point values to each choice. The point values range from 1 to 5, with 1

being assigned to *strongly disagree* up to 5 being assigned to *strongly agree* for each positively worded statement. For negatively worded statements, a point value of 5 is assigned to the *strongly disagree* choice down to the point value of 1 assigned to the *strongly agree* choice. Thus, high overall scores indicate positive attitudes toward mathematics and low overall scores indicate negative attitudes toward mathematics. The two belief subscales chosen to measure attitude in this study were *Understanding concepts is important in mathematics* and *Effort can increase mathematical ability.* The internal consistency reliability (Cronbach's a) for the *Understanding* and *Effort* subscales were computed by Kloosterman and Stage to be .76 and .84 respectively. For this study, reliability analyses calculated Cronbach's a of .69 and .83 for the *Understanding* and *Effort* subscales respectively, supporting the reliability of the scores on this instrument for this study.

CASES is a tool developed to assess academic self-efficacy and measure the confidence of college students performing frequent, routine academic behaviors (Owen & Froman, 1988). Owen and Froman (1988} employed a test-retest method to determine the reliability of the CASES instrument. It was administered twice over an eight-week period to 88 education and psychology students. They calculated the internal consistency reliability by utilizing Cronbach's a. This method yielded reliability coefficients of .90 and .92. The stability estimate over the eight-week period was measured at .85. For purposes of this study, a reliability analysis was run for the instrument and reported a

Cronbach's a of .936, confirming the reliability of the scores on this instrument for this study. Based on these reports, scores generated by using the Indiana Mathematics Belief Scales and CASES were assumed to be reliable.

Correlation Results

Bivariate correlation analyses were conducted to determine if relationships existed among the four predictor variables of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension and the dependent variable, academic achievement. Relationships were determined to be statistically significant if the p-value was calculated to be less than or equal to the significance level of .05. The matrix presented in Table 9 shows the calculated Pearson product-moment correlation coefficients *(r)* between each pair of variables.

Table 9
Correlation Matrix (N=88)

		Prior math ability	Attitude toward math	Academic self-efficacy	Reading comprehension	Academic achievement (DV)
Prior math ability	*r*	1.000	.131	.122	.369**	.564**
	Sig.		.224	.258	.000	.000
Attitude toward math	*r*		1.000	.391**	.044	.241*
	Sig.			.000	.683	.024
Academic self-efficacy	*r*			1.000	.059	.252*
	Sig.				.587	.018
Reading comprehension	*r*				1.000	.369**
	Sig.					.000

Note. DV = dependent variable. *r*= Pearson product-moment correlation coefficient. Sig. = two-tailed significance level of the correlation coefficient.
* Correlation is significant at the .05 level (two-tailed). ^^Correlation is significant at the .01 level (two-tailed).

Utilizing Cohen's (1988) table for Pearson's *r* correlation coefficient (Table 10), the strength of the relationships amongst the variables was determined. The strength of the relationships amongst the variables range from nonexistent to large based on the degree of correlation between the variables.

Table 10
Pearson's r Correlation Coefficient Strength of Relationships

Positive direction of *r*	Negative direction of *r*	Strength of relationship
.00 to .09	.00 to -.09	Nonexistent
.10 to .29	-.10 to -.29	Small
.30 to .49	-.30 to -.49	Medium
.50 to 1.0	-.50 to-1.0	Large

In the first analysis, between prior math ability and academic achievement, the Pearson product-moment correlation coefficient was .564 ($p < .01$). This would suggest a large, positive correlation between prior math ability and academic achievement, showing that the level of academic achievement was strongly and positively related to prior math ability.

In the second analysis, between attitude toward mathematics and academic achievement, the Pearson product-moment correlation coefficient was .241 ($p = .024$). This would suggest a small, positive correlation between attitude toward mathematics and academic achievement, showing theft the level of academic achievement was, to a small extent, positively related to attitude toward mathematics.

In the third analysis, between academic self-efficacy and academic achievement, the Pearson product-moment correlation coefficient was .252 ($p = .018$). This would suggest a small, positive correlation between academic self-

efficacy and academic achievement, showing that the level of academic achievement was somewhat positively related to academic self-efficacy.

In the fourth analysis, between reading comprehension and academic achievement, the Pearson product-moment correlation coefficient was .369 ($p < .01$). This would suggest a medium, positive correlation between reading comprehension and academic achievement, showing that the relationship between academic achievement and reading comprehension was moderate and positive.

Multicollinearity

The Pearson product-moment correlation coefficients between the predictor variables shown in Table 9 were used to determine the extent of, if any, multicollinearity between the predictor variables. The existence of multicollinearity can be problematic for multiple regression models and must be addressed (Pallant, 2007). Analysis of these correlation coefficients indicated that two pairs of the predictor variables were significantly related to one another. The strongest correlation amongst the predictor variables was found to be between academic self-efficacy and attitude toward math ($r = .391$, $p < .01$). This would suggest a medium, positive correlation between academic self-efficacy and attitude toward math, showing that the level of academic self-efficacy was moderately and positively related to attitude toward math.

The Pearson product-moment correlation coefficient between prior math ability and reading comprehension was found to be .369 ($p < .01$). This would

suggest a medium, positive correlation between prior math ability and reading comprehension, showing that the level of prior math ability was moderately and positively related to reading comprehension. The correlation coefficients between the remaining pairs of predictor variables (i.e., prior math ability and attitude toward math, prior math ability and academic self-efficacy, reading comprehension and attitude toward math, and reading comprehension and academic self-efficacy) were small and found to not be significant. According to Pallant (2007, p. 155), correlation coefficient values between independent variables should fall below $r = .70$ in order to avoid problems of multicollinearity. The correlation coefficient values calculated between the predictor variables in this study all fell well below $r = .70$, which indicated that there were little to no problematic effects of multicollinearity on the regression model.

As a further step, collinearity diagnostics were performed to measure the extent of multicollinearity between the predictor variables by calculating their tolerance values and variance inflation factors. According to Pallant (2007), tolerance values, which indicate the level of variability of an independent variable that is not explained by the other independent variables in a regression model, should not be less than 0.1, and the calculated inverse, which is called the *variance inflation factor,* should not be greater than 10. Pallant suggested that calculated values that come close to these values should also be carefully examined and considered. Table 11 shows the tolerance values and variance

inflation factors between each independent variable and the other independent variables.

Table 11
Tolerance and Variance Inflation Factors

	Tolerance ($1 - R^2$)	Variance inflation $1/(1 - R^2)$
Prior math ability	.85	1.18
Attitude toward math	.84	1.19
Academic self-efficacy	.84	1.19
Reading comprehension	.86	1.16

Each independent variable had a tolerance value well above the .10 limit and a variance inflation factor considerably lower than the limit of 10. Considering this, in addition to the correlation coefficient values that each fell well below the .70 limit, multicollinearity was determined not to be problematic when using all of the predictor variables in the regression model.

Multiple Regression Results

The following research question was proposed in this study: What is the multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and the outcome, college students' academic achievement in remedial mathematics? To address this research question, the dependent variable, academic achievement, was statistically regressed on the four independent

(predictor) variables of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension. Using multiple regression allowed for the examination of the combined relationship *(R)* of the four independent variables with the dependent variable.

Multiple regression assumes that the variables are normally distributed and depends on the relationships between the variables to be linear (Osborn & Waters, 2002). This helps to reduce the probability of Type I errors (rejecting the null hypothesis when it is true) and Type II errors (failing to reject the null hypothesis when it is false). If the variables are normally distributed and have linear relationships between them, then the distribution of the residuals should be generally normal as well (Munro, 2001). Figure 1 shows a distribution histogram of the standardized residuals of the dependent variable in the regression model. The standardized residuals, as shown in the histogram, are seen to generally follow the pattern of the calculated normal curve overlaying the histogram. Checking for and confirming the existence of normality and linearity is critical in helping to avoid reporting invalid findings and committing Type I or Type II errors (Osborne & Waters, 2002).

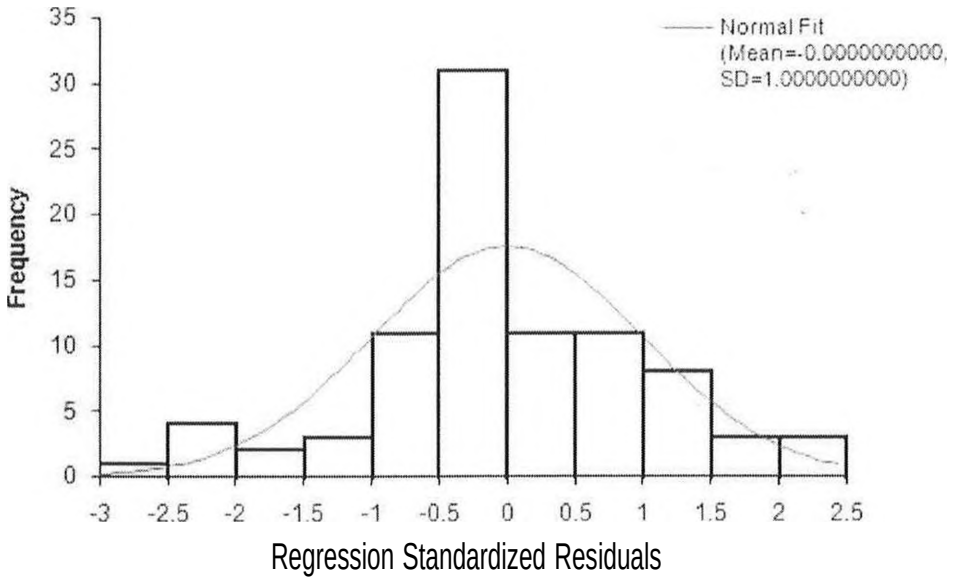

Figure 1. Distribution of the academic achievement standardized residual scores. This figure illustrates the distribution of the standardized residual scores and compares them to the normal curve.

A multiple regression analysis was conducted to determine how well all of the independent variables (i.e., prior math ability, attitude toward math, academic self-efficacy, and reading comprehension) predicted the dependent variable, academic achievement, as measured by a score on the Florida College Basic Skills Exit Test. Table 12 shows the results of the regression analysis, which allowed for the determination of a regression equation that can be used to calculate expected academic achievement scores given values of the four predictor variables.

Table 12
Multiple Regression Results

	Unstandardized coefficients		Standardized coefficients		
	B	Std. error	Beta	*t*	Sig.
(Constant)	4.094	3.515		1.165	
Prior math ability[3]	0.102	0.020	0.104	4.987	0.000
Attitude toward math	0.080	0.063	0.128	1.262	0.211
Academic self-efficacy	0.839	0.566	0.980	1.482	0.142
Reading comprehension[3]	0.050	0.025	0.062	2.002	0.049

[a]Prior math ability ($p < .01$) and reading comprehension ($p < .05$) were the only two predictor variables that had significant relationships with the dependent variable in the regression model.

The results listed in Table 12 were used to determine the multiple regression equation that follows the form $Y\ b_0 + /\wedge Xi + b_2x_2 + b_3x_3 + b_4x_4$, where *Y* is the value of the dependent variable that is being predicted, b_0 represents the value of the constant, *bi, b_2, b_3,* and b_4 are the weights (beta coefficients) of the corresponding independent variables, and x-i, $x_{2)}$ x_3, and x_4 represent the independent variables. Based on the results shown in Table 12, the regression equation that emerged is

> Predicted academic achievement = 4.094 + 0.102 (prior math ability score) + 0.080 (attitude toward math score) + 0.839 (academic self-efficacy score) + 0.050 (reading comprehension score)

The results of the multiple regression indicated that two predictor variables, prior math ability and reading comprehension, contributed significantly to the regression equation. The predictor variable, prior math ability, had an unstandardized coefficient of .102 ($p < .01$), and the predictor variable, reading comprehension, had an unstandardized coefficient of .050 ($p < .05$). The other two predictor variables, attitude toward math and academic self-efficacy, were found to not contribute significantly to the regression equation. The predictor variable, attitude toward math, had an unstandardized coefficient of 0.080 ($p = .211$) and the predictor variable, academic self-efficacy, had an unstandardized coefficient of 0.839 ($p = .142$).

Overall, the combination of the four selected predictor variables was found to relate significantly to the outcome of academic achievement as seen in Table 13. The F-ratio is a comparison of the variance due to independent variables to the variance due to chance (Pallant, 2007). Thus, the high F-ratio, $F(4,83) = 13.401$, $p < .0001$, showed that the variability in the predicted scores was more likely due to the independent variables and less likely due to chance. Despite finding that the regression model was statistically significant in predicting the outcome, academic achievement, only two of the four predictor variables, prior math ability and reading comprehension, were found to contribute significantly to the overall model.

Table 13
Multiple Regression Output: Analysis of Variance (ANOVA)

	Sum of squares	*df*	Mean square	*F*	Sig.
Regression	499.129	*4*	124.782	13.401	<0.001[a]
Residual	722.826	83	9.311	*	
Total	1271.955	87			

[a]Predictors: (Constant), prior math ability, attitude toward math, academic self-efficacy, and reading comprehension.

In analyzing the summary output (Table 14) of the multiple regression model, the multiple correlation coefficient, *R,* was found to be .626 (R^2 = .392) with an adjusted R^2 of .363. This indicated that 36.3% of the variance in academic achievement could be predicted by the combination of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension, and 63.7% of the variance in academic achievement could not be explained by this model.

Table 14
Multiple Regression Output: Model Summary

R	*R* square	Adjusted *R* square	Std. error of the estimate
0.626[a]	0.392	0.363	3.051

[a]Predictors: (Constant), prior math ability, attitude toward math, academic self-efficacy, and reading comprehension.

Results of Hypothesis Test

The following null hypothesis was addressed in this study: There is no multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test.

Alternately, the following research hypothesis was addressed: There is a multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test.

The aim of this study was to test one hypothesis through the statistical means of multiple regression analysis in which the dependent variable was regressed on four predictor variables. Analysis of the data determined a statistically significant regression equation. Specifically, significant relationships were found within the regression model between academic aehievement and prior math ability, and academic achievement and reading comprehension, at an alpha level of .05. Flowever, neither of the other two predictor variables of attitude toward math and academic self-efficacy had a significant relationship with academic achievement at an alpha level of .05 within the regression model. Based on the overall results, the null hypothesis set forth for this study was rejected. The regression model, consisting of the four selected predictor

variables, was found to be statistically significant to predict academic achievement as measured by the score on the mathematics subtest of the Florida College Basic Skills Exit Test.

H_0: There is no multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics, as measured by a score on the Florida College Basic Skills Exit Test.

H_a: There is a multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics, as measured by a score on the Florida College Basic Skills Exit Test.

Research Question

The following research question guided this study and*was addressed statistically through an analysis of data provided by the sample population: What is the multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Exit Test? Based on the data presented in this study, a multiple correlation (adjusted

R^2 = .363) was found to exist between the predictor variables and the academic achievement scores of college students enrolled in remedial mathematics.

Chapter Summary

An analysis of the data determined that there was a significant correlation between academic achievement and prior math ability, attitude toward math, academic achievement, and reading comprehension scores of college students enrolled in remedial mathematics. The data also revealed that only two predictors, prior math ability and reading comprehension, contributed significantly to the overall model. Based on the results found, the null hypothesis was rejected. The implications of these results, the limitations of the study, and suggestions for future research are discussed in the following chapter.

Chapter V

Discussion

The purpose of this study was to determine the multiple correlation between four predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and academic achievement of college students enrolled in remedial mathematics at a 4-year college. The previous chapters introduced the study, reviewed relevant literature, outlined the methodology and procedures, and provided findings from statistical analyses performed on the data collected from college students enrolled in remedial mathematics during Spring 2010. This final chapter includes a discussion on the results, limitations, implications, and recommendations based on the findings of the study.

The theoretical framework upon which this study was based is Albert Bandura's (1986) social cognitive theory. This theory views human functioning as being uniquely determined by a dynamic, reciprocating interaction between individuals' behaviors, their personal thoughts and beliefs, and the environmental conditions that exist around them (Bandura, 1986; Pajares, 2002). Bandura (1986) referred to this determination of human functioning as *triadic reciprocal determinism.* Although these three elements of behavior, personal factors, and environment interact and influence one another, they may differ in their degrees of interaction and influence given the situation (Bandura, 1986, 1989).

This framework, along with the research literature, supports the investigation of the interaction and influence of multiple determinants on human functioning such as academic achievement. Much of the research literature on academic achievement in mathematics analyzes the effect of determinants such as high school background, motivation, math anxiety and beliefs, self-efficacy, personal characteristics, social influence, and prior achievement on performance and persistence. Despite the extensive number of studies conducted, the findings are quite varied. Based on this review of the literature, this study sought to add to the existing body of knowledge by addressing the following research question: What is the multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics as measured by a score on the Florida College Basic Skills Test?

Summary of Findings

This study set out to examine the multiple correlation, if any, between the dependent variable, academic achievement, and four predictor variables (i.e., prior math ability, attitude toward math, academic self-efficacy, and reading comprehension) of college students enrolled in remedial mathematics at a 4-year college. Data from a total of 88 participants were eligible to be used from the original sample population of 162 students for an overall response rate of 54.3%. With a minimum requirement of 15 participants per variable needed in multiple

regression analyses, the minimum sample size of 60 participants for this study was achieved.

With the help of a third-party administrator and the Dean of Mathematics office, scores from the mathematics subtest of the Florida College Basic Skills Exit Test were collected for each participant. The independent variables of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension were analyzed to determine if, collectively, these variables could predict academic achievement. Descriptive and inferential statistical procedures were conducted to analyze the data collected using IBM SPSS Statistics 18 by IBM, Inc.

Correlation Matrix

A correlation matrix (Table 9) was used to determine if the predictor variables of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension correlated separately to the dependent variable, academic achievement. The correlation matrix also allowed for the assessment of the threat of multicollinearity between the predictor variables to the regression model. Along with Cohen's (1988) table for Pearson's *r* correlation coefficient (Table 10), the strength of the relationships in the correlation matrix was determined among the variables. The strength of the relationships among the variables ranged from nonexistent to large based on the degree of correlation between the variables.

Analysis of the correlation matrix indicated that, separately, each of the four predictor variables correlated significantly to academic achievement. Prior math ability showed the strongest correlation to academic achievement, with a Pearson product-moment correlation coefficient of .564 ($p < .01$). This indicated a large, positive relationship between prior math ability and academic achievement.

Reading comprehension and academic achievement showed to have the second highest correlation, with a Pearson product-moment correlation coefficient of .369 ($p < .01$). This indicated a moderate relationship between reading comprehension and academic achievement.

Academic self-efficacy and attitude toward math also correlated significantly to academic achievement. However, the strength of their relationships with the dependent variable was not nearly as strong as that of prior math ability and reading comprehension. The correlation between attitude toward mathematics and academic achievement was .241 ($p = .024$), and the correlation between academic self-efficacy and academic achievement was .252 ($p = .018$). Both of these relationships were small yet significant.

Despite the significant relationships that existed between prior math ability and reading comprehension *(r*= .369, $p < .01$) and between attitude toward math and academic self-efficacy *(r* =.391, $p < .01$), the threat of multicollinearity to the regression model was ruled out. Table 11 reported tolerance values for the

independent variables well above the .10 minimum limit and variance inflation factors considerably lower than the maximum limit of 10.

Multiple Regression

A multiple regression analysis was performed to determine how well the predictor variables of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension together predicted academic achievement scores (Tables 12, 13, and 14). The combination of the selected four predictors was found to be significantly related to academic achievement scores, $F(4,83) = 13.401$, $p < .0001$, which showed that variability in predicted scores was more likely due to the independent variables and less likely due to chance. With an adjusted *R* square value of .363, the regression model of prior math ability, attitude toward math, academic self-efficacy, and reading comprehension accounted for 36.3% of the variance in academic achievement, and 63.7% of the variance in academic achievement was left unexplained by this model.

Despite finding that each of the predictor variables significantly correlated to the dependent variable separately, only two of the four predictor variables, prior math ability and reading comprehension, were found to contribute significantly to the overall model. Nonetheless, the overall regression model was found to be statistically significant in predicting academic achievement.

These findings showed that the results of this study were similar to results found in prior remedial math studies with some exceptions. However, through analysis of the selected predictors of prior math ability, attitude toward math,

academic self-efficacy, and reading comprehension on academic achievement, unique qualities and implications in this study were also found.

In terms of prior math ability, the results of this study showed that prior math ability, as measured by a score on the Accuplacer Arithmetic Placement Test, was significantly correlated to academic achievement and was the strongest predictor to academic achievement. This supported prior studies that found the Accuplacer Placement Test to be a significant predictor of academic achievement. Day (1997) found that the Accuplacer Placement Test was a significant predictor of elementary algebra grades for remedial math students, and Keleher (2005) found that Accuplacer Placement Test scores positively correlated to the final exam scores in elementary algebra. Shalyefu (2004) also found that placement test scores significantly related to the final grades earned in a developmental elementary algebra course for one of the two cohorts in her study. Olivares (2000) found a math placement test to be a significant predictor of overall college achievement, whereas biographical characteristics and high school grades were not.

In this study, attitude toward math and academic self-efficacy were found to correlate significantly to academic achievement on an individual basis from the other predictor variables. However, when taken together with the other two variables, attitude toward math and academic self-efficacy were found not to contribute significantly to the overall regression model for predicting academic achievement. These findings ran contrary to the general consensus in the

literature that supported the notion that students' attitudes toward mathematics and their self-efficacy beliefs were either significant or the strongest predictors of success in mathematics.

In terms of reading comprehension, the results of this study showed that reading comprehension, as measured by a score on the Accuplacer Reading Comprehension Placement Test, was significantly correlated both separately to academic achievement and within the multiple regression model. This finding supports the prior studies reviewed on the subject. NCES (2007) showed a strong connection between reading and math for 15-year-olds in their findings, and the National Endowment for the Arts (2007) found a strong correlation between the numbers of books at home to scores on a national math test for 12th-grade students.

In an investigation of the correlations between reading and mathematics performance of students in grades 3 through 11, Das (2008) found that "strong and positive correlations" exist in all grades for all students (p. 54). Similarly, Hunsader (2005) found that reading ability was a significant pcedictor of math performance for the fifth-grade students who participated.

To answer the research question set forth in the study, the null hypothesis, there is no multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics, was required to be addressed, based on analysis of the results.

Analysis of the data resulted in the calculation of a statistically significant correlation coefficient within a regression model able to predict academic achievement. As a result, the null hypothesis was rejected. Thus, the answer to the study's research question was found to be that there is a multiple correlation between the four selected predictors (i.e., prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability) and college students' academic achievement in remedial mathematics.

Implications

Remedial coursework is just a part of the broader realm of developmental education used by colleges to help provide access and opportunity to students who come to college underprepared to take college-level courses. For colleges who choose to provide this access and opportunity to students, they must continue to explore, develop, and implement practices, policies, and programming to improve the educational outcomes of these students.

The finding that showed the importance of prior math ability to academic achievement was expected and, in and of itself, may not be noteworthy. However, implications do exist. Although prior math ability was found to help predict academic achievement, higher education institutions could benefit these students more by helping them and their professors understand the nature of their scores. Simply using a score earned on a 17-question, multiple-choice placement test to determine which course students must enroll in may no longer be sufficient. Colleges should revisit their entrance placement policies and

practices to assess the effectiveness of these policies and practices for the benefit of students. One consideration may be to supplement placement testing with diagnostic testing. This supplemental testing would better inform students about their specific strengths and weaknesses, which in turn could help them better address their specific deficiencies.

Although attitude toward math and academic self-efficacy did not contribute to the overall prediction model for academic achievement, the results showed that each variable did correlate positively to academic achievement separately. Given these findings, colleges could consider providing remedial mathematics instruction in smaller defined portions, which would allow students to gain incremental wins. This strategy could lead to greater academic self-efficacy and help improve their attitudes toward math, which in turn could lead to greater success.

With the findings showing the importance of reading comprehension ability to academic achievement in remedial mathematics, special attention must be directed to those remedial math students who have deficiencies in reading comprehension. One consideration is to require these students to remediate their deficiencies in reading prior to undertaking their prescribed math courses, or at least to remediate those reading and math deficiencies concurrently.

Within the remedial math classroom, instructors could focus their efforts on teaching students how to *read* math and challenge them to explain the math problems presented to them and the steps needed to solve them. This would

help students better gauge their understanding of the concepts taught as well as their interpretations of the math problems. This would be a distinctly different approach to teaching and learning remedial mathematics than merely expecting students to provide or choose the correct answer. Given this distinctly different approach, remedial mathematics professors would need the proper training to develop the appropriate knowledge, skills, and attitudes to effectively incorporate reading comprehension strategies into the teaching and learning process.

Limitations

The results of this study presented several limitations. One limitation of the study was that the study was accurate only to the extent that the responses of the participants to the survey instruments were honest and accurate. This study depended on self-reported responses to the Indiana Mathematics Belief Scales and the College Academic Self-Efficacy Scale (CASES) survey instruments. As such, these variables are subject to the possibility of human error and bias.

Another limitation of the study was that the data on those students who initially chose to participate in the study but subsequently withdrew from the Elementary Algebra course were not included. The dependent variable, academic achievement, was measured by a score on the Florida College Basic Skills Exit Test. This test served as the final exam for the students taking the course and, thus, students needed to complete the course in order to take the Florida College Basic Skills Exit Test. Information gained from those particular

students who withdrew could be beneficial and add insight to the efforts to better understand academic achievement in remedial mathematics.

A third limitation of the study was that students who took Elementary Algebra strictly via an online learning environment were not able to participate in the study. Those strictly online Elementary Algebra class sections were excluded in the random selection of classes because it was believed that the third-party administrator would not have had an equal opportunity to present the study, distribute the assessment packets, and collate the surveys with the test scores as effectively as doing so in face-to-face classrooms.

Lastly, a limitation of the study was in the generalizability of the findings. The study was limited to students enrolled in Elementary Algebra during a limited time period at a single institution and, thus, it may not be possible or appropriate to make generalizations to populations in other institutions from the findings of this study.

Recommendations

Based on the results found in the study and the limitations realized, recommendations for future studies are presented with the hope that future contributions will be made to the current body of knowledge regarding remedial mathematics. One recommendation is to include data gained from those students who withdraw from remedial mathematics. Information gained from those particular students who withdraw may prove to be beneficial and add

insight to the efforts to better understand academic achievement in remedial mathematics.

The second recommendation for future studies is to investigate possible differences that may exist between those students who are taking the remedial math course for the first time as compared to those who are repeating the course due to an initial failure or withdrawal. Differences may be found between first-attempters and repeaters, particularly in terms of their attitudes toward math and their academic self-efficacy. These variables may play a greater role in the academic achievement of these students, which could provide further insight and direction in terms of providing support and intervention for these students.

Similarly, investigations are warranted that explore the possible differences in prior math ability, attitude toward math, academic self-efficacy, reading comprehension, and academic achievement of students taking remedial mathematics online versus those taking remedial mathematics in a face-to-face environment. Conceivably, online remedial math courses may attract students who are markedly different in prior math ability, attitude, self-efficacy, and reading comprehension than those students who are attracted to face-to-face and blended classes. These insights could highlight the need for unique strategies for each of these groups of students.

Also, this study was strictly quantitative in nature. Studies that include a qualitative perspective are recommended. Gathering qualitative data on

remedial math students and their professors may yield insights and perspectives that a quantitative analysis cannot entirely provide.

Chapter Summary

This chapter presented a summary of the study, discussion of findings, and recommendations. It was concluded that there was a significant combined effect of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension on the academic achievement of college students in remedial mathematics.

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APPENDICES

Appendix A: Confidentiality Agreement

As a member of the research team investigating selected predictors of academic achievement for students in remedial mathematics courses, I understand that I will have access to confidential information about study participants. By signing this statement, I am indicating my understanding of my obligation to maintain confidentiality and agree to the following:

- I understand that names and any other identifying information about study participants are completely confidential.
- I agree not to divulge, publish, or otherwise make known to unauthorized persons or to the public any information obtained in the course of this research project that could identify the persons who participated in the study.
- I understand that all information about study participants obtained or accessed by me in the course of my work is confidential. I agree not to divulge or otherwise make known to unauthorized persons any of this information unless specifically authorized to do so by office protocol or by a supervisor acting in response to applicable protocol or court order, or public health or clinical need.
- I understand that I am not to read information and records concerning study participants, or any other confidential documents, nor ask questions of study participants for my own personal information but only to the extent and for the purpose of performing my assigned duties on this research project.
- I understand that a breach of confidentiality may be grounds for disciplinary action, and may include termination of employment.
- I agree to notify my supervisor immediately should I become aware of an actual breach of confidentiality or situation which could potentially result in a breach, whether this be on my part or on the part of^another person.

Signature Date Printed Name

Signature Date Printed Name

Appendix B: Barry University Cover Letter

Dear Research Participant:

Your participation in a research project is requested. The title of the study is Selected Predictors of Academic Achievement for Students in Remedial Mathematics Courses. The research is being conducted by Gregory K. McLeod, a student in the Higher Education Administration department at Barry University, and is seeking information that will be useful in the field of higher education. The aims of the research are to determine the effects of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability on academic achievement of college students in remedial mathematics in an effort to improve the academic outcomes of those entering college students placing into remedial mathematics courses. In accordance with these aims, a third party administrator will use the following procedures: distribute forms and surveys to all students present; explain the study, participation, and options; collect the forms and surveys in their respective envelopes; compile all of the data; remove any identifiable information; and give the data to the researcher. We anticipate the number of participants to be 100.

Your participation is strictly voluntary. However, if you decide to participate in this research, you will be asked to do the following: sign and date this informed consent form and complete the attitude and self-efficacy scales. Place the surveys and the signed consent form in the return self-sealed envelope and return to the instructor. The entire process should take approximately 10 minutes.

Your consent to be a research participant is strictly voluntary and should you decline to participate or should you choose to drop out at any time during the study, there will be no adverse effects on your performance.

Any risk of identifying individual students by the researcher i§ minimized by the following procedures: the survey can only be identified by the student number which is self-disclosed. Your prior math ability and reading comprehension is based on your placement test scores which will be retrieved by the third party administrator, and this researcher will not have access to any student names or numbers to ensure anonymity. Although there are no direct benefits to you, your participation in this research project furthers our understanding of the effects of prior math ability, attitudes toward math, self-efficacy, and reading comprehension on academic achievement in mathematics.

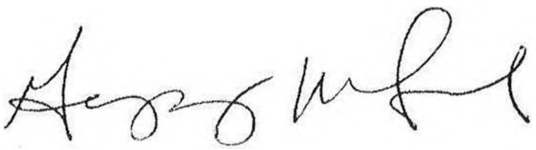
As a research participant, information you provide will be held in the strictest confidence to the extent permitted by law. Any published results of the research will only refer to group averages only and no names will be used in the study. All data utilized in this research project will be kept in a locked file in the researcher's

office. Your signed consent form will be kept separate from the data. All data will be destroyed after 5 years.

If you have any questions or concerns regarding the study or your participation in the study, you may contact me, Gregory K. McLeod, at (727) 341-3602, my supervisor, Dr. Edward Bernstein, at (305) 899-3861, or the Institutional Review Board point of contact, Mrs. Barbara Cook, at (305) 899-3020.

Thank you for your participation.

Sincerely,



Appendix C: Barry University Informed Consent Form

Your participation in a research project is requested. The title of the study is Selected Predictors of Academic Achievement for Students in Remedial Mathematics Courses. The research is being conducted by Gregory K. McLeod, a student in the Higher Education Administration department at Barry University, and is seeking information that will be useful in the field of higher education. The aims of the research are to determine the effects of prior math ability, attitude toward mathematics, academic self-efficacy, and reading comprehension ability on academic achievement of college students in remedial mathematics in an effort to improve the academic outcomes of those entering college students placing into remedial mathematics courses. In accordance with these aims, a third party administrator will use the following procedures: distribute forms and surveys to all students present; explain the study, participation, and options; collect the forms and surveys in their respective envelopes; compile all of the data; remove any identifiable information; and give the data to the researcher. We anticipate the number of participants to be 100.

Your participation is strictly voluntary. However, if you decide to participate in this research, you will be asked to do the following: sign and date this informed consent form and complete the attitude and self-efficacy scales. Place the surveys and the signed consent form in the return self-sealed envelope and return to the instructor. The entire process should take approximately 10 minutes.

Your consent to be a research participant is strictly voluntary and should you decline to participate or should you choose to drop out at any time during the study, there will be no adverse effects on your performance.

Any risk of identifying individual students by the researcher is minimized by the following procedures: the survey can only be identified by the student number which is self-disclosed. Your prior math ability and reading comprehension is based on your placement test scores which will be retrieved by the third party administrator, and this researcher will not have access to any student names or numbers to ensure anonymity. Although there are no direct benefits to you, your participation in this research project furthers our understanding of the effects of prior math ability, attitudes toward math, self-efficacy, and reading comprehension on academic achievement in mathematics.

As a research participant, information you provide will be held in the strictest confidence to the extent permitted by law. Any published results of the research will only refer to group averages only and no names will be used in the study. All data utilized in this research project will be kept in a locked file in the researcher's office. Your signed consent form will be kept separate from the data. All data will be destroyed after 5 years.

If you have any questions or concerns regarding the study or your participation in the study, you may contact me, Gregory K. McLeod, at (727) 341-3602, my supervisor, Dr. Edward Bernstein, at (305) 899-3861, or the Institutional Review Board point of contact, Mrs. Barbara Cook, at (305) 899-3020. If you are satisfied with the information provided and are willing to participate in this research, please signify your consent by signing this consent form.

Voluntary Consent

I acknowledge that I have been informed of the nature and purposes of this experiment by Gregory K. McLeod and that I have read and understand the information presented above, and that I have received a copy of this form for my records. I give my voluntary consent to participate in this experiment.

Signature of Participant *Date*

Researcher *Date*

Appendix D: Indiana Mathematics Belief Scales

Your answers to the following questions will help us to understand what students believe about mathematics. Your responses are strictly confidential and will not be shown to others. Please read each item carefully and circle the response which best describes your feeling for each item.

	Strongly Agree	Agree	Not Certain	Disagree	Strongly Disagree
I feel I can do math problems that take a long time to complete.	1	2	3	4	5
Hard work can increase one's ability to do math.	1	2	3	4	5
I find I can do hard math problems if I just hang in there	1	2	3	4	5
There are word problems that just can't be solved by following a predetermined sequence of steps.	1	2	3	4	5
Time used to investigate why a solution to a math problem works is time well spent.	1	2	3	4	5
Math problems that take a long time don't bother me.	1	2	3	4	5
In addition to getting a right answer in mathematics, it is important to understand why the answer is correct.	1	2	3	4	5
If I can't do a math problem in a few minutes, I probably can't do it at all.	1	2	3	4	5
A person who can't solve word problems really can't do math.	1	2	3	4	5
Getting a right answer in math is more important than understanding why the answer works.	1	2	3	4	5
Ability in math increases when one studies hard.	1	2	3	4	5
Word problems can be solved without remembering formulas.	1	2	3	4	5
If I can't solve a math problem quickly, I quit trying.	1	2	3	4	5
I can get smarter in math by trying hard.	1	2	3	4	5

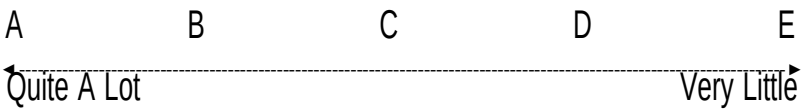
It doesn't really matter if you understand a math problem if you can get the right answer.	1	2	3	4	5
Math classes should not emphasize word problems.	1	2	3	4	5
A person who doesn't understand why an answer to a math problem is correct hasn't really solved the problem.	1	2	3	4	5
Memorizing steps is not that useful for learning to solve word problems.	1	2	3	4	5
I'm not very good at solving math problems that take a while to figure out.	1	2	3	4	5
Learning computational skills is more important than learning to solve word problems.	1	2	3	4	5
It's not important to understand why a mathematical procedure works as long as it gives a correct answer.	1	2	3	4	5
Working can improve one's ability in mathematics.	1	2	3	4	5
Any word problem can be solved if you know the right steps to follow.	1	2	3	4	5
Most word problems can be solved by using the correct step-by-step procedure.	1	2	3	4	5
Computational skills are useless if you can't apply them to real life situations.	1	2	3	4	5
By trying hard, one can become smarter in math.	1	2	3	4	5
Learning to do word problems is mostly a matter of memorizing the right steps to follow.	1	2	3	4	5
Computational skills are of little value if you can't use them to solve word problems.	1	2	3	4	5
Word problems are not a very important part of mathematics.	1	2	3	4	5
I can get smarter in math if I try hard.	1	2	3	4	5

Appendix E: College Academic Self-Efficacy Scale

College Student Questionnaire

DIRECTIONS. Your responses are strictly confidential and will not be shown to others. Do not sign your name. We hope you will answer each item, but there are no penalties for omitting an item.

How much confidence do you have about doing each of the behaviors listed below? Circle the letters that best represent your confidence.



CONFIDENCE

Lots				Little	
A	B	C	D	E	1. Taking well-organized notes during a lecture.
A	B	C	D	E	2. Participating in a class discussion.
A	B	C	D	E	3. Answering a question in a large class.
A	B	C	D	E	4. Answering a question in a small class.
A	B	C	D	E	5. Taking “objective” tests (multiple-choice, T-F, matching).
A	B	C	D	E	6. Taking essay tests.
A	B	C	D	E	7. Writing a high quality term paper.
A	B	C	D	E	8. Listening carefully during a lecture on a difficult topic.
A	B	C	D	E	9. Tutoring another student.
A	B	C	D	E	10. Explaining a concept to another student.
A	B	C	D	E	11. Asking a professor in class to review a concept you don’t understand
A	B	C	D	E	12. Earning good marks in most courses.
A	B	C	D	E	13. Studying enough to understand content thoroughly.
A	B	C	D	E	14. Running for student government office.
A	B	C	D	E	15. Participating in extracurricular events (sports, clubs).
A	B	C	D	E	16. Making professors respect you.
A	B	C	D	E	17. Attending class regularly.
A	B	C	D	E	18. Attending class consistently in a dull course.
A	B	C	D	E	19. Making a professor think you’re paying attention in class.
A	B	C	D	E	20. Understanding most ideas you read in your texts.
A	B	C	D	E	21. Understanding most ideas presented in class.
A	B	C	D	E	22. Performing simple math computations.
A	B	C	D	E	23. Using a computer.
A	B	C	D	E	24. Mastering most content in a math course.
A	B	C	D	E	25. Talking to a professor privately to get to know him or her.
A	B	C	D	E	26. Relating course content to material in other courses.
A	B	C	D	E	27. Challenging a professor’s opinion in class.
A	B	C	D	E	28. Applying lecture content to a laboratory session.
A	B	C	D	E	29. Making good use of the library.
A	B	C	D	E	30. Getting good grades.
A	B	C	D	E	31. Spreading out studying instead of cramming.
A	B	C	D	E	32. Understanding difficult passages in textbooks.
A	B	C	D	E	33. Mastering content in a course you’re not interested in.

Thank you for your help!

Appendix F: Permission to Use Indiana Mathematics Belief Scales

From: Kloosterman, Peter W. [mailto:klooster@indiana.edu]
Sent: Sunday, January 24, 2010 5:39 PM
To: Greg McLeod
Subject: Re: Permission to use the IMBS

Greg,
You are welcome to use the Indiana Scales for your dissertation. Good luck with your study.

Peter Kloosterman
Professor of Mathematics Education
School of Education 3274
Indiana University
Bloomington, IN 47405

klooster@indiana.edu
(812) 856-8147
http://profile.educ.indiana.edu/klooster

Appendix G: Permission to Use College Academic Self-Efficacy Scale (CASES)

23 January 2010

Dear Greg,

Thank you for your inquiry about the College Academic Self-Efficacy Scale (CASES). You are certainly welcome to use CASES. I've attached a copy of the scale. Here are a few summary points about the scale.

Items are scored as A ("quite a lot") = 5...E ("very little") = 1. On the other hand, because we read from right to left, data entry is faster letting A = 1, and E = 5. If you enter data with A = 1, then let the computer recode the values so that A becomes 5, B becomes 4, etc. In calculating an overall CASES score, we prefer calculating a mean rather than a sum.

You may wish to modify questionnaire instructions to best fit your application. For example, if you need informed consent, you might say something like "Filling out this questionnaire is completely voluntary and confidential. There are no penalties for not participating, and you may quit at any time."

The next page shows the CASES items. Following that is a conversation about scoring CASES, plus some normative data.

Best wishes in your research.

Sincerely,

Steven V. Owen, Professor (retired)
Department of Epidemiology & Biostatistics
University of Texas Health Science Center at San Antonio
7703 Floyd Curl Dr., MC 7802
San Antonio, TX 78229-3900

Internet: svo@vbbn.com